DEPARTMENT OF LABOR

Occupational Safety and Health Administration

29 CFR Part 1910

[Docket No. H-004E]

Occupational Exposure to Lead; Supplemental Statement of Reasons; and Amendment of Standard

AGENCY: Occupational Safety and Health Administration (OSHA), U.S. Department of Labor.

ACTION: Final Rule; Supplemental Statement of Reasons; and Amendment of Standard.

SUMMARY: This supplemental statement of reasons sets forth OSHA's reasoning and conclusions with regard to the technological and economic feasibility of meeting the permissible exposure limit (PEL) for lead of 50 micrograms per cubic meter ($\mu g/m^3$) as an 8-hour time weighted average for 46 specified industries or occupations. The statement is made in response to an order of the U.S. Court of Appeals for the D.C. Circuit which required OSHA to reconsider the question of feasibility for these industries. For most of the 46 categories, the supplemental record demonstrates that the standard is feasible either because exposure levels do not generally exceed the PEL, thus requiring minimal or no compliance actions, or because exposure levels above the PEL can be controlled by available and affordable engineering controls or work practices within the time periods permitted for compliance. Additionally, for a few industry categories, the record shows that feasible control measures are available, but that an extension in the compliance schedule is needed to assure the feasibility of their implementation. For some operations within certain industries, respiratory protection *may* be the only technologically feasible means of compliance.

EFFECTIVE DATE: February 20, 1981.

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SUPPLEMENTARY INFORMATION:

A. Regulatory and Judicial History

On October 3, 1975, OSHA proposed a standard for occupational exposure to lead (40 FR 45934) to replace the permissible exposure limit which had been adopted from a national consensus standard pursuant to § 6(a) of the Occupational Safety and Health Act (Act). A lengthy informal hearing was held in Washington, D.C. and two regional hearings were held in St. Louis, Missouri, and San Francisco, California, in the spring of 1977. In the fall of the same year, hearings were held for the receipt of additional information on certain specific issues, including medical removal protection. The hearing record was closed in January of 1978. On November 14, 1978, a final standard which limited occupational exposure to airborne concentrations of lead to 50 $\mu g/m^3$ (micrograms per cubic meter) based on an 8-hour time weighted average (TWA) was published in the **Federal Register** (43 FR 52952). Additional protective provisions included environmental monitoring, recordkeeping, employee education and training, medical surveillance, medical removal protection, hygiene facilities, and other requirements. Supplemental attachments were published November 21, 1978 (43 FR 54354).

Immediately after promulgation, the lead standard was challenged by both industry and labor in several U.S. Courts of Appeals. All cases were transferred and consolidated in the U.S. Court of Appeals for the District of Columbia Circuit. Simultaneously, various parties sought administrative reconsideration and stays of the regulation, one of which was granted. On March 1, 1979, the D.C. Circuit partially stayed the lead standard by delaying the requirement for installing engineering controls and instituting work practices. However, enforcement of the PEL and provisions for environmental monitoring, recordkeeping, employee education and training, medical surveillance, and medical removal protection was permitted to begin on March 1, 1979.

In a lengthy opinion issued on August 15, 1980, the United States Court of Appeals for the District of Columbia Circuit, per Chief Judge Wright, upheld the validity of OSHA's lead standard in most respects. However, the court found that OSHA failed to present substantial evidence or adequate reasons to support the feasibility of the standard with respect to certain industries, and remanded the standard to the Agency for reconsideration of the question of the technological and economic feasibility of the standard for those industries.

With respect to the following industries, the court found OSHA's analysis of the feasibility of the standard to be adequate and upheld the validity of the entire standard: primary smelting; secondary smelting; printing; can manufacturing; battery manufacturing; paint and coatings manufacturing; ink manufacturing; wallpaper manufacturing; electronics manufacturing; and gray-iron foundries.

The court also found that:

> OSHA failed to present substantial evidence or adequate reasons to support the feasibility of the standard for the following industries: Nonferrous foundries; pigment manufacture; shipbuilding; auto manufacture; solder manufacture; wire patenting; pottery; brick manufacture; agricultural pesticides manufacture; leather manufacture; pipe galvanizing; gasoline additives manufacture; linoleum-rubber-plastics manufacture; paint spraying; ammunition manufacture; smelting and refining of zinc, silver, gold, platinum, copper, and aluminum; machining; lead burning; glass manufacture; textile manufacture; book binding; steel alloy manufacture; terne metal manufacture; glass polishing and spinning; cutlery manufacture; diamond processing; plumbing; jewelry manufacture; pearl processing; casting; cable coating; electroplating; explosives manufacture; lamp manufacture; sheet metal manufacture; tin rolling; telecommunications; and independent collecting and processing of scrap lead (excluding collecting and processing that is part of a secondary smelting operation): (*United Steelworkers of America* v. *Marshall*, No. 79-1048 (D.C. Cir. Aug. 15, 1980), slip opinion, pg. 245).

The court did not vacate any portion of the lead standard. Rather, it stayed the enforcement of 29 CFR 1910.1025(e)(1) (requiring compliance with the PEL through engineering controls and work practices alone) for those industries for which OSHA failed to present substantial evidence or adequate reasons to support the feasibility of the standard. The court gave OSHA 6 months in which to complete its reassessment of the feasibility issue.

Accordingly, on September 24, 1980, OSHA published a **Federal Register** notice (45 FR 63476) which reopened the rulemaking record and scheduled a hearing for the limited and express purpose of soliciting and receiving additional information pertaining to the technological and economic feasibility of meeting the 50 $\mu g/m^3$ PEL solely by engineering controls and work practices. To supplement the notice, OSHA mailed nearly 200 letters urging participation in the rulemaking to representative business concerns, trade associations and unions so that the record might be more fully developed. Enclosed with the letters were copies of the notice. The notice requested information only for those industries for which the court ruled that OSHA had failed to present substantial evidence or adequate reasons to support feasibility, or for any other industry not heretofore identified as involving lead exposure. To help facilitate the formulation of comments, OSHA included in the notice a list of 30 specific questions pertaining to feasibility. OSHA indicated that it expected to submit additional information to the record.

In attempting to meet the remand deadline set by the court, OSHA set October 27, 1980, as the date by which all comments must be received and notices of intention to appear at the hearing filed—a 33-day period. While this time period constituted legally adequate notice (see 29 U.S.C. 655(b)), the Agency recognized that it was a relatively short time period in which to conduct an OSHA rulemaking. The time allowed was nonetheless considered necessary if the rulemaking were to be completed in accordance with the court's deadlines. In the view of the Agency, the scheduled hearing together with the posthearing comment period would provide additional opportunity for input from interested parties.

To further develop the record, OSHA conducted several research efforts. Computer and other types of literature searches were conducted to find control technology studies relevant to these industries. NIOSH Health Hazard Evaluations concerning lead exposure were researched for relevant feasibility evidence. EPA environmental emission identification and control studies and other EPA data were searched for relevant evidence. In an attempt to obtain data from its own collective experience, OSHA researched several enforcement case files using MIS (Management Information System) data. Looking for relevant economic feasibility data, OSHA economists culled large amounts of publicly available economic and financial data—e.g., SEC 10-K reports and FTC quarterly financial reports. Additionally, a contractor, Radian Corporation, was employed to generate data by contacting industry sources.

During this concerted data collection effort OSHA looked for all relevant evidence and did not exclude from the record any documents relating to technological or economic feasibility. This information generated and collected by OSHA, which consists of approximately 500 entries, was compiled and presented to the OSHA Docket Office by October 27, 1980, receiving the exhibit number, 476.

In response to the notice, OSHA received 41 timely comments (Exhibit 475) and 9 late comments (Exhibit 478). Additionally, 28 interested parties filed timely notices of intention to appear at the hearing (Exhibit 477). The informal public hearing ran from the fifth to the seventh of November and was recorded by 800 pages of transcript. OSHA presented six expert witnesses who were vigorously cross examined. Although 28 parties had filed intentions to appear, only two industry presentations were made and were subject to questioning. Both unions who had filed appeared and, following their testimony, answered questions.

The record remained open for the receipt of additional comment and data until December 1, and, for posthearing argument until December 10, 1980. Thirty-four such submissions were received. Final certification of the record was completed on December 17, 1980, by Administrative Law Judge Feirtag.

In light of the above efforts to obtain all available evidence, any absence of evidence in the record cannot be due to the lack of notice or an opportunity to submit it or to any deficiencies in the agency's efforts. Where the record has factual gaps, it is because there is no additional evidence or because parties uniquely in possession of certain information have chosen not to submit it.

B. Decision by the U.S. Court of Appeals and the Remand Order

A brief review of the court's decision will assist in an understanding of these remand proceedings. By a 2–1 vote, the court rejected substantive and procedural challenges to the standard's validity, and except for the application of the engineering control provision to specified industries, affirmed the standard and lifted the partial stay in effect since March 1, 1979. In responding to a variety of arguments against the validity of the standard, the court concluded:

1. The rulemaking leading to the new lead standard was free of procedural error.

2. The substantive provisions of the lead standard, including the medical removal protection program, the multiple physician review program, and the rules governing access to medical records, fall within the scope of OSHA's statutory power and are reasonable exercises of that power.

3. OSHA presented substantial evidence for its decision that a Permissible Exposure Limit of 50 $\mu g/m^3$ was necessary to prevent material impairment of employees' health.

4. OSHA presented substantial evidence for the feasibility of the lead standard for the following industries: primary lead smelting, secondary lead smelting, battery manufacture, electronics, gray iron foundries, ink manufacture, paints and coatings manufacture, wallpaper manufacture, can manufacture, and printing. For these industries the standard shall go fully into effect.

Ibid., p. 244.

With respect to certain other industries, the court found that OSHA failed to present substantial evidence or adequate reasons to support the feasibility of the standard. These industries are listed above.

For these industries, the court remanded the rulemaking record and gave OSHA 6 months to reconsider the feasibility of the standard with instructions to "return the record * * * with sufficient evidence and fuller explanation * * *" *Ibid.*, p. 245. During this 6 month period the court stayed the effectiveness of a single provision (section (e)(1) which requires compliance with the PEL by engineering controls and work practices) for these industries. All other provisions were immediately put into effect.[1]

In deciding the feasibility issues presented in the case, the court provided detailed guidelines against which the feasibility of the standard for the industries covered by the remand order will be judged. These are briefly discussed here as a framework for the specific industry discussions which follow. For the most part, the court affirmed the guidelines OSHA had used for its initial feasibility determinations in Attachment D to the preamble (43 FR 54474–54476). The court concluded:

First, within the limits of the best available evidence, and subject to the court's search for substantial evidence, OSHA must prove a reasonable possibility that the typical firm will be able to develop and install engineering and work practice controls that can meet the PEL in most of its operations. OSHA can do so by pointing to technology that is either already in use or has been conceived and is reasonably capable of experimental refinement and distribution within the standard's deadlines.

The effect of such proof is to establish a presumption that industry can meet the PEL without relying on respirators, a presumption which firms will have to overcome to obtain relief in any secondary inquiry into feasibility in any of the proceedings we discuss below.

* * * * *

Second, as for economic feasibility, OSHA must construct a reasonable estimate of compliance costs and demonstrate a reasonable likelihood that these costs will not threaten the existence or competitive structure of an industry, even if it does portend disaster for some marginal firms.

Ibid., p. 159.

Of significant note, the court ruled that feasibility will be reviewed on an industry-by-industry basis, therefore requiring OSHA to "examine the feasibility of each industry individually" *Ibid.*, p. 223. OSHA's failure to include in the preamble separate industry-by-

[1] On December 8, 1980, the Supreme Court stayed additional provisions of the standard for all affected industries pending the filing and disposition of petitions for certiorari in the Supreme Court. The Supreme Court's stay is identical to the one originally imposed by the Court of Appeals on March 1, 1979, and supersedes the Court of Appeal's limited stay.

industry analyses of all relevant factors led the court to reject the Agency's general finding of feasibility. Of the 38 industries which the court remanded, only four (nonferrous foundries, pigment manufacture, shipbuilding, and auto manufacture) had any individual discussions of both technological and economic feasibility. The court rejected OSHA's attempt to infer that a 1-year compliance period would be feasible for a large class of diverse industries whose only common characteristics were that exposure levels were generally low and that conventional engineering controls and work practices could probably be utilized at small cost. *Ibid.*, p. 218–224.

The court however, did not require that OSHA

> always present a detailed analysis for individual operations in supporting the feasibility of the standard. In industries where lead exposures are generally very low, or where strong evidence shows the standard to be technologically practicable for the most troublesome parts of the industry, OSHA can find the standard generally feasible and allow the variance process to account for unanticipated difficulties in isolated operations. But such an operation-by-operation analysis seems crucial in an industry where the evidence clearly suggests impracticality in important stages of the industrial process.
> *Ibid.*, p. 214, n. 155.

The court also reaffirmed the often-stated view that the OSH Act is a "technology-forcing" statute, *ibid.*, p. 142, and found that in proving technological feasibility

> [the court] cannot require of OSHA anything like certainty. Since "technology-forcing" assumes the agency will make highly speculative projections about future technology, a standard is obviously not infeasible solely because OSHA has no hard evidence to show that the standard has been met. More to the point here, we cannot require OSHA to prove with any certainty that industry will be able to develop the necessary technology, or even to identify the single technological means by which it expects industry to meet the PEL. OSHA can force employers to invest all reasonable faith in their own capacity for technological innovation, *Society of Plastics Industries, Inc.* v. *OSHA, supra*, 509 F. 2d at 1309, and can thereby shift to industry some of the burden of choosing the best strategy for compliance. *OSHA's duty is to show that modern technology has at least conceived some industrial strategies or devices which are likely to be capable of meeting the PEL and which the industries are generally capable of adopting.*
> *Ibid.*, p. 145 (emphasis added).

Reliance on "technology forcing" to achieve compliance with the PEL must however recognize the need to allow an industry adequate time for technological development. In sustaining the 10-year compliance schedule for the primary smelting industry, the court affirmed OSHA's application of this principle, and it is applied again here in the analysis of, for example, the automobile industry.

In proving the economic feasibility of the standard, the court ruled that cost estimates are generally required but that exact compliance costs are not. OSHA need only provide a reasonable assessment of the likely range of costs attributable to the regulation and evaluate the effect of those costs on the industry. *Ibid.*, p. 147. The costs will e examined "in relation to the financial health and profitability of the industry and the likely effect of such costs on unit consumer prices," *ibid.*, p. 144, taking into account industries' ability to pass regulatory costs forward onto purchasers or backward onto suppliers. *Ibid.*, p. 147. However, actual cost estimates and assessments of economic impact were not provided for certain industries and yet the Agency's conclusions on economic feasibility were affirmed. For example, in the electronics industry, the court ruled that "the ease with which this industry can adapt to the standard technologically essentially moots the economic question." *Ibid.*, p., 225. Similarly, in the wallpaper manufacturing industry where the "paucity of evidence [was] likely due to the industry itself," *Ibid.*, p. 229, OSHA's adaptation of the Short Reports conclusion was found to have been based on the "best available evidence."

In the manufacture of inks, the court upheld OSHA's determination of economic feasibility based on an inference from cost estimates for the proposed 100 $\mu g/m^3$ limit "in the absence of contrary evidence or argument." *Ibid.*, p. 227. Where similar circumstances exist, OSHA has used this mode of analysis in responding to the remand order.

When estimating costs, OSHA need not blindly rely on cost estimates submitted to the record by industry or by the Agency's own consultants. Citing Judge Bazelon's opinion in the cotton dust case, the court said that where the Agency finds specific faults in cost estimates, it "can produce its 'own' estimate" by making modifications, so long as the source and magnitude of the overestimates are identified and the Agency offers a counterestimate of costs which thoroughly and precisely explains its revisions. *Ibid.*, pp. 147–148. It also concluded that "OSHA can revise any gloomy forecast that estimated costs will imperil an industry by allowing for the industry's demonstrated ability to pass costs through to consumers." *Ibid.*, p. 147. It was precisely these actions the court upheld in affirming OSHA's conclusions regarding the standard's feasibility in the primary and secondary smelting industry.

C. Remand proceedings—Legal issues

In response to the remand order, OSHA reopened the rulemaking record to obtain additional evidence. To assure optimal procedural and due process rights to individuals interested in providing information to the record, the reopening was announced in a detailed notice in the **Federal Register** and actual notice was given to nearly 200 interested persons. A 30-day period for written comments was established, and a public hearing, although not required, was held.

During the remand proceedings several questions arose concerning the procedures employed by OSHA. Specifically, several industry parties contended that OSHA denied rulemaking participants the right to effective cross-examination (*see*, for example, the LIA posthearing brief, Ex. 516) by three alleged actions: (1) the remand proceedings, particularly the hearing, were scheduled without providing participants enough time for adequate preparation of comments, testimony and cross-examination; (2) OSHA's Docket Office was unable to provide copies of documents in the record on request because of mechanical breakdowns, further hampering the participants' ability to effectively cross-examine OSHA's witnesses, and (3) OSHA's failure to produce all consultants whose feasibility studies are included in the record denied participants the right to cross-examination on "crucial issues."

OSHA believes each of these claims is without merit. First, in an effort to maximize public participation and to avoid further procedural obstacles to implementation of the standard, OSHA decided that notice and public comment on remand would be the fairest and most effective course. Accordingly, OSHA reopened the lead record, allowing 30 days for written comments, and at the same time established a timetable which afforded interested parties an opportunity to participate in the hearing (45 FR 63881). This schedule allowed an initial comment period of 30 days and a posthearing comment period of 30 days. The procedure exceeds the requirements of the OSH Act, 29 U.S.C. 655(b) and the Administrative Procedure Act, 5 U.S.C. 553, and has enabled OSHA to meet the Court's 6-month remand deadline. OSHA believes that this schedule did not hamper the ability of affected parties to participate meaningfully in the remand proceeding. Much of the information OSHA requested from the participants was already in existence and within industry's possession; e.g., job classifications for exposed employees, air monitoring data collected pursuant to 29 CFR 1910.1025(d), and industrial assets and net worth, although few of these data were actually submitted to the record.

Second, although OSHA's Docket Office experienced certain mechancial problems during the week of the remand hearings, no participants were prejudiced as a result. As soon as OSHA's staff was advised of copying difficulties, every effort was made to provide the participants with the requested documents. (Tr. 184, 250–57, 297, 315, 322, 262–63). In fact, no one was required to question any witnesses without the benefit of first reviewing the accompanying documentary evidence.

Third, the American Iron and Steel Institute (AISI) reiterated a claim rejected by the Court of Appeals, Opinion, pp. 59–62, that unless Dr. John Short was produced as a witness and subjected to cross-examination, OSHA should not be allowed to rely on the Short Report in its assessment of technological feasibility. (Tr. 38, 90). Moreover, although during the original lead proceedings AISI was unaware of the fact that David J. Burton had actually prepared the technological assessment within the Short Report, *see Ibid.*, p. 60, it now had this information and had the opportunity to cross-examine him during the remand. OSHA produced Mr. Burton as a witness and AISI chose not to question him concerning his earlier conclusions. It is OSHA's view, confirmed by the court's decision, that it clearly was not required to produce John Short at these proceedings. Also the Lead Industries Association (LIA) contended (Ex. 516, p. 6; Tr. 17) that representatives of Charles River Associates (CRA) should have been subjected to cross-examination during the remand hearing. CRA did no work for OSHA on remand (Tr. 27, 68); no useful purpose could have been served by CRA's appearance at the hearings.

Finally, it has been suggested during these proceedings that OSHA is required to (1) make a threshold finding under Section 3(8) of the Act that a "significant risk of harm" from lead exposure exists in each of the remand industries and (2) that the benefits to be derived from application of the standard exceed its costs. The Court of Appeals has already ruled on both points. The court found that "OSHA has carried its burden under Section 3(8)," in finding that lead poses a significant risk of harm to workers, opinion, p. 112, and "that in fact cost-benefit analysis would contravene the Congressional goal of protecting worker health and safety within the limits of economic possibility." *Ibid.*, p. 140, n. 102. Furthermore, OSHA has made it clear from the beginning of these proceedings that the record was reopened for the "limited and express purpose" of soliciting information relevant to feasibility. No information on issues other than feasibility was requested. (45 FR 63476).[2]

D. Conclusions

I. *Generally.* The Court of Appeals remanded the record to OSHA to reconsider the feasibility of the standard in 38 specific industrial or occupational categories. These categories were listed in the Short report (Ex. 22) as having potential lead exposure. For the purpose of the remand, OSHA has additionally considered the standard's feasibility for industries or occupations where lead exposure is present, but which were not included in the group of 38 (e.g., stevedoring), and has in some cases modified the category to better describe the actual processes. The final list has 46 categories; each is discussed in detail below.

For most of the 46 categories, the supplemented record demonstrates that the standard is feasible either because exposure levels do not generally exceed the PEL, thus requiring minimal or no compliance actions, or because exposure levels above the PEL can be controlled by available and affordable engineering controls or work practices within the time periods permitted for compliance.

For a few industry categories, the record supports the availability of feasible control measures, but indicates that an extension in the compliance schedule is necessary to assure the feasibility of their implementation. This is true, for example, in the primary steel manufacturing and automobile manufacturing industries.

[2] Several industry participants have suggested that "significant risk" must be established for each industry where lead exposures occur. (Ex. 475–22; Ex. 499; Ex. 500; Ex. 517). OSHA disagrees with this view. The "significant risk" findings OSHA has made, and which have been upheld by the D.C. Circuit, are equally applicable to the remand industries. In any event, the evidence submitted by some parties in an effort to demonstrate the absence of significant risk in their industries is without merit and does not detract from the earlier conclusion that employees exposed to lead even in the workplace circumstances presented by these industries, face a significant risk of material impairment of health.

An interpretation of the standard, initially made by the Agency in response to a petition by Ethyl Corporation in 1979, will achieve the same result for a few other industries, thereby enhancing their capability to comply in a feasible manner. This interpretation construed the term "secondary lead production" in Table I of Section (e)(1) of the standard to apply to all operations in any industry in which new or used scrap or waste materials were smelted through a chemical reduction process and refined to produce lead metal, whether the operation was performed by a firm whose primary purpose was to produce lead metal or was a captive process in the manufacture of other products (Ex. 476–74).

Ethyl Corporation manufactures tetraethyl lead, a chemical additive used in gasoline. As part of the process, it recycles a sludge-like waste and smelts it in a reverberatory furnace to return unused lead to the process stream. Similar activities may occur, for example, in the manufacture of solder and ammunition. Where an operation can be described as secondary lead production, the appropriate compliance period is 3 years for the interim 100 $\mu g/m^3$ limit and 5 years for the PEL. This interpretation covers only those operations and equipment pertinent to the secondary lead production operation. (This interpretation has been incorporated into OSHA's compliance directive for the lead standard; see OSHA Instruction CPL 2–2.8A, page A–3.)

Another interpretation of the standard may be required in some cases. Where one process within a facility is within the zone of contamination of another process and one of the two processes has an extended compliance period, the one with the shorter time may require the longer time period to achieve full compliance. This is necessary because contamination of one process by the other would preclude effective engineering solutions.

For example, Bunker Hill's zinc fuming furnace is within the confines of its primary lead smelter: the zinc operation has one year to achieve compliance, the primary smelter 10 years. However, due to cross contamination, complete control of the zinc operation may not be possible until emissions from the primary smelter have been controlled. The entire facility, therefore, may realistically require 10 years to comply with the standard, although all feasible engineering controls and work practice are still required to be used in the interim even if they are not capable of reaching ultimate compliance. Where similiar compliance problems arise, the affected employer should incorporate this information into its compliance plans or seek an official interpretation from OSHA.

For some limited operations within certain industries, respiratory protection *may* be the only technologically feasible means of compliance with the PEL in light of known or currently available technology. These cases, discussed in more detail in the industry-by-industry analysis below, include certain spray painting operations, activities in certain confined spaces (e.g., in some areas inside ship hulls), activities at non-fixed worksites or workstations (e.g., repair and manintenance), and excursions in exposure caused by unpredictable and uncontrollable changes in conditions (e.g., spills, equipment failure). In these specific but limited instances, the presumption in favor of the feasibility of engineering controls and work practices would not be applicable and would not support a violation of section (e)(1). However, as the court stated:

> Insufficient proof of technological feasibility for a few isolated operations within an industry, or even OSHA's concession that respirators will be necessary in a few such operations, will not undermine this general presumption in favor of feasibility (for that industry). Rather, in such operations firms will remain responsible for installing engineering and work practice controls to the extent feasible, and for using them to reduce lead exposure as far as these controls can do so. In any proceeding to obtain relief from an impractical standard for such operations, however, the insufficient proof or conceded lack of proof will *reduce* the strength of the presumption a firm will have to overcome in justifying its use of respirators.
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> Opinion, page 159.

It should be noted that many workers in occupations or industries listed in the remand order will be excluded from coverage because of the exemption for the construction industry from the standard. 29 CFR 1910.1025(a)(2), as corrected in 44 FR 50338, August 28, 1979. This exemption would apply, for example, to welders, lead burners, painters, and plumbers employed by the construction industry. Accordingly, this preamble only addresses nonconstruction aspects of those occupations.

II. Industry-by-industry Analyses

The following is a discussion of the general principles of control of hazardous materials, the specific application of these controls to lead exposures, the cost of implementing these controls and the economic impact on the industries affected. Each of the individual industry analyses includes a section on the use of the particular industrial commodities; a description of the processes and the areas where lead exposure may occur; the control technology currently being used by the industry; the current exposure levels in the industries; the population exposed; the additional controls needed to comply with 50 $\mu g/m^3$; the summary of the technological findings; the cost of compliance with paragraph (e) of the standard; an economic profile of the affected industry; and finally a summary of the Agency's economic feasibility findings.

TABLE OF CONTENTS

(d) Exposure Levels
(e) Additional Controls
(f) Conclusion: Technological Feasibility
(g) Economic Feasibility

14. Explosives Manufacture

(a) Uses
(b) Process Description and Exposure Areas
(c) Controls Currently Used
(d) Exposure Levels
(e) Population Exposed
(f) Conclusion: Technological Feasibility
(g) Economic Feasibility

15. Gasoline Additive Manufacture

(a) Summary

16. Glass Manufacture

(a) Primary Glass Manufacture
(i) Uses
(ii) Process Description and Exposure Areas
(iii) Controls Currently Used
(iv) Exposure Levels
(v) Population Exposed
(vi) Additional Controls
(b) Secondary Glass Manufacture
(i) Process Description and Exposure Areas
(ii) Controls Currently Used
(iii) Exposure Levels
(iv) Population Exposed
(v) Additional Controls

17. Gold, Silver and Platinum Smelting

(a) Primary Gold Smelting and Refining
(i) Uses
(ii) Process Description and Exposure Areas
(iii) Controls Currently Used
(iv) Exposure Levels
(v) Population Exposed
(vi) Additional Controls
(vii) Conclusion: Technological Feasibility
(b) Primary Silver Smelting and Refining
(i) Uses
(ii) Process Description and Exposure Areas
(iii) Controls Currently Used
(iv) Exposure Levels
(v) Population Exposed
(vi) Additional Controls
(vii) Conclusion: Technological Feasibility
(c) Platinum Smelting
(i) Uses
(ii) Process Description and Exposure Areas
(iii) Controls Currently Used
(iv) Exposure Levels
(v) Population Exposed
(vi) Additional Controls
(vii) Conclusion: Technological Feasibility
(d) Secondary Smelting of Gold, Silver and Platinum
(i) Uses
(ii) Process Description and Exposure Areas
(iii) Exposure Levels
(iv) Population Exposed
(v) Additional Controls
(vi)
(vii) Conclusion: Technological Feasibility
(e) Gold, Silver and Platinum as By-Products of Lead and Copper Smelting Operations
(i) Uses
(ii) Process Description and Exposure Areas
(iii) Controls Currently Used
(iv) Exposure Levels
(v) Population Exposed
(vi) Conclusion: Technological Feasibility
(vii) Economic Feasibility
(f) Economic Feasibility: Precious Metals
(i) Cost of Compliance
(ii) Industry Profile
(iii) Conclusion: Economic Feasibility

18. Jewelry Manufacture

(a) Uses
(b) Process Description and Exposure Areas
(c) Controls Currently Used
(d) Exposure Levels
(e) Population Exposed
(f) Additional Controls
(g) Conclusion: Technological Feasibility
(h) Economic Feasibility

19. Lamp Manufacture

(a) Uses
(b) Process Description and Exposure Areas
(c) Controls Currently Used
(d) Exposure Levels
(e) Additional Controls
(f) Conclusion: Technological Feasibility
(g) Economic Feasibility

20. Lead Burning (Brazing/Welding)

(a) Uses
(b) Process Description and Exposure Areas
(c) Controls Currently Used
(d) Exposure Levels
(e) Additional Controls
(f) Conclusion: Technological Feasibility

21. Lead Casting

(a) Uses
(b) Process Description and Exposure Areas
(c) Controls Currently Used
(d) Exposure Levels
(e) Population Exposed
(f) Additional Controls
(g) Conclusion: Technological Feasibility
(h) Economic Feasibility

22. Lead Chemical Manufacture

(a) Uses
(b) Process Description and Exposure Areas
(c) Controls Currently Used
(d) Exposure Levels
(e) Population Exposed
(f) Additional Controls
(g) Conclusion: Technological Feasibility

23. Lead Pigments Manufacture

(a) Uses
(b) Process Description and Exposure Areas
(c) Controls Currently Used
(d) Exposure Levels
(e) Population Exposed
(f) Additional Controls
(g) Conclusion: Technological Feasibility
(h) Cost of Compliance
(i) Industry Profile
(j) Conclusion: Economic Feasibility

24. Lead Sheet Metal Manufacture

(a) Summary

25. Leather Manufacture

(a) Uses
(b) Process Description and Exposure Areas
(c) Controls Currently Used
(d) Exposure Levels
(e) Population Exposed
(f) Additional Controls
(g) Conclusion: Technological Feasibility
(h) Cost of Compliance
(i) Industry Profile

26. Machining

(a) Uses
(b) Process Description and Exposure Areas
(c) Exposure Levels
(d) Controls Currently Used
(e) Additional Controls
(f) Conclusion: Technological Feasibility
(g) Economic Feasibility

27. Miscellaneous Lead Products

(a) Uses
(b) Process Description and Exposure Areas
(c) Controls Currently Used
(d) Exposure Levels
(e) Population Exposed
(f) Additional Controls
(g) Conclusion: Technological Feasibility
(h) Economic Feasibility

28. Nickel Smelting

(a) Uses
(b) Process Description and Exposure Areas
(c) Controls Currently Used
(d) Exposure Levels
(e) Population Exposed
(f) Additional Controls
(g) Conclusion: Technological Feasibility
(h) Economic Feasibility

29. Nonferrous Foundries

(a) Uses
(b) Process Description and Exposure Areas
(c) Controls Currently Used
(d) Exposure Levels
(e) Population Exposed
(f) Additional Controls
(g) Conclusion: Technological Feasibility
(h) Cost of Compliance
(i) Industry Profile
(j) Conclusion: Economic Feasibility

30. Pipe Galvanizing

(a) Uses
(b) Process Description and Exposure Areas
(c) Controls Currently Used
(d) Exposure Levels
(e) Population Exposed
(f) Additional Controls
(g) Conclusion: Technological Feasibility
(h) Economic Feasibility

31. Plastics and Rubber Manufacture

(a) Uses
(b) Process Description and Exposure Areas
(c) Controls Currently Used
(d) Exposure Levels
(e) Additional Controls
(f) Conclusion: Technological Feasibility
(g) Cost of Compliance
(h) Industry Profile
(i) Conclusion: Economic Feasibility

32. Plumbing

(a) Uses
(b) Process Description and Exposure Areas
(c) Controls Currently Used
(d) Exposure Levels
(e) Additional Controls
(f) Conclusion: Technological Feasibility
(g) Economic Feasibility

33. Pottery and Ceramics

(a) Uses

A. General Feasibility

OSHA has determined that compliance with the standard may be generally achieved by the application of existing methods of exposure control. In this section OSHA presents the basic principles on which its conclusions regarding feasibility for each industry are based.

There are several methods available to control a worker's exposure to lead. These approaches include isolation, enclosure, the use of ventilation, and process or product changes. These principles were discussed at length in the original preamble, 43 FR 54476–54479, and will not be reiterated here. OSHA reaffirms and adopts the general principles concerning feasibility discussed therein.

Isolation consists of the construction and use of primary, secondary, or tertiary barriers or containments around the process, the operation, or the equipment for the purposes of containing material, minimizing the release of airborne contaminants to the workplace, and minimizing, limiting, or otherwise preventing access to the area near the contaminant (Ex. 487).

Enclosure includes construction of a partial barrier around the process or operation (usually with access from one side), typically represented by a paint spray booth or a laboratory fume hood, and accompanied by directed air movement to control dispersion of the contaminant. (Id.) Ventilation is the engineered application of air motion and direction to capture, contain, and convey contaminants from the source at the workplace, away from the worker into the ventilation system. (Id.) Industrial ventilation is a widely used and effective method of control of workplace airborne contamination. Local exhaust ventilation is usually more effective and less costly than general ventilation.

Product or process changes may be used for specific problems and are usually central to a structural change in the industry involving new plant and larger capital investment. Elimination is the removal or replacement of the hazardous substance or condition from the work environment. Both types of changes may result in a change in the manufacturing method or machine, or the process or operation to reduce or eliminate hazards, and both represent permanent solutions to the occupational health problem. Substitution usually involves removal (elimination) of one component and its replacement in the process by another less or non-toxic substance.

During the initial lead hearing, Dr. First discussed at length the use of these methodologies in achieving control in any industrial setting. His testimony was relied upon initially; OSHA continues to find his reasoning persuasive and applicable to the remand industries. (See 43 FR 54477; Ex. 270)

Dr. First's testimony, echoed by many engineers and industrial hygienists during the first lead rulemaking (e.g., Schneider, Tr. 2957–2100; Stewart, Tr. 2577–2619), leads to the conclusions that rigorous and innovative application of basic engineering and industrial hygiene techniques will, in almost all cases, enable employers to comply with the standard.

When one correctly applies principles of engineering control, an operation or a machine is totally controlled. That is to say, when an operation or a machine is properly enclosed, it no longer discharges lead dust to the workroom atmosphere; when an operation or a machine is properly exhaust ventilated, it no longer is capable of discharging lead dust or fumes into the workroom; when a process has been automated, no worker is in the vicinity to be exposed to lead emissions. Therefore, as a practical matter, machines and processes are "controlled" or they are "not controlled"; there are no way-stations on the road to process control. You either do it or you don't (Ex. 270, pp. 23–24).

Schneider added:

My contention is that with proper engineering control coupled with good maintenance and good work practices; proper design of process to minimize emissions, and education of workers and good hygiene that we can today achieve levels in the atmosphere of less than 50 micrograms per cubic meter of air. (Tr. 2065–66).

Dr. Billings of the Johns Hopkins School of Public Health reaffirmed and reiterated the views of Dr. First and others concerning the use of engineering controls to achieve compliance with the lead standard, and stated:

There appears to be no technological limitation to application of engineering control technology to most manufacturing technologies and operations. There may be limiting economic constraints in certain specific applications, but these are usually structural to the industry in question. (Ex. 487, p. 13)

Dr. Billings also stressed the importance of housekeeping (e.g., to prevent the redispersion of contaminants or to eliminate personal contacts); dust suppression (e.g., wetting down dusty sources, wet drilling, use of soil, stock or waste pile stabilizers, windbreaks and the like); maintenance (e.g., continued maintenance of effective control system performance, as well as of process, operation, or manufacturing equipment to reduce or eliminate inadvertent releases of hazardous materials); sanitation (e.g., use of hygienic principles to reduce or eliminate hazardous materials from the person as with clothing changes, shower-in or shower-out, sterilization chlorination, pasteurization, and so on); work practices (e.g., specification of proper work procedures to reduce or control release, dissemination, or inadvertent exposure to hazardous substances or conditions); education (of worker and managment, and of the public, to the nature of a hazard and how properly to minimize risk and most importantly, education of engineers to discover, develop, and design products, processes and systems with minimum hazard to workers and users); and administrative control to achieve compliance.

Dr. Billings stated that the engineering controls he discussed were relevant to the industries under consideration in this proceeding. Dr. Billings further testified:

Any defined industrial health hazard can be controlled to any degree required with creative innovative ingenuity, experience, and resources adequate to develop cost-effective control measures.

Some industrial processes lend themselves more readily to applications of conventional control technology, most commonly those processes that contain continuous, repetitive, or automated operations.

Other processes are less amenable to simpler solutions and may require somewhat greater effort to solve satisfactorily, such as, e.g.; spray painting in confined spaces, shot blasting of lead-based paints on large structures, and possibly welding, lead burning maintenance tasks, or similar transient, intermittent, or mobile operations. Effective technical solutions in these instances may require some worker participation. (Ex. 487 p. 20)

Dr. First also testified that the time required for a conscientious employer to comply can vary from 9 to 12 months for the design, construction, and installation of relatively simple and conventional systems, such as exhaust ventilation hoods and associated dust systems, enclosed automatic conveyors, and central vacuum cleaning systems, to approximately 4 to 5 years for the construction of an entirely new modern plant that incorporates innovative, mechanized, and automated production and materials handling systems and processes. (Tr. 2309). DBA's estimates of the time frames were similar. David J. Burton of DBA states that as a general matter the implementation of simple controls could take as little as "several months: while a very complex system could take as much as 40 months". (Tr. 1025) Dr. First (Tr. 2310, 2328, 2382) and Knowlton Caplan of IHE (Tr. 3931–33) also noted time limitations on obtaining equipment parts, and adequate engineering assistance. These factors are incorporated into the implementation schedule provided in the standard so that many firms need not apply for a temporary variance.

Given the myriad of controls available to the industry, compliance with the standard appears readily feasible. As Dr. First testified, drastic reductions in exposure to coal dust, vinyl chloride monomer, and asbestos fibers were achieved very rapidly where the effort was made (Ex. 270, pp. 18–19). The union representatives from the URW also testified that changes in the rubber and plastics industry were made readily when OSHA citations indicated such were necessary. (Tr. 740). However, for some firms in some industries (for example in the manufacture of lead pigment, the steel industry, and the auto industry), compliance with the 50 $\mu g/m^3$ standard will require reliance upon technological change. The extended compliance deadlines granted these industries have been provided so that these changes may be implemented.

In establishing the requirements of this standard and evaluating whether compliance is feasible, OSHA has identified affected industries and investigated the available technology in those industries based on the best available evidence. It has attempted to estimate the length of time necessary to implement the technology required, taking into account firms' need to plan, construct, test and refine their efforts, as well as the economic factors involved. The result is that OSHA has incorporated into its compliance scheme an implementation schedule based on OSHA's judgment in view of the record evidence, of the time each industry, as a whole, will need to effect the technological changes necessary for compliance. Interim milestones are required for some industries where ultimate compliance will take several years and where significant protection can be accomplished in a shorter period. The time limits also take economic factors into account in that they are expected to enable firms in the industry to implement these changes without serious economic repercussions to the industry as a whole. In some cases, the implementation schedules take into account the industries' modernization plans, etc., in planning compliance activities.

The implementation schedule represents a merging of both economic and technological factors used to evaluate feasibility. Firms can choose from an array of technical solutions over a time frame sufficient for long-run economic optimization. The implementation schedule is incorporated into the "methods of compliance" parargaph of the standard, and the basis for the time limit for each industry is explained in the industry-by-industry analysis below.

After analyzing the techological feasibility of compliance with an OSHA regulation, the Agency estimates the costs of controlling the workplace hazard at issue. Given an estimate of compliance costs, OSHA then assesses the economic feasibility of compliance with the regulations. Thus, compliance costs link the technological and economic aspects of feasibility and are fundamental to determining feasibility.

Several methods can be used to estimate compliance costs. The methods vary in reliability and are largely dependent on the type of data available. For example, in decreasing order of accuracy, there are piece or component estimates, unit cost estimates, experience estimates, and hypothetical cost estimates (Tr. 418–419).

Piece estimates are compiled by actually summing the individual costs of the components of a control system. For instance, the cost of a ventilation system can be broken down into the separate costs for fans, ductwork, hoods, other materials, labor require for installation, and routine maintenance (Ex. 482). Unit cost estimates are developed by applying publicly available costs for items or approaches that can be used to control hazardous exposures (Ex. 482); for example, dollars per cubic foot per minute of ventilation, average costs of installing hygiene facilities, or costs of personal protective equipment, such as gloves, safety shoes, or respirators, can be used to determine compliance costs. Where detailed engineering estimates or unit costs are unavailable, the professional judgment and experience of labor and industry experts in the field may be relied on to develop experience cost estimates (Ex. 482). Finally, a hypothetical model of a production process and necessary control requirements may be costed out, thereby generating hypothetical cost estimates (Tr. 419).

In the analyses of feasibility in these industries, OSHA has primarily relied on unit cost and experience estimates. These estimates constitute the best available evidence and were provided by OSHA's contractor and by industry. Industry submissions from previous rulemaking and new data submitted in response to the **Federal Register** notice of September 24, 1980, were included in OSHA's consideration of costs.

Most of the industry estimates are experience estimates that are not supported by detailed engineering studies. In these cases, OSHA has adjusted some of these estimates downward on the basis of Agency experience. Where the estimates appear to overstate compliance costs, OSHA's reasons for rejecting these estimates are explained. The sources of overestimates are summarized below.

First, many estimates include the costs associated with controls required by the Environmental Protection Agency rather than OSHA. Since these costs are frequently substantial, their inclusion greatly inflates the costs presented. Second, some estimates were calculated on the basis of replacing entire plants or pieces of equipment that are at the end of their economic lives. In these cases, the replacement costs would be incurred even in the absence of an OSHA regulation. Thus, the cost appropriately attributable to the OSHA regulation is the difference between simple replacement of plant and equipment and replacement that achieves compliance with the regulation. Third, many controls are currently in place or required by other regulations and are double-counted if attributed to the lead standard. Further, some of these controls may simultaneously reduce exposure to other toxic substances. Thus, the costs attributable to the lead regulation are actually some fraction of the total costs of the control. Fourth, OSHA notes that historically industry has overestimated compliance costs consistently in all rulemakings. Thus, the Agency concludes that it is likely that these estimates are similarly biased on the high side. While OSHA has not attempted to adjust the estimates downward by some consistent factor, the Agency cautions that past industry predictions of high costs and consequent economic disruption have proven to be unfounded. (See Ex. 475–1). The costs presented by OSHA in the following analyses are, therefore, presented on the best available evidence and accurately represent the anticipated compliance costs that potentially affected industries may incur.

Capital costs of compliance, however, are not typically incurred in any one year because firms borrow money to finance the investment. In making a determination of feasibility, OHSA concludes that the appropriate comparison is between the costs incurred in any one year and the financial condition of the affected industry in that year. Therefore, the Agency compares total industry shipments, sales, profitability or other measures of economic viability with annualized capital costs. OSHA converted the capital costs to an annual rate based on the standard captial recovery formula $i(1+i)^n/(1+i)^n-1$, retaining DBA's assumptions of a 10 year equipment lifetime and a 12% interest rate (Ex. 26).

B. *Specific Industries.* On the basis of all the evidence accumulated during the rulemaking proceeding, OHSA has determined that by the dates specified in paragraph (e)(1) of the standard, compliance with the PEL by the use of engineering controls, work practices, and, in some limited instances, respiratory protection is feasible.

These conclusions are based on the best available evidence of what each affected industry, taken as a whole, can achieve with presently available production and control technology. These conclusions are necessarily industry-wide generalizations, and since some involve projected compliance activities, they rely in part on policy judgments. OHSA recognizes that compliance problems may exist at individual plants or work areas, but concludes that these problems can be better dealt with through enforcement activities where solutions can be worked out by affected parties.

The following is a detailed discussion of the technological and economic factors in the major industries affected by the standard. In making these industry-by-industry analyses of feasibility, OHSA relies fully on the general principles expressed by Dr. First, Dr. Billings and others that were treated in this section. Throughout the following discussion, phrases such as "meeting the PEL", "achieving compliance", or "meeting 50 $\mu g/m^3$" all refer to the permissible exposure limit, which is 50 $\mu g/m^3$ as an 8-hour time-weighted average. (See 43 FR 52987).

1. Agricultural Pesticides

(a) *Uses*

There are approximately 1.5 billion pounds of pesticides produced yearly, which account for $2.5 billion in sales. Production, as measured by consumption, is growing slowly at a rate of 1.4 percent per year, with insecticide production showing the slowest rate of increase (less than 1 percent per year). Twenty-six percent of total pesticide production can be attributed to the production of insecticides (Ex. 476–50).

Exposure to lead in the insecticide industry may occur during the manufacture or formulation of the insecticide, lead arsenate (also known as acid lead arsenate, ortho arsenic acid, basic ortho arsenate, or basic lead arsenate). Acid lead arsenate has been used extensively to control fruit insects in apple and other orchards. However, synthetic organic chemicals have largely replaced acid lead arsenate (Ex. 476–50). Basic lead arsenate is only used on peach and other fruit trees grown in moist climates, where the less stable acid form causes leaf burn (Ex. 476–50). The Environmental Protection Agency restricts the use of lead arsenate as an insecticide to Florida.

Data indicating what percentage of total insecticide production lead arsenate represents were not available. Based on record evidence submitted by Woolfolk Chemical, Dupont Chemicals, Dow Chemicals and Los Angeles Chemicals (Ex. 476–45, 49, 52, and 54), OHSA found that only one domestic firm, Landia Chemicals of Lakeland, Florida (Ex. 476–53), formulates lead arsenate. The company formulates a lead arsenate pesticide during approximately 3 months each year and only one employee is exposed to lead during this time (Ex. 476–53).

Representatives of Woolfolk Chemical Co. (Ex. 476, #54) indicated that they, along with Allied and Dow Chemical, stopped producing lead arsenate in 1972 as a result of the hazards associated with arsenic exposure and the difficulties of reducing this exposure (Ex. 476–45).

(b) *Process Description and Exposure Areas*

When lead arsenate is manufactured by batch process, the greatest potential for exposure to lead occurs during the mixing of lead oxide with arsenic acid (Ex. 476–50). The resulting precipitated slurry may either be piped to drying drums and packaged or shipped as a liquid.

Exposures may also occur during the cleanup of liquids spilled from batch mix vats, although spill pans installed below each processing unit capture most spills and then recycle the liquid back into the processing line (Ex. 476–50). Other exposures may occur during drying operations, although water vapor collected from the dryers is usually vented through the stacks (Ex. 476–50). Finally, the handling of lead arsenate for packaging and distribution is also a potential source of exposure (Ex. 476–50).

Based on the record evidence, Landia Chemical Co. appears to be a formulator rather than a manufacturer of lead arsenate. The company has stated that it receives lead arsenate, mixes it with water to form an aqueous solution, and packages the substance for distribution. Exposure to lead appears to occur primarily in the handling or processing of lead arsenate and does not appear to occur during the handling of the raw materials used in the manufacture of lead arsenate.

(c) *Controls Currently Used*

Various control technologies are available to contain dusts generated by the handling or mixing of toxic powders, including: ventilation control, process enclosure, automated weighing and handling equipment, and equipment operator booths to reduce worker exposure (Ex. 476–50). Depending upon the quantity of lead substance to be handled, the following control measures are available for reducing or eliminating exposure to lead during materials handling operations.

Portable bins (e.g. Tote Bin or Invert-a-Bin) may be used to handle dry compounds, thereby minimizing manual handling of the pesticide. Multi-wall, 50-pound paper bags (instead of single walled paper bags) may be used when transporting finely powdered ingredients. The dumping of bags, in general, is not recommended because this presents the greatest potential for dust emissions. To minimize exposures, it is recommended that unloading occur by breaking bags or cutting them open with a stationary knife over a grill equipped with proper ventilation, or by dumping bags into the boot of an elevator. The emptied bags, which still contain some powder, should be disposed of using the same hood used for emptying. Bag opening machines, which permit the operator to unload paper bags without opening them, thereby avoiding contact with the contents, may also be used. These machines may be moved from one process line to another. Drums can be opened under local exhaust ventilation to minimize dust hazards and drum dumping can be performed in enclosed booths. Pneumatic vacuum systems may also be used in unloading or loading lead compounds to vented storage bins. In charging operations, enclosed drum-dumping cabinets have been developed to mechanize this process, thereby reducing manual handling of toxic substances. Specially designed hoods which capture the dust at the source of exposure have been used, in some cases, to minimize employee exposure (Ex. 476–50, p. 84–107).

Dr. Billings suggested a control method for lead pigment formulators that OHSA believes to be applicable to pesticide manufacturers and formulators as well. He suggested the use of containers which are soluble in the particular vehicle or solvent being used (Tr. 116). Mr. Brustein, representing the United Rubber Workers, supported Dr. Billings' testimony and indicated that Goodyear produces a product called Elastifilm which can be used as a soluble container (Tr. 736).

Representatives of the Landia Chemical Company did not indicate which (if any) of the engineering control technologies discussed above were in use in their establishment, nor did they indicate which work practices were being used.

(d) *Exposure Levels*

The Landia Chemical Company did not submit data indicating the exposure levels to lead which result from the formulation of lead arsenate. The company did indicate, however, that complying with the 50 $\mu g/m^3$ standard (Ex. 476–53) was not expected to present any problems for them, and the company therefore declined to submit comments in response to the **Federal Register** notice of September 24, 1980 (Ex. 476–53).

(e) *Additional Controls*

The data presented to the Agency by the Landia Chemical Company indicate that additional engineering controls and work practices are not necessary to achieve compliance with the 50 $\mu g/m^3$ standard.

(f) *Conclusion: Technological Feasibility*

The Agency assumes, based on its knowledge of the control technology available to the pesticides industry (Ex. 476–50), its knowledge of the comparability of material handling in pesticide manufacturing and similar processes, and Landia Chemical's own statement that achieving 50 $\mu g/m^3$ poses no problem, that the company must be using tranditional control methods for materials handling. In addition, the company may be relying, in some part, on the use of good work practices, housekeeping, and worker rotation to aid in maintaining exposures below 50 $\mu g/m^3$. Furthermore, Landia Chemical, the only known processor of lead arsenate, has indicated that only one employee is exposed to lead exposure and this employee is potentially exposed for only 3 months annually (Ex. 476–53). Present engineering controls appear to be adequate to reduce this worker's 8-hour time-weighted exposure to below the PEL.

(g) *Cost of Compliance*

It appears that the technology already in use is sufficient to maintain levels below the 50 $\mu g/m^3$ limit. As a result, expenditures need not be made to retrofit existing equipment with improved ventilation systems or to invest in housekeeping equipment (such as a central vacuum system). Because these expenditures are not necessary, no costs will be incurred as a result of complying with the lead standard.

(h) *Industry Profile*

Production data on lead arsenate are classified in SIC 2879, Agricultural Chemicals, Not Elsewhere Classified. Lead arsenate is further disaggregated into SIC 2879807, however, entries for quantity and value in dollars of production and shipments were withheld by the U.S. Commerce Department to avoid disclosing operations of individual companies (Ex.

476-20). By 1972, major domestic producers of lead arsenate had withdrawn from the market (Ex. 476-45, 49, 52, 53, and 54). Landia Chemical, the only known formulator of lead arsenate in the United States, is a small, privately held firm. The company did not submit financial information indicating that the regulation would be burdensome.

(i) *Conclusion: Economic Feasibility*

The economic impact of the lead standard on the agricultural pesticides market and, specifically, on the production of lead arsenate, will be insignificant. This finding is based on the fact that no compliance costs will be incurred by this industry as a result of the lead standard.

2. Aluminum Smelting

(a) *Uses*

Aluminum is used in the manufacture of chemical vessels, kitchenware, electrical transmission lines and other products. It has architectural applications and is used extensively in the land, sea, and air transportation industries. (Ex. 476-5G)

(b) *Process Description and Exposure Areas*

Although aluminum ores are widely distributed in the earth's crust, only bauxite has proven to be economical as an ore from which the metal can be smelted (Ex. 476-5G). Bauxite is usually mined through the open-pit method, crushed, sometimes washed to remove clay, and dried. It is then refined through the Bayer process into aluminum oxide or "alumina." In this process, dried, finely ground bauxite is charged into a digester where it is treated, under elevated pressure and temperatures, with caustic NaOH solution to form sodium aluminate. (Ex. 476-5K)

After the digestion process is completed, the residue (containing impurities) is forced out of the digester through filter presses and discarded. The liquid, which contains extracted alumina in the form of sodium aluminate, is pumped to precipitator tanks where seed crystals are added to aid in separating aluminum hydroxide from the solution. The aluminum hydroxide that settles out from the liquid is filtered and then calcined in kilns which convert the alumina to a form suitable for smelting (Id.).

Metallic aluminum is produced by an electrolytic process that reduces the alumina into oxygen and aluminum. In this process, pure alumina is dissolved in a batch of molten cryolite (sodium aluminum fluoride) in large electrolytic furnaces called reduction cells or "pots." An electric current is passed through a carbon anode suspended in the bath mixture, causing metallic aluminum to be deposited on the carbon cathode at the bottom of the cell. The heat generated by passage of this electric current keeps the bath molten so that alumina can be added as necessary to make the process a continuous one. At intervals, aluminum is siphoned from the pots and the molten metal is transferred to holding furnaces either for alloying or impurity removal. It is then cast into ingots of various sizes for further fabrication. (Id.)

Exposures to lead arises from trace amounts in the ore. Exposures may occur at materials handling equipment or during pyrometallurgical processing (Ex. 481). Since most of the bauxite processed in this country comes primarily from Jamaica, Brazil, Surinam, Australia, and Ghana and contains only traces of lead (Ex. 476-56), very little exposure occurs during the handling of raw ore. In fact, the principal source of lead exposure during ore handling is not from the ore itself but rather from the acid leach (the process by which the impurities are separated from the ore) which contains traces of lead (0.004 percent lead sulfite) (Ex. 476-57)

The primary exposure problems in the pyrometallurgical process occur when ores containing lead undergo smelting, thereby releasing fugitive emissions, such as lead oxide, or from emissions resulting from impurities which rise to the top of the molten aluminum and must be periodically skimmed off as dross from the melting and holding furnaces. This dross is transferred to a floor area known as a dross pad where it is dumped and raked out to cool. After cooling, the dross is mixed with salts and charged into a rotary melting furnace, where more of the aluminum is recovered.

(c) *Controls Currently Used*

(i) Materials handling controls include: Pneumatic conveyance; elimination, by redesign or use of dead drops or long material drops; belt wipes; conveyor curtains and skirts; ventilation hoods at transfer points; complete enclosure of conveyors; liquid sprays to suppress dust; chemical dust suppressants; vacuuming (preferably wet vacuuming) instead of dry sweeping of spilled or otherwise deposited materials; and clean air pulpits (Ex. 481).

The selection of the appropriate control strategy depends upon the material being handled, the extent of the exposure problem, the process involved, and the extent to which engineering controls are already in place.

(ii) Pyrometallurgical controls include: Exhaust hoods for tapping and skimming ports; exhaust hoods for ladles, pots, and kettles; covers and hoods for launders; maintaining the unit at negative pressure; enclosure of the entire unit or pertinent parts of the unit; ventilation to capture fugitive emissions which cannot be contained otherwise; enclosed control rooms supplied with clean air; and controlled air pulpits (Ex. 481).

(d) *Exposure Levels*

During aluminum smelting, lead is present as lead sulfide in bauxite ores. Bauxite containing .04% lead would produce an air lead concentration of 4 $\mu g/m^3$ when bauxite concentrations are 10 mg/m^3. "Therefore, lead exposure would be well below existing or proposed limits." (Ex. 491)

Sampling data in a NIOSH report on the Martin Marietta Aluminum Company in Lewisport, Kentucky (Ex. 476-58) revealed nondetectable lead exposure levels, in most instances, although one sample showed 7.5 $\mu g/m^3$ of inorganic lead (Id.). These figures indicate that exposure levels are well below the OSHA permissible exposure limit of 50 $\mu g/m^3$ and the 30 $\mu g/m^3$ action level. The results of the NIOSH survey are consistent with the statements made by Kaiser and Alcoa Aluminum indicating that lead exposure is not a significant problem in aluminum smelting (Ex. 476-56, 57).

(e) *Additional Controls*

The exposure data indicate that lead levels in aluminum smelting are well below 30 $\mu g/m^3$. Control technology already in use has been effective in maintaining lead exposure levels below the PEL. Additional engineering controls, work practices, housekeeping and worker rotation are not needed. Compliance with the PEL has been achieved (481)

(f) *Conclusion: Technological Feasibility*

The record shows that bauxite ores processed in the United States contain only trace quantities of lead and that alumina (aluminum oxide), from which aluminum is reduced, contains virtually no lead (Ex. 476-56, 57; Ex. 22). Exposures to lead above the PEL are unlikely to occur, as representatives from both Kaiser and Alcoa Aluminum have acknowledged (Ex. 476-56, 57).

Control technologies already in use will be sufficient to control any exposures to lead which may occur.

(g) *Economic Feasibility*

Because the exposure levels are so low, the industry need not enhance existing ventilation systems, establish additional work practice programs, enhance housekeeping practices or rotate workers as a result of this regulation. Therefore, there will be no costs of compliance nor any economic impact incurred as a result of the lead standard.

3. Ammunition Manufacturing

(a) *Uses*

Lead continues to be the major metal used to produce sport ammunition in the form of shot and small caliber shells. Although lead ammunition is no longer used in wartime applications, it is still used in military training (Ex. 476–123). The Federal Government has enacted legislation requiring steel shot for water fowl shotgun loads in some parts of the country. If this were universally adopted, it would eliminate the manufacture of lead shot, and also the problem of lead exposure from this material (Ex. 476–26).

(b) *Process Description and Exposure Areas*

Ammunition fabrication may be done using either a hot or cold lead process (Ex. 22, p. 231). Lead used in the manufacture of ammunition may be in the form of ingots or may be processed from scrap lead. Lead processing from scrap requires smelting prior to refining and is therefore considered a secondary smelting operation. Companies that just melt lead prior to fabrication are not considered as secondary smelters.

OSHA has proven the technological feasibility of achieving compliance for secondary smelting operations and the Agency's findings have been upheld by the court Slip Op. at 181–97. The implementation dates and interim levels for secondary smelting and refining operations are applicable to ammunition manufacturers whose initial operations are, in fact, secondary smelting operations. In addition to fabrication, ammunition manufacturers also maintain ballistics ranges which are used to test the quality of the ammunition manufactured.

(i) *Fabrication.* Lead exposures occur during the melting, drossing, pouring, casting, extrusion, cut-off and assembly portions of the process of fabricating bullets from hot lead (Ex. 475–35). In the fabrication of lead shot, lead exposure occurs during the melting, drossing, dropping, polishing and loading of lead shot. (Id.)

(*a*) *Hot Lead Processes.* Lead is melted in refining kettles and treated by drossing to remove impurities. Further refining may be necessary to achieve a specific composition prior to casting lead into molds to produce bullets by extrusion or by dropping lead to form shot (Id.). Finishing processes for bullet manufacturing include extrusion, cut-off, assembly, inspection and packaging. (Id.) Finishing processes for the manufacture of lead shot include shot lubrication, screening, polishing, packaging, and loading cartridges with shot. (Id.)

(*b*) *Cold Processes.* In the cold processes, lead is used to form bullets by feeding wire into forming machines which extrude the projectiles (Ex. 476–65). Employees working at the forming machines may be exposed to lead, but such exposures appear to be very low (Ex. 476–65).

(ii) *Testing of Ammunition (Firing Ranges).* Ammunition that has been fabricated must be tested, and manufacturers use ballistics ranges for this purpose. Most firing ranges are equipped for the firing of handguns, shotguns, rifles, and machine guns. They are used by ammunition manufacturers to check ballistics, as practice ranges for firearms enthusiasts and as practicing and qualifying ranges for law enforcement officers.

It should be noted that while many persons may be exposed to lead at a firing range, only the exposures of range employees (of ammunition manufacturers or private ranges) fall within the scope of the standard: the exposures of firearms enthusiasts who use the ranges for practice are outside the scope of this standard because they are not occupationally related.

The dimensions of firing ranges vary in length from 70 to 120 feet, in width from 20 to 80 feet, and in height from 8 to 10 feet, and the range may house any number of firing booths. Ranges are installed in "available" space (Ex. 476–64) or they may be constructed as part of a manufacturing process, as is the case with some ballistics test ranges. (Ex. 475–35)

The bulletproof firing booths are approximately 4 feet wide, 6 feet long, and 9 feet high, and the distance from the firing line to the bullet trap is approximately 75 feet. Ranges are usually equipped with a steel bullet trap in which the spent lead accumulates in a trough at the bottom of the trap. The spent lead is removed from the trough when necessary, and may either be discarded or remelted and cast into small ingots for sale or reincorporation into the manufacturing process.

Lead dust and fumes are generated from the bullet primer when weapons are fired. The primer is approximately 35 percent lead styphnate and lead peroxide. The lead styphnate is used as a detonator. Lead vapors (because of cylinder and barrel misalignments and gaps from wear and manufacturing tolerances) pass through the weapon after firing and are expelled at right angles to the direction of fire. This effect is commonly known as "side blast." The side blast creates turbulence in the breathing zone of the shooter, thus increasing his exposure to lead dust and fumes (Ex. 476–64).

Another source of lead contamination occurs when the bullet is fragmented as it strikes the bullet trap. In this situation, personal exposure to lead is believed to be minimal, since the distance between the shooter and the bullet trap is normally at least 75 feet (Ex. 476–64).

(c) *Controls Currently Used*

(i) *Fabrication.* The refining operation for ammunition manufacture is comparable to refining in secondary smelting operations, and therefore some of the difficulties associated with secondary lead refining may be applicable to ammunition refining.

In fact, it may be difficult to control lead exposures in refining operations depending upon the size of the operation (43 FR 54484). Operations requiring the use of overhead cranes are difficult to control (Tr. 5695). Local exhaust ventilation, either in a stationary or portable form (43 FR 54484), is used primarily at drossing operations (Ex. 26, p. 5–32).

Submissions from Remington Industries and a NIOSH HHE of the Hoyt Plant indicate that local exhaust ventilation is being used by some facilities (Ex. 475–35; Ex. 476–309) in casting and fabrication areas.

Local exhaust ventilation used in the die casting areas, hooding of the drop shot kettles and the enclosure or separation of some processes from others are methods being used to reduce lead exposures. In the lubrication of lead shot, substitute lubricants have been used which appear to reduce lead exposures (Ex. 475–35).

(ii) *Testing of Ammunition (Firing Ranges).* The controls to reduce lead exposure require local or general ventilation to control the air flow so that the concentration of lead in the environment does not continue to increase after the number of shooters has been reduced. (Systems should be capable of preventing airborne lead "build-up.") Floors are also often painted smooth concrete surfaces which can be easily cleaned using wet vacuuming methods. Spent lead is often collected in water traps to further minimize the lead exposure (Ex. 476–64; Ex. 475–35).

(d) *Exposure Levels*

(i) *Fabrication.* Data submitted indicate that typical exposures in ammunition manufacturing range from 10–170 μg/m³ (Ex. 22, p. 231). Remington did not provide specific exposure data but indicated that at one plant of 465 exposed employees, 425 were exposed to less than 50 μg/m³ of lead, with 40 employees exposed to levels in excess of 50 μg/m³. Remington further qualified that statement by stating that this number of employees was exposed prior to the installation of certain engineering controls (Ex. 475–35). No information was submitted indicating what effect these controls had on reducing the number of workers exposed above 50 μg/m³. In another Remington plant, 590 of 600 employees are exposed to levels below 50 μg/m³ and 10 are exposed above 50 μg/m³. Some of these 10 individuals worked on the firing ranges and were not directly associated with the manufacturing process (Ex. 475–35).

Exposure data (Ex. 476–309) from N.L. Industries Hoyt Plant indicate that respirable dust levels were 10 μg/m³ for the buckshot kettle operator, 30 μg/m³ for the lead man in the shot building and 30 μg/m³ for the shot drop operator.

(ii) *Testing of Ammunition (Firing Ranges).* Surveys such as those taken at La Salle College (Ex. 476–66), New York State Police Facilities (Ex. 476–67), St. Bernard Police Firing Range (Ex. 476–68), and the U.S. Customs House Firing Range (Ex. 476–70), have all found lead levels in excess of the 50 μg/m³ PEL. Remington Arms also indicated that compliance with 50 μg/m³ on their ballistics range would be difficult (Ex. 475–35).

(e) *Population Exposed*

(i) *Fabrication.* In a previous report to OSHA (Ex. 22, p. 231) it was estimated that 500–900 workers are exposed to lead in the manufacture of ammunition (id.). The percent of these individuals exposed above and below 50 μg/m³ is not know.

Remington submitted data that indicated that out of 1,065 employees (number of workers in the entire plant) only 50 were exposed in excess of 50 μg/m³ (Ex. 475–35). It is also believed that 95 percent of all ammunition manufacturing is done by three large companies, one of which is Remington (Ex. 22, p. 231). Extrapolating from Remington's data, OSHA estimates that only 150 to 200 employees are exposed to lead in excess of 50 μg/m³.

(ii) *Testing of Ammunition (Firing Ranges).* There is no way of estimating how many employees are exposed to lead in public firing ranges or in ranges operated by ammunition manufacturers (Ex. 22, p. 231).

(f) *Additional Controls*

(i) *Fabrication.* Remington discusses four difficult areas of compliance in their plants: the ballistics range (see discussion of firing ranges), shot tower (especially where lead dross is handled), the maintenance of certain exhaust systems (see discussion of maintenance) and production equipment, and primer mixing and charging (see discussion of explosive manufacture). Remington suggests that improved ventilation will be required at drossing operations and that vacuuming has already greatly reduced exposures by reducing dust levels in maintenance operations. In addition, employees should be instructed in the proper manner of handling lead materials to minimize their exposures (Ex. 487).

In finishing processes local exhaust ventilation can be used on extruding machinery, at cut-off machinery, etc., as suggested by Dr. Billings. Isolation, local ventilation and housekeeping may also be used. Workers handling extruded products and those filling and inspecting cartridges should be cautioned to use appropriate work practices to minimize dust exposures and should also be instructed to wash their hands and forearms thoroughly before eating, smoking, etc. (Ex. 487).

(ii) *Testing of Ammunition (Firing Ranges).* NIOSH recommends that to control lead fumes, dust and gaseous combustion products in the firing range, a minimum ventilation rate of 50 feet per minute (fpm) should be maintained at the firing line, with all of the air being exhausted at the bullet trap (Ex. 476–64). The firing range should be maintained at a slight negative pressure in relation to adjacent areas.

Floors should be constructed with a drain and should be made of dense, continuous-poured concrete or steel. The concrete should be finished to a smooth surface to facilitate proper clean-up, using either the wet method or the vacuum cleaner method. A routine range maintenance program is essential. NIOSH recommends that employees performing maintenance or removing lead from the trays wear an approved respirator.

In addition, worker rotation may be necessary, especially in firing range maintenance operations, to meet the 50 μg/m³ limit.

Data have been compiled which indicate that levels have been reduced using minimal controls. For example, the Springdale firing range made improvements in the ventilation system by increasing the flow rates, which resulted in dust levels being reduced from 200 μg/m³ to approximately 60 μg/m³ (Ex. 476–69). Additional efforts, such as increased housekeeping and maintenance, should bring this range into full compliance.

Remington also presented data which discussed the difficulties encountered in bringing their ballistic range into compliance with the 50 μg/m³ limit. The company felt that engineering controls, such as improved ventilation and improved water bullet traps, had been successful and that work practices such as vacuuming and wetting down shooting booths have also helped (Ex. 475–35) to reduce lead levels. However, they felt that 1 year was not a long enough period to bring the lead levels into full compliance.

A great deal of data was presented on firing range design and emission controls for firing ranges generally; however, little data were furnished by ammunition manufacturers who have ballistic ranges. While the controls peculiar to firing range use are the same whether the range is privately owned or owned by a manufacturer, the degree to which controls must be implemented depends upon the extent to which the range is used by employees and the level of exposures. Ammunition manufacturers who use their ranges constantly will have to install more sophisticated controls than a range that has one or two occasionally used booths. Therefore, Remington may, in fact, need more time to implement sophisticated engineering controls to reduce levels to 50 μg/m³

(g) *Conclusion: Technological Feasibility*

(i) *Fabrication.* The technology to achieve 50 μg/m³ is available and is apparently being effectively used by the Hoyt Plant in its shot operations. Remington also indicated that improvement of existing ventilation systems would be necessary to achieve compliance with 50 μg/m³, although they admit that reducing exposures in some operations solely through the use of engineering controls might prove difficult; in addition, Remington stated that one of the most difficult operations to control would be the drossing process. Caplan (Ex. 138D) recommended that controls used in primary lead drossing plants should be used in refining operations also. Many of these controls would also be applicable to melting operations. It appears that the available engineering controls, when coupled with good work practices, effective housekeeping, and worker rotation, will bring lead levels down to 50 $\mu g/m^3$. Exposure data from the Hoyt Plant indicate that the PEL is feasible and has been achieved.

Most of these operations involve the use of machinery to produce finished products. As Dr. Billings stated, "you can put control technology on a machine" (Tr. 146).

The technology to control finishing operations exists and may require isolation, ventilation, careful housekeeping and perhaps worker rotation to achieve compliance with the 50 $\mu g/m^3$ standard for lead.

In addition, the making of ammunition by cold lead processes presents few, if any, exposure hazards. Manufacturers may substitute this process and significantly eliminate lead exposures in projectile formation. OSHA finds that compliance with the standard in one year is feasible.

(ii) *Testing Ammunition (Firing Ranges).* While Remington anticipates difficulty in bringing its firing range into compliance in a year, other ranges have made substantial progress in reducing levels in considerably less time. The Springfield Firing Range was surveyed in September of 1977 and resurveyed in December of 1977. During this 3 month period, ventilation controls were implemented which reduced exposures from 200 $\mu g/m^3$ to approximately 60 $\mu g/m^3$ (Ex. 476–69).

Ventilation controls are not the only acceptable means of achieving compliance with the 50 $\mu g/m^3$ level. Work practices, housekeeping, and worker rotation may be used. OSHA believes that Remingon, like other owners of firing ranges, can achieve compliance with the 50 $\mu g/m^3$ level simply by enhancing existing ventilation controls with appropriate work practices and administrative controls. Respirators may be required for some operations, such as cleaning traps, where engineering controls, work practices, or rotation are not sufficient to reduce levels to the 50 $\mu g/m^3$ limit. However, the Agency believes such situtations will occur infrequently and will be of short duration. Remington does not dispute that given the appropriate time period for compliance, lead levels can be reduced to 50 $\mu g/m^3$ through the use of engineering controls (Ex. 475–35). Based on these factors, OSHA concludes that compliance with the standard in one year is technologically feasible for firing ranges.

(h) *Cost of Compliance*

None of the potentially affected manufacturers of ammunition presented cost data to OSHA. However, Remington Arms submitted a comment that described its progress in reaching the 50 $\mu g/m^3$ standard and asked for 3 to 5 years to reach this goal (Ex. 475–35). The record indicates that small arms projectile manufacturing, as typically done, is a cold process operation (Ex. 476–65). However, the production of lead shot may require hot processes, in which case controls may be necessary. Ventilation systems already in place, may require upgrading, however, the less costly use of housekeeping and worker rotation will significantly aid in achieving compliance and will also reduce arsenic exposures. Therefore, compliance costs will be minimal.

The record does not contain data on the costs of compliance with the standard for indoor firing ranges. However, a NIOSH study of the problem of excessive exposures of this nature indicates that with appropriate planning in the design and construction of indoor firing ranges, the lead hazard could be eliminated. (Ex. 476–64) OSHA contends that such planning will result in cost-effective implementation of control measures. In addition, NIOSH points out that many firing ranges have very poor housekeeping. Remington also indicated that housekeeping improvements have had a great effect on reducing exposures (Ex. 475–35). Good housekeeping is an effective and inexpensive aspect of controlling overexposure to lead dust.

(i) *Industry Profile.* There are 65 establishments employing a total of 7,700 workers in the production of small arms ammunition (SIC 3482). Shipments were valued at $436,200,000 in 1977. In addition, 81 establishments employ 13,000 production workers in the manufacture of ammunition other than that for small arms (SIC 3483). The 1977 value of these shipments are reported at $775,000,000.

In SIC 3482, two establishments with 250 to 499 employees produce shipments valued at $394,700,000. Forty establishments in this SIC employed less than five workers. In SIC 3483, $415,900,000 in shipments was produced by six establishments with 1,000 to 2,499 employees. Twenty-five establishments employed less than five workers (Ex. 476–20). Thus, there is significant market concentration in the production of small arms ammunition and less concentration in the production of other forms of ammunition.

If there are significant exposure problems in smaller companies, and if the costs of compliance with this regulation are large, smaller companies may be at a competitive disadvantage with the large producers. Some smaller companies might not be able to pass on the higher costs of production and would exit from the market, thereby increasing industry concentration. However, it appears that the current trend of increasing concentration will continue even in the absence of the lead regulation, and it is likely that the effect of OSHA on market concentration will be relatively small. Therefore, OSHA concludes the lead regulation is economically feasible for this industry.

4. *Artificial Pearl Processing*

(a) *Uses*

Artificial pearls serve as substitutes for natural pearls in jewelry manufacture.

(b) *Process Description and Exposure Areas*

United States plants manufacture the pearlescent coating; Japanese and Puerto Rican firms usually dip the pearls. (Ex. 22, p. 289)

Lead-based pigments, such as lead carbonate, are used as a base coat to cover the bead being coated. A pearlescent coating, quanine, is used to cover this base coat, resulting in a bead resembling a pearl.

(c) *Controls Currently Used*

The pearl coating is applied by spraying or dipping the bead into the pigment. Spraying is done in a booth with an exhaust hood system (Id.).

(d) *Exposure Levels*

No data were submitted indicating the extent to which workers may be exposed to lead as a result of the manufacture of pearlescent coating. However, data from comparable operations, such as the glazing of bricks, pottery or glass, in which lead based compounds are applied, indicate that levels in artifical pearl making may range from 0.002 (brick glazing), to 60 $\mu g/m^3$ (hand-dipping of pottery). The degree of exposure will vary depending upon many factors, including the degree of automation. The manufacture of the pigment, lead carbonate, is discussed in the lead pigment section.

(e) *Population Exposed*

The Short Report estimated that 50 people are exposed to lead as a result of this process in the United States (Id.). The number of workers exposed above and below 50 $\mu g/m^3$ is not known.

(f) *Additional Controls*

Ventilation controls appear to be effective in maintaining acceptable lead levels. The Agency believes that existing ventilation, when coupled with improved work practices and effective housekeeping, will be adequate to achieve the 50 $\mu g/m^3$ PEL. Where spontaneous high levels of exposure occur, worker rotation may also be necessary.

Finally, nonlead based undercoats may be substituted for lead-based coatings in the pearlizer process (Id.).

(g) *Conclusion: Technological Feasibility*

None of the firms manufacturing artifical pearls submitted any exposure data or control technology data to OSHA, although the trade association for this industry was contacted. OSHA has extrapolated exposure levels from levels in comparable operations. The Agency believes exposures to be below 50 $\mu g/m^3$, in general, and that current controls will be sufficient to achieve compliance. No evidence or arguments to the contrary were offered by industry representatives who were contacted by OSHA. They did, however, indicate that compliance with the proposed standard of 100 $\mu g/m^3$ or the 50 $\mu g/m^3$ action level posed no problems for the industry.

OSHA concludes that compliance with the 50 $\mu g/m^3$ standard within 1 year is feasible for this industry.

(h) *Cost of Compliance*

None of the potentially affected firms in this industry offered any cost data to OSHA for use in this analysis of feasibility. Because exposures are presumed to be below the PEL, the industry need not enhance existing ventilation systems, establish additional work practice programs or improve housekeeping programs. Therefore, no significant costs will be attributable to the lead standard. If, however, exposures exceed the PEL, some minimal compliance costs may be incurred.

(i) *Industry Profile*

There were only six to eight firms in the United States working with pearlings or artificial pearls in 1976, each employing, at most, six workers (Ex. 22, p. 289) who were potentially exposed to lead. The greatly reduced demand for pearls over the past 10 years and the availability of less expensive imported pearls from the Orient have contributed to the reduction in the size of this industry (Id.). Sales of pearlescent pigments have dropped from an average of 200 pounds per customer order in 1960 to, at most, 3 pounds per customer order in 1976 (Id.). The economic impact of the OSHA lead regulation on this industry is expected to be negligible.

5. Automobile Manufacture/Soldering

(a) *Uses*

Soldering of welded joints with lead-tin solder may be necessary in auto body assembly. This is the major use of lead in the auto industry, although several other operations may also use lead products, e.g., spraying automotive bodies with lead-based paints or primers. Exposure to lead in these operations is covered under other industry classifications as appropriate.

(b) *Process Description and Exposure Areas*

In the assembly of an automotive body, it may be necessary to apply solder to some welded joints. Excess solder must then be removed to achieve a smooth finish of the joint. Removal of the excess solder is accomplished in solder grinding booths. These booths, which vary from about 100 to 200 feet in length, can accommodate a line of several car bodies, with about 6 feet on either side for the solder grind operators to work. These workers use grinding and finishing tools to remove excess solder and smooth the finish. The first operator in the line will use a relatively coarse abrasive, with successive employees using finer abrasives as the car body passes through the booth (Ex. 475–20). Other related operations in the automotive body shop where there may be some lead exposure are joint preparation, tinning, solder filling, door hanging, stud welding and metal finishing.

(c) *Controls Currently Used*

Industry, in general, has not found the exclusive use of engineering methods practical for controlling airborne lead produced by the use of power tools on solder. To control exposures, the automotive industry has developed exhaust-ventilation booths in which grinders must also wear air-fed helmets known as hoods. The industry has thus combined engineering controls with elaborate personal protective equipment. The Motor Vehicle Manufacturers Association asserted that "the technical state-of-the-art regarding engineering and administrative controls have (sic) been reached." (Ex. 28(36)) Refinements of the process, of course, are still possible. Two companies have reported some success with high velocity/low volume tool ventilation systems. (Ex. 26, p. 5–135)

Spokesmen for the United Auto Workers Union (UAW) suggested that not all feasible engineering controls have been installed. Dr. Mirer, for example, testified that "the essential engineering design feature of the grinding booth is that it is a negative pressure enclosure that seeks to contain the airborne lead, but the design specifications do not include measures to reduce the airborne lead by such measures as a downdraft or a specified capture velocity downwards." (Tr. 5252) Frank Nix, health and safety representative for UAW Local No. 10, stated that, in his plant, particles are thrown out of both ends of the booth and, because the car bodies do not go through a water wash after grinding, subsequent workers on the assembly line are exposed to lead. He also expressed concern about lack of a grinding booth for repair work. (Tr. 5242–47)

(d) *Exposure Levels*

Data submitted as part of variance requests by Chrysler, Ford, and General Motors indicated that lead levels in solder/grind booths were far in excess of the 50 $\mu g/m^3$ standards (Ex. 476–77, 80). Data have not been submitted by other vehicle manufacturers which indicate the levels of exposure in their operations.

Some vehicle manufacturers have been successful in controlling lead exposures during solder grind operations. One manufacturer had lead levels of 231 $\mu g/m^3$ (TWA) prior to installing a solder grind booth. After installation of engineering controls, lead levels were reduced to 17 $\mu g/m^3$ and 40 $\mu g/m^3$ (Ex. 476–16, #TO–3). In another instance, lead levels were 907, 63 and 180 $\mu g/m^3$. After substitution of epoxy resins, lead levels were non-detectable.

(e) *Population Exposed*

The Short Report estimated that between 13,000 and 15,500 employees are potentially exposed to lead in all operations in this industry. (Ex. 22, p. 214) The record does not contain data permitting an estimate to be made of the number of workers exposed to lead from the soldering process or at what levels.

(f) *Additional Controls*

Maintenance of solder grinding booths is of the utmost importance in attempting to achieve exposure levels below 50 $\mu g/m^3$. In addition, work practices must be strictly adhered to and employees must be educated with respect to safe work practices. Vacuuming of surfaces (preferably wet) and maintenance of stringent housekeeping programs will also be necessary for this industry to minimize exposure levels. Worker rotation may be necessary.

(g) *Conclusion: Technological Feasibility*

Dr. Mirer stated that "ultimately, the only solution is engineering the solder out of the car body by redesign of the body or finding a substitute material for filling out the seam." (Tr. 5249) OSHA agrees with this statement. In fact, industry has already reduced the use of solder in automobiles by substituting plastics and epoxies. One line of cars has totally eliminated the use of solder in production. (Ex. 26, p. 5–133)

General Motors and Chrysler (Ex. 476–77) have petitioned for, and received, a permanent variance from the lead and arsenic standards (45 FR 46922, 45 FR 74096). Ford's application is still pending with the Agency. (Ex. 504B) The variances permit the continued use of air-supplied respirators while the automakers engineer the solder out of the auto body. OSHA granted the variances because: (1) Each company has committed itself to eliminate the need for lead solder in the auto body assembly process by redesigning certain exterior solder joints; and (2) during the interim, employee health is being protected by the use of personal protective equipment.

In their applications, three major automobile manufacturers have admitted that it is technologically and economically feasible for them to eliminate the use of lead solder within seven years (See, e.g., Ex. 476–80; Ex. 504B; 504C). No comments have been received from the remaining automobile manufacturers, but there appears to be no reason why they should not similarly be able to eliminate lead solder within seven years. For this reason, OSHA finds that the auto industry has an economically and technologically feasible means of complying with the lead standard.

Accordingly, OSHA has decided to regulate the automobile industry in accordance with the mutually agreed upon variances and has extended the compliance time for this operation to seven years from the effective date. The table in paragraph (e)(1) of the standard has been amended to reflect this decision.

Some firms may choose not to engineer solder out of the auto body design because they can achieve compliance through the application of engineering controls to existing equipment and work practices. The record indicates that in some plants engineering controls are being used to achieve compliance with the 50 $\mu g/m^3$. (Ex. 476–16, #TO–3). In addition, emphasis should be placed on the importance of housekeeping, booth maintenance, work practices, and worker rotation in achieving compliance with the standard.

6. Book Binding

(a) *Summary*

No person could be located who had any knowledge of lead exposure in the book binding process itself. However, it appears that if lead is present, it is in the form of a bonding agent or adhesive.

Contacts were made with the Binding Industries of America, Book Manufacturer's Institute, Library Binding Institute, and the Guild of Book Workers (Ex. 22 p. 259). These organizations indicated that they were not aware of problems with lead exposure resulting from lead use in book binding. If exposures are present they are clearly below the action level.

7. Brick Manufacture

(a) *Uses*

Bricks have many uses in construction and repair work. Tiles are thin brick-like structures used for facings.

(b) *Process Description and Exposure Areas*

Red or yellow bricks or tiles are made from clay. As the clay comes from the pit or storage bins, it is ground in dry pans and carried to a pug mill, where it is tempered with water to give it a stiff, mud-like consistency. From the pug mill it is forced by an auger screw through a steel die to the shape and size desired for the finished ware. The clay issues from the die head as a continuous column. A few feet from the die head, a cutter, generally automatic and consisting of piano wires set at proper distances on a jog (movable frame), cuts the column into the correct lengths. The cut raw ware continues on a belt conveyor, from which it is transferred to a dryer car. From the dryers, the ware is taken to the kiln (usually of the downdraft type) for firing (Ex. 476–5G).

In districts without clay resources, bricks are made from sand, or crushed sandstone mixed with approximately eight percent hydrated lime. Sand and water are added to create a dough which may be shaped in presses. The new bricks are loaded on small trucks and pushed into autoclaves. This operation is called "curing" and corresponds to the firing of the red clay bricks.

Firebricks are the material used in the construction of linings for open-hearth steel furnaces, for iron and other blast furnaces and stoves, for cupolas, calciners, and many other types of chemical engineering apparatus. They are used to line fireboxes and furnaces.

Bricks may be glazed prior to being fired or autoclaved. Glazing compounds are usually applied to facing bricks and tile to provide a smooth coat or finish (Ex. 476–5G). Glazes are usually applied automatically by spraying.

Lead exposure results primarily from the application of lead-based glazes on bricks. There appears however, to be limited industrial use of these glazes (Ex. 476–81, 82, 83). Exposure may also occur at the kiln area when glazed bricks are being fired.

(c) *Controls Currently Used*

The brick manufacturing industry already uses extensive control technology, consisting of mechanical handling and mixing of clays, automated material conveyance systems, automated glazing operations, and ventilation in kiln areas, to control worker exposure to crystalline silica. These controls also reduce lead exposures. (Refractory Institutes submissions to ANPRM for crystalline silica).

(d) *Exposure Levels*

A NIOSH Health Hazard Evaluation at the Colorado Brick Company (Ex. 476–84) found that of 10 lead samples taken at the furnace area, all levels were 0.002 $\mu g/m^3$, far below the 30 $\mu g/m^3$ action level. Data supplied by one manager of a large brick manufacturing facility also indicated that "no exposure exists in the industry." (Ex. 22, p. 203)

(e) *Population Exposed*

No information regarding the number of workers exposed to lead during brick manufacturing was furnished by the industry. Because exposure levels are so low, however, OSHA assumes that only a small percentage of brick workers are exposed in this industry.

(f) *Additional Controls*

No additional controls will be needed to reduce lead levels to below 50 $\mu g/m^3$ in this industry. The data indicate that exposure levels are currently less than 50 $\mu g/m^3$ with existing controls.

(g) *Conclusion: Technological Feasibility*

Based on record information it appears that this industry is already in compliance with the 50 $\mu g/m^3$ limit. Therefore, requiring compliance with the standard within the one year period is technologically feasible.

(h) *Conclusion: Economic Feasibility*

This industry will not have to improve existing ventilation equipment, train employees in proper work practices, enhance existing housekeeping or rotate workers, and therefore expenditures need not be made by this industry to comply with the lead standard. Therefore, no costs of compliance nor any economic impact will be incurred as a result of this standard.

8. Cable coating

(a) *Uses*

Lead-sheathed cable is used to weigh down underwater cable; eliminate air, water or corrosive substances; as a rodent control; or in tinning processes where the ends of steel wires are coated prior to being joined. Also, lead soaps may be used as lubricants during the installation of locomotive and power equipment control cables. (Ex. 22, p. 299)

Information regarding this industry was provided by several sources, some of whom requested that their identities remain confidential. One source indicated that the domestic use of lead-jacketed cables has declined. Production is now limited to three companies: Perelli at Union, N.J.; Okonite at Ramsey, N.J.; and Phelps Dodge at Yonkers, N.Y. (Ex. 476–88). Reportedly, lead is still being used to jacket cable for some underwater uses (Ex. 476–88) and for use in insulated high voltage cables (Ex. 476–87). In addition, lead is being used in the process of tinning stranded wires (Ex. 476–89), and is also used by the telecommunications industry (Ex. 475–22). Apparently, at least one company, Keyrite, is involved only in the splicing of lead-jacketed cable (Ex. 476–92).

Although lead-sheathed cable is still manufactured by certain companies, the use of led cable is declining and is being replace by aluminum, which is lighter, cheaper, easier to extrude and less toxic to the environment. Lead, as a jacketing material, is also being replaced by rubber, nylon, polyvinyl chloride, paper cloth and plastics (Ex. 22, p. 299).

(b) *Process Description and Exposure Areas*

Prior to pressing, the wire needed for coating is made by drawing a hot-rolled wire rod through one or more dies to decrease its size and enhance its prhysical properties. The wire rod is rolled from a single billet and cleaned in an acid bath to remove scale, rust or any protective coatings.

Single-draft or continuous drawing processes may be used. In single draft, a coil is placed on a reel or frame and the end of the rod pointed so that it will enter the die. The end is grasped by tongs on a drawbench and pulled through to appropriate lengths for winding around a drawing block or reel (Ex. 476–5K). In continuous drawing, wire is fed through several dies and drawn blocks are arranged in series. This permits maximum drawing in one operation before annealing is necessary (Ex. 476–5K).

Lead powders are mixed at coating blenders and conveyed to press areas where coatings are pressed into the wire by pressurized steel dies (Ex. 476–5K). The lead-sheathed cable is then passed through a water bath to cool the materials prior to winding (Ex. 22, p. 300).

Tinning is frequently used as a coating prior to bonding or soldering. This process involves the dipping of the workpiece in a molten tin-lead bath. Often, the molten metal is quenched in cold acidified water or warm soapy water so that bonding or soldering may be performed sooner (Ex. 476–4A).

Operations in the lead coating process (which presents the greatest exposure hazard) are the lead press, coating blender, pulverizing and catching operations, mixer operations, and stripping operations at wire drawing machines (Ex. 22, pp. 299–301). Reports concerning the tinning process stated that mixing of the tin-lead solution created the highest lead exposure (Ex. 476–89). No specific exposure problems were associated with lead cable splicing operations (Ex. 476–92).

(c) *Controls Currently Used*

Several companies already maintain very low exposure levels because of their excellent ventilation systems (Ex. 22, p. 301). Another source agreed with this comment, stating that lead exposures are generally well controlled (Ex. 476–92). Dr. Billings of Johns Hopkins University also indicated that simple, straightforward technology is effective to control lead exposures in cable coating. He noted, "If it is an industrial situation, and the control technology will work, (and) there is no reason why it wouldn't; if you are coating a cable, and you have a machine that is doing it, then you can put control technology on a machine" (Tr. 146).

Exposures within the cable coating industry are generally low (Ex. 22, p. 303) and most companies maintain ventilation systems. Ventilation systems on the processes were described as simple, straightforward hood and duct designs, already existing in the plant. One company involved in lead coating operations uses vacuum charge presses in batch operations processing 700-pound charges. Twelve employees are engaged in these operations, which produce 15 percent of all domestic lead-coated cable (Id.).

A second lead-cable coating processor reported that standard hooding and duct ventilation equipment had been on its machines for years. This company has 9 employees with potential lead exposure and produces approximately 33 percent of the domestically manufactured product (Ex. 476–91).

In general, local exhaust ventilation must be used at lead presses, stripping (wire drawing), compounding, and soldering operations (Ex. 22, p. 301). Handling and mixing of lead powders is the most difficult operation to control. The process should be automated and controls such as those described for similar materials handling operations in pesticides, pigments, and plastics and rubber production should be used. Therefore, even in the most difficult to control operation, mixing, feasible engineering controls are available to reduce exposure. (Ex. 476–89).

(d) *Exposure Levels*

Initially, the Short Report (Ex. 22, p. 300) reported exposure levels of 500 $\mu g/m^3$ in the blending rooms, 140 $\mu g/m^3$ in the duct, 37 $\mu g/m^3$ for the catcher, 20 $\mu g/m^3$ in the coiling department, and 30 $\mu g/m^3$ in the mixer. Most companies reported both areas of high level exposure and areas of low exposure (Id.). More recent data, however, indicate that lead levels in some operations are well below the 30 $\mu g/m^3$ action level. In fact, actual breathing zone samples furnished by one company's insurance carrier indicated that lead levels of 3, 5.5 and 13 $\mu g/m^3$ exist (Ex. 476–91). Several companies indicated that these low exposure levels are maintained because of their excellent ventilation systems (Ex. 22, p. 301).

Despite low air-lead levels, several high blood lead levels were reported. In two instances, however, industry sources attributed the few elevated blood lead levels among cable-coating employees to poor personal hygiene rather than elevated airborne concentrations (Ex. 476–89).

(e) *Population Exposed*

The Short Report estimated that 40 cable companies processed lead sheathing and assumed that 105 employees were employed by each company for a total of 4,200 persons potentially exposed to lead (Ex. 22, p. 301). However, more recent data indicate that only three companies make lead sheathing and one of these companies has estimated that only nine of its employees are exposed to lead (Ex. 476–91). Assuming that 9 is an average number, approximately 27 employees would be exposed to lead in this industry. Information is not available indicating how many employees are exposed above or below 50 $\mu g/m^3$. Additional number of employees may be exposed in tinning operations and during the application of lead soaps as lubricants in the locomotive and power control cable operations. However, the total number of such affected employees is unknown.

(f) *Additional Controls*

Recent data submitted to OSHA indicate that additional engineering controls will not be necessary (Ex. 476–89, 90, 91). Although, improvement and maintenance of existing controls will be needed (Ex. 22, p. 300). Increased housekeeping may also be necessary (Id.). Emphasis should be placed on personal hygiene practices to reduce some elevated blood lead levels which have been attributed to poor hygiene practices rather than high airborne concentrations (Ex. 476–89).

(g) *Conclusion: Technological Feasibility*

This industry appears to be in compliance with the existing 50 $\mu g/m^3$ standard, or nearly so in most cases (Ex. 476–89, 90, 91). The industry has achieved compliance through the appropriate use of ventilation equipment (Ex. 22, p. 301, Ex. 476–91). Firms not yet in compliance can use other measures such as equipment maintenance, housekeeping and worker rotation to attain the PEL within one year. The industry realizes the importance of worker training and has indicated that poor personal hygiene has resulted in elevated blood levels (Ex. 476–89). Through proper training in appropriate work practices, the firms currently having difficulty with elevated blood lead levels should be able to eliminate this problem.

(h) *Costs of Compliance*

Manufacturers of lead-coated, sheathed or jacketed cable have not presented cost estimates for complaince with this standard. Costs of compliance may be incurred as a result of maintenance and housekeeping activities. These costs will be relatively low when compared to use of more costly engineering controls to achieve compliance.

(i) *Industry Profile*

Of all the domestic producers of cable, only three remain in the lead-sheathed or coated cable industry. The three firms, Perelli Company, Okonite, and Phelps-Dodge, are located in close proximity to each other in New York and northern New Jersey. The record also indicates that Japan produces a significant quantity of lead-sheathed cable; however, there is no evidence of domestic competition with Japanese cable or of Japanese exports of this product to the United States. (Ex. 476–88)

The public record shows that power cable, formerly insulated with paper and coated with lead, is now insulated with polyethylene and covered with plastic, other synthetic, or aluminum jackets (Ex. 22, pp. 299–301). These substitutions have occurred in most cable products. Exceptions are underwater cable and other applications requiring mechanical strength (Ex. 22, pp. 299–301) and, possibly high voltage paper-insulated cables (Ex. 476–87). In addition to some performance problems associated with lead cable, there is a strong economic incentive to substitute other coatings because of the high costs associated with repairing lead cable (Ex. 476–87).

(j) *Conclusion: Economic Feasibility*

In summary, the declining use of lead cable, the curent low exposure levels, and the minimal compliance costs have convinced OSHA that the economic impact of the lead standard will be insignificant in this industry. Moreover, in those few markets where the performance of lead cable cannot be matched by substitutes, the continued demand for these products will permit producers to pass on a significant part of these costs to the purchasers of the cable.

9. Collection and Processing of Lead Scrap:

(a) *Uses*

The lead scrap from radiators, solder, telecommunications parts, cables, sheet lead, batteries, lead bearing dross, etc., are received by waste recyclers which sort, pack and ship the scrap lead to secondary lead smelters. (Tr. 245–246) The recycler may melt the scrap prior to shipment in an effort to handle the scrap more efficiently. (Id.). However, Mr. Ness, of the National Association of Recycling Industries, indicated that waste recyclers usually do not melt scrap. (Ex. 476–103) More than half of the lead scrap recycled in secondary lead smelters consists of used lead-acid batteries (Ex. 476–319, p. 341). This section does not apply to recyclers who process scrap lead as part of a secondary smelting operation. In addition, scrap processing of gold, silver, platinum, copper, zinc, brass and bronze are discussed as secondary smelting processes, in the appropriate sections.

(a) *Battery Breaking*

(i) *Process Description and Exposure Areas.* Battery breaking is accompished by various methods. (1) Quick acting guillotine devices may be used to cut the battery in half, after which the lead-bearing contents are emptied from the case and the case discarded. (2) Batteries may be ground in a mill and the lead-bearing materials separated from the case through flotation. (3) Batteries may be run over by large tractors, after which the lead-bearing materials are separated from the case. (4) The top of the battery may be cut off, using a hand saw, or slow-moving guillotine shears may be used to separate the top of the battery case from the battery. The contents of the battery are then emptied out and the case discarded (Ex. 476–319). Battery breaking has traditionally been one of the most difficult operations in which to control exposure to lead; exposures to acid mist and lead have been high (Ex. 476–319).

In recent years, polypropylene cases have replaced hard rubber cases. Polypropylene batteries can be charged to the blast furnace in larger quantities than the rubber-cased batteries. Typically, however, these batteries must also be broken so that efficient heating and smelting can occur in the blast furnace. (Ex. 476–319)

The primary exposure hazards resulting from the battery breaking operation are lead particulate and acid mist. Further, acid mist, lead sulfate and lead oxide may become airborne during the process of shearing the battery top, emptying the battery case, and transporting lead materials from the battery breaking building. Lead becomes airborne through two basic mechanisms: (1) The mechanical action of shearing, emptying, etc., which causes leaded mists and particulates to become airborne; or (2) the drying of lead oxide on adjacent surfaces which are then redispersed into the air by the agitation of heavy equipment. (Ex. 476–319).

(ii) *Controls Currently Used.* The chief method of exposure control require that all surfaces be wet to suppress dusts; that enclosed exhausted plastic battery shredders be used; that equipment or operations which would tend to provide energy for pulverization be avoided; and that slow-moving hydraulic shears be used to remove battery tops. The shear, the batteries, the floor, the conveyor belts, and all equipment in the building may be kept wet with automatic and manually applied water sprays. This approach is intended to minimize the secondary introduction of contaminants into the air (Ex. 476–319).

With polypropylene battery shredders, lead mists may be controlled through the use of an enclosed negative-pressure exhaust system coupled with a venturi/cyclone contaminant separator. The scrubber consists of a primary venturi scrubber, a secondary venturi scrubber, and a cyclone. The polypropylene shredder costs approximately $150,000 in 1974. It is capable of processing 1,000 batteries per hour, and is designed primarily to increase the production rate rather than as an environmental control for lead exposure. (Id.)

These controls are found in some operations. However, many scrap companies do not apply the technology that the more advanced plants have. Some still do not use ventilation at battery saws, dumping stations, or at guillotine knives. (Ex. 26, pp. 5–31). Side terminal batteries and industrial batteries may also be broken manually, with no controls to protect employees.

(iii) *Exposure Levels.* Exposure levels in battery breaking operations have been estimated to average between 50 and 150 $\mu g/m^3$ of lead (Ex. 476–319, p. 347). Battery breaker levels ranged from 107 to 785 $\mu g/m^3$; control room levels were measured at 31 to 86 $\mu g/m^3$, and levels outside the building were 149 to 359 $\mu g/m^3$. (Id.). The Short Report concluded that exposures in battery breaking operations would pose no significant problem if the plates were kept damp (Ex. 22).

(iv) *Population Exposed.* Mr. Ness, of the National Association of Recycling Industries, indicated that there are approximately 7,000 to 8,000 scrap processors (Ex. 476–103), with approximately one to ten workers per plant (Ex. 476–) No data are available which indicate how many workers may be exposed to lead above or below 50 $\mu g/m^3$.

(v) *Additional Controls.* The control data available were taken from one battery breaking operation. Other battery breakers with similar capacities will be required to use a comparable degree of technology, including automated battery shredding or shearing of some sort (Ex. 476–319). In smaller operations, the wetting of all surfaces with manually applied sprays and the use of local exhaust ventilation equipment may be relied upon to reduce exposures.

Of utmost importance is maintaining working surfaces and areas as free of accumulated lead dust as practical. Scrupulous attention to immaculate housekeeping forms an important strategy for compliance regardless of the size of the operation (Ex. 480).

The control technology necessary to achieve a 50 $\mu g/m^3$ standard in battery scrap processing is available. These technologies include containment, suppression using water, use of local exhaust ventilation, and mechanized handling of materials (Tr. 248). In addition, preventive maintenance, work practices and vacuum systems for housekeeping also can be used to reduce the concentrations of airborne lead (Tr. 248). On a large scale, battery breaking, in general, may be replaced by methods discussed in the secondary smelting section of the final standard (Ex. 476–319).

The data also indicates that lead levels outside of the battery breaking plants are in excess of 50 $\mu g/m^3$ (*Id.*). Where possible, compliance with ambient air standards should also compliment control of lead in the occupational setting by prohibiting the re-entry of lead into the work environment.

Benjamin Wake, an OSHA expert witness, concluded that the 50 ug/m³ level is achievable in most operations, most of the time, using available control options. This concludion seems appropriate (Tr. 249).

(b) *Processing of Lead Scrap from Radiators, Solder, Telecommunications Parts, Cables, Lead Sheet and Lead Bearing Dross*

(i) *Process Description and Exposure Areas.* Scrap may be merely cut, bundled and shipped to secondary smelters or may be melted, cut, bundled and shipped. Processors of scrap fall into two broad categories: melters and non-melters. (Tr. 245–246).

Non-melters may be scrap processors who handled dross and flue dust. They must ship, transfer, load, unload, weigh and store the scrap. The potential for lead exposure occurs at all handling operations and in mechanized processes at transfer points. (Ex. 22, pg. 143)

The Metal Salvage Company of Salt Lake City, Utah, is another type of non-melting scrap processor. It receives scrap lead sheets, radiators, etc., and sorts, chops or cuts, and bales or bundles the lead scrap to be sold to secondary smelters (Ex. 476–102). It does not melt lead scrap, nor does it process dross or flue dust (Ex. 476–102). Further, no battery breaking is done. Melters may be companies such as Keystone Resources, of Mars, Pennsylvania, which, in the past, remelted lead from telecommunications equipment, cables, and boxes. Part of the process involves the stripping of lead from the wires prior to melting (Ex. 476–101).

(ii) *Controls Currently Used.* The technology available and currently being used by these scrap processors includes water sprays to suppress dusts and local exhaust ventilation (Ex. 476–101). Melting pots are provided with exhaust ventilation (Ex. 476–112).

(iii) *Exposure Levels.* Little exposure data was provided to OSHA (Ex. 476–94, 96, 101, 102). Some companies, however, did indicate that controlling lead exposure presents no problem (Ex. 476–101, 102). These firms represent both melters and non-melters. One company stated that they are very close to compliance with the 50 $\mu g/m^3$ standard. (Ex. 476–112)

(iv) *Population Exposed.* No data was available on the number of workers exposed. The number of workers employed by scrap processors appears to range between 6 and 25 (Ex. 476–93–117). Since available exposure data indicates that many of these companies may be nearly in compliance with the standard, OSHA estimates that the number of exposed employees exposed above 50 $\mu g/m^3$ is probably very small.

(v) *Additional Controls.* Based on the data available, controls other than those existing and already applied in some cases, are probably not necessary (Ex. 476–101, 112). The melting scrap processor, that indicated that it was in compliance used both wet suppression and local exhaust ventilation (Ex. 476–101). The processor that used only exhaust ventilation was very nearly in compliance. (Ex. 476–112) The processor that did no melting did not indicate that any controls were necessary and mentioned no compliance problems. (Ex. 476–101). Thus the application of controls already existing within the industry seems sufficient to achieve compliance. (Ex. 476–102, 112).

(c) *Conclusion: Technological Feasibility.* The National Association of Recycling Industries argued extensively regarding the infeasibility of collectors and processors as well as secondary smelters and refiners in achieving compliance with the 50 $\mu g/m^3$ limit. Basically, the Association contends that collectors and processors should have the same 5 to 10 years compliance period as do secondary smelters and refiners. They also stated that "these small collectors and processors cannot comply within one year much less through the use of respirators alone." (Ex. 447–17, 478). In its post-hearing submission, the Association argued that is it "technologically infeasible for these additional scrap collectors and processors to comply with the OSHA lead standard—without the continued use of respirators in most of their operations." (Ex. 498, p. 37)

It appears to OSHA that the industry, apart from alleging that it cannot comply with the standard has not provided the Agency any consistent evidence as to why compliance is not feasible. OSHA has repeatedly requested this Association to provide data on exposure, on controls being used, and on controls to be implemented. However, all the Agency has received are assertions that it is not technologically or economically feasible for the industry to comply. On the contrary, OSHA concludes that the controls discussed in the general feasibility section of this document could also be used to reduce exposures in the recycling industry.

NARI contends that most scrap handlers only handle lead scrap occasionally and also that they are small businesses that lack the resources to implement costly controls. As a result of these factors, NARI believes OSHA should designate collectors and processors of scrap as part of the construction industry and thus relieve them of the burdens of complying with the standard (Ex. 498, p. 37).

OSHA notes that while the construction industry is not covered by *this* lead standard, it is covered by a lead standard in Part 1926. The attempt to analogize the recycling industry validity in the NARI arguments for concluding that being a small business or handling various kinds of scrap (some of which contain lead, and some of which do not) warrants exemption from the standard. In fact, the intermittent nature of processing leaded scrap could, itself, serve to maintain levels below 50 $\mu g/m^3$.

Also, based on the data submitted to the record, it appears that in processing scrap, other than batteries, the simplest control technologies are being used, including wet suppression and local exhaust ventilation (Ex. 476–101), with substantial success. Many of the companies that supplied data to OSHA were small businesses (less than 10 employees) who indicated that lead exposure posed no problem (Ex. 476–101, 102). Perhaps, this is because they did not envision, nor anticipate, constructing the grossly exaggerated solutions suggested by NARI, but instead used the simplest of controls (water suppression and portable exhaust ventilation) to reduce lead levels.

Melting operations may require somewhat more effort for exposure control. However, as one commenter contended, melting pots are provided with exhaust ventilation (Ex. 476–112). Containment of fugitive emissions from melting pots is a standard operation with many different industries using general ventilation, local ventilation at emission points, negative pressures, maintenance of seals, etc., to achieve compliance with many standards, in addition to lead. These controls are "tried and true" and used by industry as a whole, as noted by Billings and First. (Ex. 487, 104).

Battery breaking operations may require that some firms use extensive controls to achieve compliance with 50 $\mu g/m^3$ if only the use of engineering controls and work practices are employed. Extra efforts may be necessary to encourage use of automated materials handling operations. However, this industry appears to be adding more automated production equipment to increase productivity and this will also achieve worker protection as a benefit. Once again, materials handling controls, are controls that are used by industry as a whole and are generally applicable to all situations (Ex. 487, 104). However, extensive use of engineering controls will only be necessary when very few controls currently exist. Also, the industry should consider the positive effects housekeeping alone would have on dust suppression. In addition, the less costly alternative of worker rotation could also be used effectively to achieve compliance with the 50 $\mu g/m^3$ limit. Those firms not in compliance should look to the implementation of a variety of control techniques and use such interchangeably to achieve compliance.

For manual battery breaking operations done by sole proprietors or small operations, compliance will not be difficult only if proper consideration is given to controls available. For example, portable ventilation units are available and can be purchased very inexpensively. In addition, the less costly alternatives of worker rotation, wet suppression, etc., may be used. It should be noted, however, that as battery breaking operations become more automated, the larger companies which adopt these processes can sell scrap lead at a lower price, which will affect the markets of the small operators.

This industry can comply with a 50 $\mu g/m^3$ standard and, in some cases as previously discussed, has already complied with the standard. The engineering controls used are readily available with the only problems in implementation, in some cases, stemming from the fact that very little in the way of controls was done in the past. Most change in this industry has come about as a result of process productivity (battery breaking) with little thought being given to safety and health related changes. However, OSHA has allowed this industry, as well as others, to use worker rotation to achieve compliance with the 50 $\mu g/m^3$ PEL and, even in the very smallest of operations, hiring one more individual may prove the least costly alternative for complying with the standard.

(d) *Cost of Compliance*

The record contains sparse and unsupported industry estimates of costs of compliance in some scrap facilities. One recycler of lead scrap reported that the installation of a water spray system (costing $6000) and the use of administrative controls were effective in achieving compliance with the standard (Ex. 476–100). Another recycler had a 20 ton remelting operation in which all pots were equipped with exhaust hoods. These hoods were installed at a cost of $15,000 and the firm was reported to be very close to compliance with the standard. With increased attention to personal hygiene, the firm expected to achieve full compliance (Ex. 476–112).

The majority of scrap recyclers are not remelters, therefore, potential compliance costs for most firms will be low. Remelters may require more significant investments in ventilation equipment. A multifaceted approach to reducing air lead levels can result in cost-effective compliance with the lead standard, while simultaneously controlling exposures to other toxic substances present in scrap.

(e) *Industry Profile*

There are an estimated 7428 establishments in SIC 5093, Scrap and Waste Materials (Ex. 476–109). These establishments are primarily engaged in collecting, cleaning, breaking, sorting, chopping, baling, and distributing all types of scrap for delivery to remelters and secondary smelters (Ex. 476–103). The public record indicates that approximately 4000 to 5000 of these establishments employ a total of 40,000 workers to handle lead scrap (Tr. 246). These scrap processors, however, do not ordinarily melt lead (Ex. 476–103) and, in fact, it is estimated that only 200 of these establishments may perform remelting operations (Tr. 246).

There is evidence to support positive prospects for the scrap industry in the future. There is a continuing national emphasis on the recovery and reuse of natural resources (Ex. 476–106). In addition, current deposits of lead-bearing ores are diminishing (Ex. 476–108).

Firms within the industry are widely distributed across the nation with concentrations in California, New York, Pennsylvania, Illinois, and Texas (Ex. 476–109). Because of the high cost of transportation, it is unlikely that potential increases in price as a result of compliance would cause major changes in market structure or increased concentration. During ebbs in the business cycle, scrap dealers may be forced to cut prices if their customers, also complying with the lead standard, attempt to shift costs back to them. However, on balance the potential economic impact on this industry should be negligible, since the firms that enage in remelting operations are generally the larger firms that will be able to afford any required additional capital investment. The smaller firms do not ordinarily melt lead and, therefore, will face few new compliance costs.

10. Copper Smelting

(a) *Primary Copper Smelting*

(i) *Uses.* The largest use of copper is in electrical equipment and supplies. Electrical instruments and test equipment, power distribution systems including transformers, switchgears, and electrical lighting and wiring equipment require large quantities of copper. Copper also has widespread uses in the construction industry, in the production of nonelectrical industrial machinery, and in the transportation industry (Ex. 476–122).

There are 15 primary copper smelters in the U.S. Seven of them are located in Arizona. Most of the firms engaged in the smelting of copper ore also engaged in the mining, beneficiation, refining and fabrication of copper products and in the processing of other non-ferrous metals such as arsenic, lead, zinc, gold, cadmium, etc. (Ex. 476–119).

(ii) *Process Description and Exposure Area.* Pyrometallurgical smelting methods are used extensively in the United States to produce copper from sulfide ores. These ores usually contain less than one percent copper when mined and, therefore, must be concentrated before being transported to the smelter. This is accomplished by crushing, grinding, and flotation operations at the mine site. The sulfur content of the concentrate is generally 25 percent and the water content 10 percent. Some concentrates also contain boron, antimony, precious metals and other heavy metals (Ex. 476–118).

The operations for pyrometallurgical copper smelters in the United States include roasting, reverberatory or electric furnace smelting, and conversion to produce blister copper from concentrate. The remaining impurities are usually removed by fire refining and electrolytic refining. About half of the smelters in the United States do not use the roasting step, but instead feed wet or "green" charge directly to the smelting furnace. The roasted product, called calcine, serves as a dried and preheated charge for the smelting furnace. Either multiple-hearth or fluidized-bed roaster furnaces are used for roasting copper concentrate (Ex. 476–118).

After roasting, the copper concentrate is smelted. In this process, hot calcines from the roaster, or raw, unroasted concentrate are fused with limestone and siliceous flux in reverberatory or electric-arc furnaces to produce copper matte. Slag floats on top of the molten bath and is removed continuously. Copper matte remains in the furnace until poured (Ex. 476–119).

The final step in the production of blister copper is converting. Converting is normally performed in a Pierce-Smith shell. An opening in one side of the converter functions as a mouth through which molten matte, siliceous flux, and scrap copper are charged to the converter and gaseous products are vented. Air or oxygen-enriched air is blown through the metal to form a slag, which floats on the surface, and pure Cu_{2s}, which is collected on the bottom of the coverter. After removal of the slag, a renewed air blast oxidizes the sulfur into SO_2 leaving blister copper in the converter (Ex. 476–118).

Blister copper usually contains from 98.5 to 99.5 percent pure copper. Impurities may include gold, silver, antimony, arsenic, bismuth, iron, lead, nickel, selenium, sulfur, tellurium and zinc. To further purify the blister copper, fire refining and electrolytic refining are used. In fire refining, air is blown through the metal to oxidize remaining impurities.

The principal sources of lead exposure are the solid particulate materials in handling circuits and the vaporized metal oxide fumes from pyrometallurgical processes (Ex. 481). Materials handling exposures result from the handling of the ores and the calcine, matte, etc. Pyrometallurgical emissions result from roasters, reverberatory furnaces, converters, and other processes associated with the use of these furnaces.

The principal source of fugitive emissions from roasters is the process of removing hot solid calcine from the roaster. Both lead dust and residual sulfur dioxide may be released. When the process also involves dumping the calcine into cars for transfer to the reverberatory furnace, as is the case with some multiple-hearth roasters, the sudden dissipation of kinetic energy as the calcine strikes the car causes the generation of a puff of lead dust and trapped gases. Emissions may also result from leaks in the roaster (Ex. 476–118).

Reverberatory furnaces produce molten matte from either "green" charge or calcine. Charging and tapping of the furnace are carried out intermittently while melting continues. Although the furnace operates at slightly less than atmospheric pressure, the charging operation is conducted through openings in the furnace from which some lead dust or fume and sulfur dioxide may escape (Ex. 476–118).

Molten matte is removed from the furnace through tap holes which are normally plugged. During tapping, the holes are opened and the matte flows through channels called launders to ladles. Most furnaces have two or three matte tap holes on each side. Because the matte is still close to furnace temperature as it is removed, the remaining sulfur (in the form of sulfides) can continue to oxidize, outside of the furnace, for a time, forming sulfur dioxide. Oxides of volatile metals may be emitted also as materials are transported to the converters (Ex. 476–118). The less dense slag that floats on top of the matte in the reverberatory furnace is also removed periodically through slag tap holes and launders. Some emissions result from this operation but they are generally not as intense as those from the matte (Ex. 476–118).

(iii) *Controls Currently Used.* At the materials handling stage, jaw crushers are used to crush and grind the ore which is then sent to bedding bins. Typical controls include: the mechanical conveyance of ores to the jaw crusher; containment of the dust through the elimination (by redesign or use of dead drops) of long material drops; belt wipes; conveyor curtains and skirts; ventilation hoods at materials handling points; complete enclosure of conveyors; liquid sprays to suppress dusts; vacuuming (wet) of spilled materials; and the use of clean air pulpits for workers operating mechanical conveying systems (Ex. 481).

Pyrometallurgical processes may be controlled by using various ventilation control schemes, depending upon the equipment used in the process and the emission sources.

Reverberatory furnaces are constructed of refractory bricks. Because of the need to allow room for thermal expansion, it is difficult to design a leakproof furnace. Leaks in reverberatory furnaces may be sealed by the spraying of a slurried refractory (Ex. 476–118).

Fugitive emissions associated with copper converting generally result from ineffective capture of fumes and sulfur dioxide during certain phases of the converter operation. During blowing, the exhaust hood placed over each converter generally fits rather tightly; thus, fugitive emissions are minimal. The fit is not perfect, however, as there must be a gap between the hood and the opening to prevent freezing of the hood to the converter as a consequence of molten copper splashes. A chain-curtain closure is sometimes used at the edge of the hood to minimize this gap while still providing durability and flexibility. A metal skirt is sometimes used to improve the seal and minimize deterioration of the converter. In a properly designed system it is possible to collect nearly all of the emissions during the "roll-in" and blowing phases (Ex. 476–118).

Automatic damper controls are generally used to prevent excess dilution air from being drawn into the system, while at the same time maintaining effective fume collection from most phases of converter operation. If the damper control point is improperly set, or if the charge level in the converter is higher than normal, fugitive emissions can result (Ex. 476–118).

When the converter is rolled out for the pouring of either slag or blister copper, the hood draft is usually shut off by dampers to maintain a higher concentration of sulfur dioxide in gases that are fed to the by-product acid plant (if such a plant is provided). When the dampers are closed the converter emissions are not captured and discharged directly into the atmosphere. This operation can amount to 3 to 6 hours out of every 24-hour period for each converter (Ex. 476–118).

Another minor source of fugitive lead emissions is fire refining. The residual sulfur content of blister copper is only about 2 percent and only small amounts of impurities remain. Therefore, when final blowing is conducted the potential for lead emissions is small. These furnaces are, therefore, not hooded (Ex. 476–118).

(iv) *Exposure Levels.* A great deal of exposure data has been compiled for the copper smelting industry. Industry-wide area sampling averages of airborne lead concentrations indicate: 70 $\mu g/m^3$ at reverberatory furnace charging deck areas; 60 $\mu g/m^3$ around reverberatory furnace floors; 50 $\mu g/m^3$ in converter aisles; and 10 $\mu g/m^3$ in the anode casting areas. Personal breathing zone sampling showed lead levels of: 70 $\mu g/m^3$ on the charging decks; 70 $\mu g/m^3$ on the reverberator furnace floors, 30 $\mu g/m^3$ in the converter aisles; and 10 $\mu g/m^3$ in the anode casting areas (Ex. 481).

While these data suggests that compliance with 50 $\mu g/m^3$ has almost been achieved in primary copper smelters, it should be emphasized that these figures represent averages and do not reflect conditions in any one smelter at any given time (Ex. 481). They are very useful, however, for determining the magnitude of exposures.

However, the specific industry data is consistent with these industry-wide averages. At the Tacoma smelter (Ex. 481) forty-two samples were taken on workers in the roaster area with the low value being non-detectable, the high value being 180 $\mu g/m^3$, and the average 42 $\mu g/m^3$. Twenty-nine samples were taken in the reverberatory furnace area, with the low value being non-detectable, the high value 110 $\mu g/m^3$, and the average 12 $\mu g/m^3$. Thirty-two samples were taken in the converter area (excluding flue dust pullers), with a low value of 10 $\mu g/m^3$, a high value of 290 $\mu g/m^3$, and an average of 82 $\mu g/m^3$. Exposures for flue dust pullers were quite high, four samples ranged from 280 $\mu g/m^3$ to 4060 $\mu g/m^3$, and averaged 2180 $\mu g/m^3$. In an earlier survey at the Tacoma smelter in July 1972 (Exhibit 481–10), nine area samples were taken on the charge deck of the reverberatory furnace with a low value of 10 $\mu g/m^3$, a high of 140 $\mu g/m^3$, and an average of 63 $\mu g/m^3$. The concentrate was 1.3 percent lead, which is relatively high for a copper smelter concentrate.

ASARCO's El Paso plant was surveyed by NIOSH in April 1972 (Ex. 481), at which time area and personal samples were taken in the copper smelter (which also includes a zinc fuming operation). Twenty-two areas samples were taken ranging from less than 10, to 290 $\mu g/m^3$, and averaging 99 $\mu g/m^3$. Samples were taken in cranes, on the converter skimming platform, in the reverberatory furnace area and the zinc-fuming area also. The 10 personal samples ranged from 10 to 190 $\mu g/m^3$ and averaged 61 $\mu g/m^3$. At the time, the smelter building was relatively open. This building has since been enclosed to comply with EPA standards. An OSHA survey of this facility in 1977 (Ex. 481) indicated that lead exposures, however, remained relatively low. Two beltmen in the roaster area had exposures of less than 10 $\mu g/m^3$ and 4 personal samples taken in the anode furnace area showed levels of 24, 26, 28, and 41 $\mu g/m^3$.

A survey conducted at Kennecott Copper Company's McGill, Nevada, facility in August 1972 (Ex. 481–3) consisted of one sample on the reverb furnace charge deck of 20 $\mu g/m^3$. The green feed to the reverberatory furnace contained 0.03 percent lead. Kennecott's Hayden, Arizona, plant was surveyed in March 1973 (Ex. 481–6) and 9 area samples, taken on the reverb charge floor, ranged from less than 10 to 20 $\mu g/m^3$. The concentrate contained 0.06 percent lead.

A survey of Kennecott's Hurley, New Mexico, smelter consisted of 5 area samples from the reverb charge deck which averaged 4 $\mu g/m^3$ (Ex. 481). The range was less than 2 to 10 $\mu g/m^3$. The concentrate contained 0.016 percent lead.

Kennecott has rebuilt its Garfield smelter near Salt Lake City and instead of using reverberatory furnaces, it is now using three modified Noranda continuous smelting furnaces. During a NIOSH Health Hazard Evaluation conducted in December 1979 (Ex. 481–12), 24 personal samples were taken with lead values ranging from less than 5 to 290 $\mu g/m^3$ and averaging 64 $\mu g/m^3$. Thirteen of the samples (54 percent) were below 50 $\mu g/m^3$.

Two area samples taken on the reverb charge deck at the Phelps-Dodge smelter at Ajo, Arizona, in March 1972 (Ex. 481–4), indicated that lead levels were less than 0.001 $\mu g/m^3$. The concentrate contained 0.10 percent lead. The Phelps-Dodge smelter at Douglas, Arizona, was studied a year later (Ex. 481–7) and 11 area samples taken from around the reverberatory furnace charge floor averaged 11 $\mu g/m^3$. The range of values was from less than 10 to 320 $\mu g/m^3$.

Inspiration Consolidated Copper Company's smelter at Inspiration, Arizona, was surveyed by NIOSH in 1973 (Ex. 481–11). All of the 36 area samples taken from around the reverb charge deck indicated lead levels of less than 10 $\mu g/m^3$. The concentrate contained 0.05 percent lead. The reverberatory furnace at Inspiration has recently been replaced with an electric furnace.

Extensive surveys were also conducted at White Pine, Michigan, in 1972 (Ex. 481, 8 and 9). Twenty-seven area samples from the reverb furnace, converter furnace, fire refining, casting, holding furnace, and waste heat boiler areas averaged only 3.6 $\mu g/m^3$ (the high value was 13 $\mu g/m^3$). Personal samples which obtained for the reverb furnace operator, tripper man, flue dust man, conveyor belt operator, laborer, tapper, tapper helper, brick mason, converter puncher, craneman, refining furnace operator, rappler, and research technician job titles averaged 2.8 $\mu g/m^3$. Estimated time-weighted-average exposures ranged from non-detectable to 50 $\mu g/m^3$. This upper value is inconsistent with the personal sampling data, because the concentrate contained only 0.005 percent lead at the time of the survey. (Ex. 481).

The above data, as Dr. Wagner stated, as OSHA consultant, indicates that "there is considerable variability in airborne lead concentrations among individual smelters and among areas within individual smelters." (Ex. 481).

OSHA estimates that the number of workers potentially exposed includes all 5,000 workers who are directly involved in copper smelting activities. (Ex. 481).

(vi) *Additional Controls.* According to information contained in the public record:

Some smelters are already substantially in compliance with the OSHA standard of 50 $\mu g/m^3$; others would only have to concentrate their engineering efforts in certain areas or on certain processes. A few smelters would have to make a major effort throughout the entire operation and even consider making major process changes. The variabilty in concentrations is a function of the amount of lead in the raw materials and feed, the type of equipment and process, the adequacy of existing controls, and the maintenance and operation of controls (Ex. 481).

The technology needed to comply with the lead standard in the smelting industry generally was discussed at length in the gold, silver, and platinum section. This technology is currently available and its application to copper smelting requires little innovation in order for existing controls to be adopted to existing equipment. (Ex. 481).

In addition, the types of controls necessary for lead are already in place in many smelters, needing only to be upgraded, modified, and/or maintained (Ex. 481). Quite often, airborne lead concentrations can be reduced by properly fitting the components of the control system or by improving enclosures so that emissions are captured more efficiently. In some instances, otherwise adequately designed systems lack sufficient capture velocity to provide proper ventilation under changing conditions. (Ex. 481).

Maintenance and proper operation of control systems is a major problem throughout the industry (Ex. 481). Housekeeping is also usually poor; certainly part of the airborne lead comes from dust and materials found lying around throughout many smelters (Ex. 481). Many of the witnesses felt that if increased emphasis should be placed on control system design, maintenance and operation, and on good housekeeping, to lower the concentrations of airborne lead (Ex. 481 and 487).

The time required for each smelter to come into compliance will vary with individual situations (Ex. 481). Some smelters are already in compliance, some have only a few areas which need additional control, and some need only to upgrade existing systems, initiate improved maintenance and housekeeping programs, and enforce their better operating procedures (Ex. 481). In general, smelters appear to be able to come substantially into compliance within one year. (See 43 FR 54477–78). A few smelters may have problems achieving compliance in all operations within a year, but can make substantial improvements in air levels and will have many areas in compliance (Ex. 481). Some smelters may have to consider expensive, long-term changes in their processes in order to come fully into compliance (Ex. 481). Where the process cannot be entirely controlled or enclosed, the worker can be provided a clean air control room in which to work or a clean air pulpit in which to stay during periods when only observation is required. Many jobs in the copper industry, such as matte tapping, slag skimming, and charge deck work, are performed intermittently and, if clean air pulpits were provided, the time-weighted-average exposures of these workers would be significantly reduced (Ex. 481).

(vii) *Conclusion: Technological Feasibility.* ASARCO submitted comments during the hearing stating that the technology for controlling lead exposure in copper smelters does not exist (Ex. 475–28). The company's position was premised on the notion that processes invoved in the primary production of copper and zinc are similar to those involved in primary lead production, and that similar technology is necessary to control exposure to lead in zinc and copper operations. The company also argued that primary lead smelters were given extended periods to comply because innovation was necessary (Ex. 475–28) and that allowing copper smelters one year to comply was inconsistent with the number of years allowed for primary lead smelting (10 years) and secondary lead smelting (5 years).

While there may be similarities in processes, the underlying problems associated with control of lead exposure depend on the percentage of lead in the ore. Dr. Wagner testified that this percentage was extremely variable and that copper smelters smelt ore ranging from less than .01 to 1.3 percent (Ex. 481). Smelters smelting ores containing a higher percentage of lead may have more difficulty in controlling lead exposures and may require additional time to come into compliance than those using ores with lead concentrations at the lower end of the range. (Tr. 353–354). However, the comparison to lead smelting is not accurate. Primary and secondary lead smelters process sulfide ores with lead content far greater than 1 percent and, therefore, have much higher lead exposures. The technology necessary to reduce these exposures is not the same in that it requires a much greater degree of control which involves application of engineering controls and major process and equipment modifications. As stated above, upgrading and modifying existing controls is all that is required for most copper smelters in the United States, and one year is an appropriate time limit for these smelters.

Many of these copper smelters must also comply with the OSHA arsenic standard (29 CFR 1910.1018). The control technology necessary to comply with that standard will also control lead concentratons to lower levels (Ex. 481).

However, in a minority of plants smelters may have peculiarities, aged plants are in need of extensive renovation, or lead in ore concentrations are particularly high, compliance with the standard within one year may be difficult. Individual firms' claims of infeasibility in one year can be considered through compliance or variance mechanisms between the company and OSHA (43 FR 52991).

(b) *Secondary Copper Smelting*

(i) *Uses.* The secondary copper industry processes scrap metals for the recovery of copper. Products include refined copper or copper alloys in forms such as ingots, wirebar, anodes, and shot. Copper alloys are combinations of copper with other materials, typically, tin, zinc and lead. For special applications, combinations may include such metals as cobalt, manganese, iron, nickel, cadmium and beryllium as well as nonmetals, such as arsenic and silicon (Ex. 476, 118).

(ii) *Process Description and Exposure Areas.* The principal processes involved in copper recovery are scrap metal pretreatment and smelting. Pretreatment includes the cleaning and concentration processes necessary to prepare the material for the smelting furnace. Smelting involves heating and treating of the scrap to achieve separation and purification of special metals (Ex. 476–118).

The feed material used in the recovery processes can be any metallic scrap containing a useful amount of copper, bronze (copper and tin), or brass (copper and zinc). Traditional forms are punchings; turnings and borings; defective or surplus goods; metallurgical residues such as slags, skimmings and drosses; and obsolete, worn out, or damaged articles, including automobile radiators, pipe, wire, bushings and bearings (Ex. 476–118).

The type and quality of the feed material determine the processes the smelter will use. Due to the large variety of possible feed materials available, the method of operation varies greatly between plants. Generally, a secondary copper facility deals with less pure raw materials and produces a more refined product, whereas brass and bronze alloys processors take cleaner scrap and perform less purification and refining (Ex. 476–118).

Pretreatment of the feed material can be accomplished using several different procedures, either separately or in concert. Feed scrap is concentrated by manual and mechanical methods such as sorting, stripping, shredding, and magnetic separation. Feed scrap is sometimes briquetted in a hydraulic press. Pyrometallurgical pretreatment may include sweating, burning of insulation (especially from wire scrap), and drying (burning off oil and volatiles) in rotary kilns. Hydrometallurgical methods include flotation and leaching with chemical recovery (Ex. 476–118).

In smelting, low-grade scrap is melted in a cupola furnace, producing "black copper" and slag; these are often separated in a reverberatory furnace from which the melt is transferred to a converter or electric furnace to produce "blister" copper.

Blister copper may be poured to produce shot or castings, but is often further refined electrolytically or by fire refining. The fire-refining process is essentially the same as that described in the primary copper smelting industry and includes: (1) Charging; (2) melting in an oxidizing atmosphere; (3) skimming the slag; (4) blowing with air or oxygen; (5) adding fluxes; (6) "poling" or otherwise providing a reducing atmosphere; (7) reskimming and (8) pouring (Ex. 476–118).

To produce bronze or brass, rather than copper, an alloying operation is required. Clean, selected bronze and brass scrap is charged to a melting furnace with alloys to bring the resulting mixture to the desired final composition. Fluxes are added to remove impurities and to protect the melt against oxidation by air. Air or oxygen may be blown through the melt to adjust the composition by oxidizing excess zinc (Ex. 476–118).

The final step is casting of the alloy or refined metal into a desired form. This form may be shot, wirebar, anodes, cathodes, ingots, or other cast shapes. As in the case of primary smelters, exposure to lead dust can be expected from materials handling, furnace charging, and uncaptured or uncontrolled furnace emissions (Ex 476–118).

(iii) *Controls Currently Used.* The technology to control lead in the secondary copper industry is the same as that required in other smelter operations; it requires mechanized methods of handling scrap and installation of additional or improved systems for collecting emissions (see discussion in copper smelting).

The Southwire Company submitted data indicating that its anticipated scheme for achieving compliance with 50 $\mu g/m^3$ requires the use of available controls, such as hooding of the Maerz charging area and blast furnaces; adding more duct work; hooding the converter charge and blast furnace tops and adding six baghouse additions, two fans, a 60-meter stack and a sample furnace exhaust (Ex. 475–32).

(iv) *Exposure Levels.* The Lead Industries Association indicated that exposures in smelter departments, casting operations, furnace areas, sampling departments, and maintenance operations are consistently in excess of 200 $\mu g/m^3$ (Ex. 475–27). It is not clear whether these levels represent workers' time-weighted averages, however. The Southwire Co. has indicated that exposures in its plants are above the 50 $\mu g/m^3$ limit, but has also indicated that past exposures were higher before engineering controls were installed. Controls are being implemented currently which are intended to reduce levels to below 50 $\mu g/m^3$ (Ex. 475–32). NIOSH, in its report on the secondary nonferrous smelting industry (Ex. 476–133) found that secondary brass and bronze smelters have lead levels as high as 200, 320, and 380 $\mu g/m^3$ at the tapping/pouring hood and 220, 320 and 490 $\mu g/m^3$ at the reverberatory furnace charging hood (Ex. 476–133). However, exposure levels are a function of the percentage of lead in the brass or bronze, and lead concentrations were not available in this report to make comparisons. The controls at these secondary smelters discussed by NIOSH were not anywhere near the "state of art" as are those found at the Southwire Corporation's smelter.

(v) *Population Exposed.* No data has been submitted which indicate how many workers may be exposed to lead as a result of secondary copper operations.

(vi) *Additional Controls.* The engineering controls necessary to comply with lead exposure limits in secondary copper smelters have been described previously and are already commercially available. Southwire, in fact, is using many of these technologies in its plant and anticipates achieving compliance with the standard (Ex. 475–32). Improved housekeeping and worker rotation may also be necessary in some plants.

(vii) *Conclusion: Technological Feasibility.* The Lead Industries Association has indicated that engineering controls are theoretically feasible to achieve compliance with 50 ug/m^3 in this industry, but states that it does not know whether implementing such controls will, in fact, achieve compliance (Ex. 476–32). However, primary lead smelters, where the lead content of the raw material is much higher, have been shown to have the technology necessary to comply. Therefore, if primary lead smelters, with higher concentrations of lead, can comply, secondary copper smelters, using materials containing less lead, should be able to use similar, but much less extensive controls to achieve compliance. Further, one must consider that as not all scrap copper contains lead, the intermittent nature of exposure in many operations makes worker rotation a viable control alternative.

The National Association of Recycling Industries (NARI), in its post-hearing comments, discussed extensively the lead exposure problems of the Southwire Corporation. NARI has portrayed the Southwire facility as one of the most modern, technologically advanced secondary copper smelters and, despite Southwire's expectations that compliance with the PEL will be achieved, NARI has stated that there are no guarantees that implementation of the best engineering controls will meet a 100 $\mu g/m^3$, much less a 50 $\mu g/m^3$ standard (Ex. 498).

NARI, however, ignores two things. It does not consider the use of housekeeping, effective maintenance and worker rotation in complying with a 50 $\mu g/m^3$ standard as, in all cases, only the use of engineering controls is discussed as the method to achieve compliance (Ex. 498, pp. 61, 62). The use of less costly alternatives has not been considered. These work practices and administrative controls would be especially appropriate in this operation because of the varying and intermittent nature of exposure. OSHA has determined that compliance is possible (Slip op. at 159).

(c) *Economic Feasibility: Primary and Secondary Copper Smelting*

(i) *Cost of Compliance.* ASARCO has submitted data on the cost of compliance with the lead standard in primary copper smelters (Ex. 475–28). The following compliance expenditures have been estimated for ASARCO's four facilities: Hayden, Arizona, $16,628,000; Tacoma, Washington $20,941,000; Amarillo, Texas, $667,000; and El Paso, Texas, $18,504,500. These calculations are based on the cubic feet of air per minute necessary to ventilate specific areas of the plants and on the costs of vacuum systems. Costs of associated devices designed and installed to prevent the emission of pollutants into the general atmosphere also appear to be included in these estimates. For instance, wet scrubbers and wet scrubber gas cleaning systems, costing a total of $1,540,000, have been included in three of the estimates. Thus, ASARCO claims that total expenditures of $56,740,000 would be required and also claims that this amount would not guarantee compliance with the standard.

Three secondary copper smelters—Southwire Copper, AMAX, and ASARCO—have submitted cost estimates to OSHA (Ex. 475–32, Ex. 475–31, and Ex. 475–28). In addition, Lead Industry Associates (LIA) has expressed concern as to continued viability of one unidentified secondary copper producer. LIA contends that the smelter is not currently in compliance and is confronted with technological difficulties that will require "several million dollars" to correct. However, LIA did not submit the specific data that OSHA requires to evaluate this particular situation (Ex. 475–27).

Southwire plans expenditures of $1.1 million in capital costs and $60,000 in annual operating costs to control lead emissions. These figures combine both EPA and OSHA-related expenditures. For example, six baghouse additions and a 60-meter stack are included in the estimate. The submission divides the $1.1 million figure into $902,000 for air quality and $198,000 for blast furnace charge fume control (Ex. 475–32). The Cadre Report prepared for Southwire disaggregates, in detail, the costs of ventilation approaches to fume control to be attributed to OSHA requirements. These costs total $244,084 (not including installation) (Ex. 475–32A). Southwire cautions that these expenditures even with careful planning do not guarantee full compliance with the 50 $\mu g/m^3$ standard.

AMAX submitted costs of compliance for its subsidiary, United States Metals Refinery. Cost estimates are broken out by areas in the plant. However, the types of equipment to be installed are not specified (Ex. 475–31). AMAX predicts that compliance would not be guaranteed by USMR's expenditure of $13,240,000 in capital costs and $5,034,000 in annual costs (Ex. 490). The components of annual costs include maintenance, power, and capital costs annualized at 20 percent.

ASARCO submitted costs of compliance for a secondary copper facility in Houston, Texas. The firm estimated that a vacuum system would cost $53,000 and that ventilation would cost $70,200 for a total cost of $123,200 (Ex. 475–28).

The record shows that estimates of compliance costs for secondary copper smelters vary significantly from $123,200 to over $12 million, and estimates of costs for ASARCO's primary facilities vary from $667,000 to $20,941,000. Such wide variations can be explained by differences among firms in costing methodologies, and perhaps more importantly, by differences in the initial levels of workplace exposures for primary and secondary producers. In other words, those firms attempting to reduce levels from conditions in excess of the previous lead standard of 200 $\mu g/m^3$ may be facing greater absolute expenditures than those firms that have already invested in control technology. However, based on expenditures per unit of abatement, firms with higher lead levels may, in fact, be spending less than firms that have made previous efforts to reduce lead levels.

Three major omissions in the calculation of costs by industry bias these estimates of compliance costs upward. First, industry estimates have not always reflected a cost-effective method for reducing lead levels. For example, the submissions tend to reflect only the mechanical ventilation approach to the control of lead when, in fact, housekeeping, work practices, and administrative controls in combination with ventilation would be both less expensive and more effective in achieving compliance (Ex. 481). Therefore, OSHA contends that the proper approach to reducing exposure levels is through an effective, multi-faceted approach to the problem. In this way, industry can minimize the resources spent on achieving a given level of lead in the workplace. Second, industry estimates do not reflect the value obtained by the firm from the reclamation of copper and other metals that are captured by control systems. This financial gain will to some extent offset the costs of compliance. However, industry has not presented data indicating the magnitude of the offset. Third, primary and secondary copper smelters have simultaneous legal obligations to comply with other regulations, such as the arsenic regulation. To the extent that actions taken to reduce arsenic levels also reduce lead levels, these expenditures are not attributable solely to the lead standard. In addition, costs attributable to EPA regulations are sometimes included in the estimates. Thus, doublecounting has substantially inflated many industry estimates.

Considering the above factors, OSHA concludes that Wagner's estimates of the total costs for *all* potentially affected copper smelters are reasonable counterestimates to the compliance costs as estimated by industry. Wagner has estimated that costs will not exceed $6 million and might be as low as $1.3 million (Ex. 481). However, because Wagner did not have definitive data on the compliance status of all firms in the industry, he placed caveats on this estimate. Wagner stated that he could have underestimated the costs by as much as 200 percent. Assuming an underestimate of this magnitude, the upper bound on capital costs for the primary copper producers would be only $18 million. If the costs of compliance for primary producers are the same as the costs for secondary producers, OSHA calculates an upper bound of $30 million in compliance costs for secondary copper producers. Thus, total capital costs in the copper industry will be at most $48 million. Annualized over the useful life of the equipment, primary copper producers will incur $3.2 million in total annual costs, and secondary producers will incur total annual costs of $5.3 million.

(ii) *Industry Profile.* The primary copper industry consists of establishments engaged in smelting copper from ore and in refining copper by electrolytic or other processes. Total value of shipments amounted to $3.9 billion in 1977, an increase of 41 percent from 1972 (Ex. 476–20). Historical statistics show that, since 1967, the number of companies in the industry declined from 15 firms, operating 32 establishments, to 11 firms, with 31 establishments in 1972, and 9 firms, with 27 establishments in 1977.

More recent Bureau of Mines data list the primary producers ranked in order of output as: (1) Phelps Dodge, (2) Kennecott, (3) ASARCO, (4) Magma Copper, (5) Copper Range, (6) Inspiration Consolidated Copper, and (7) Cities Services. These companies operated smelters and/or refineries. Several domestic producers, through subsidiaries or stock holdings, have interests in foreign copper-producing facilities in Australia, Canada, Peru, Mexico, South Africa, and Namibia (Ex. 476–122).

Prior to the exit of Anaconda from the market in October, 1980, the top three companies produced about 60 percent of the total industry output (Ex. 476–119).

The net profit margins in 1979 for Phelps-Dodge, Kennecott, and ASARCO were 8.7 percent, 5.4 percent, and 15 percent, respectively, with estimated net profit margins in 1982 through 1984 of 11 percent, 7.2 percent, and 15.9 percent (Ex. 476–130, 476–131, 476–132). Kennecott's lower profits were attributed to its relatively high and rising cost structure, which results from "ancient and outdated equipment" (Ex. 476–131).

Although the market shares and profitability of the top three producers indicate that the domestic market is moderately concentrated, the copper market is internationally competitive. Hence, the ability of the primary producers, regardless of individual market share, to raise prices is limited. Although it appears that the domestic market is not currently threatened by foreign copper imports, forward shifting of costs to customers is to some extent constrained. Producers largely eliminated foreign price advantages by basing domestic prices on the New York Commodity Exchange (COMEX) in 1978 (Ex. 476–26). Proximity to markets, a stable political situation, the existence of an advanced infrastructure, and scale of operations should maintain a viable domestic copper industry even in the face of a potentially worsened position vis-a-vis foreign competition (Ex. 476–122).

The ability to pass costs on is also limited by potential substitutes for copper. For instance, in electrical applications, aluminum, cryogenic power transmission techniques, microminiaturization circuitry, and use of satellites may impede the growth in demand for copper. In construction, the trend toward multiple housing units (which reduces the materials needed per unit), and the substitution of plastic pipes may curtail the demand for copper. Uses of copper in transportation vehicles is expected to continue to decline. In 1975, 34 pounds of copper per automobile were used. In 1979, this was reduced to 29 pounds. The use of only 25 pounds of copper per automobile is forecast for 1985 (Ex. 476–33). However, growth in armaments production may increase the demand for copper. On balance, total U.S. demand for copper is forecast to rise by the year 2000 to 5.1 million tons, representing an annual growth rate of 3.6 percent (Ex. 476–122). This demand is expected to strain supply sources as growth in demand for electrical equipment, computers, and underground power distribution systems rises.

Because the demand for copper parallels the demand for durable goods, the market is volatile and quite sensitive to national economic business cycles. The demand for copper also increases sharply with increased military activity because of its use in ammunition and military equipment. Typically, the industry expands to meet military demand and suffers from overcapacity during times of peace (Ex. 476–118).

In 1978, the International Trade Commission recommended that an import quota be imposed through 1982 to protect domestic copper producers. However, the petition was rejected, largely because the action carried an unacceptable risk of accelerating inflation, but also because the copper market was in the process of recovering from its depressed condition (Ex. 476–122).

At least two factors have contributed to increasing costs in the copper industry. First, fuel costs, which account for a major portion of production costs in smelting and refining, rose significantly between 1974 and 1978. The second major factor affecting production costs is the long-term declining yield of copper from ores. From 1950 to 1977, average yield has dropped from 18 pounds of copper per ton of ore to 10 pounds, with some deposits containing only 8 pounds of copper per ton of ore. (The cutoff grade is 4 pounds.) In addition, surface mines, which now account for 82 percent of domestic output, have large ratios of overburden (earth that must be removed during mining operations) to ore (Ex. 476–122).

However, a new process has been developed to recover copper from low ore concentrates (Ex. 476–124). The new hydrometallurgical process is pollution-free. Initial testing demonstrates that it is competitive with conventional smelting techniques. Diffusion of this new process throughout the industry may result in significant changes since costs of producing copper are both currently variable and highly dependent on location and physical composition of ore deposits.

Capital expenditures for new buildings, plant, and equipment in 1977 in the copper industry were withheld by the Commerce Department to avoid disclosing operations of individual companies. However, expenditures rose steadily from 1963 to 1975 from $13.1 million to $164.6 million. In 1976, the industry's investments dropped to $52.4 million, reflecting the depressed state of the market beginning in 1974 (Ex. 476–20).

Copper production is considered to be a capital intensive industry. On average, $7,000 per annual ton of new capacity for facilities is required for a totally integrated facility. Expansion of existing facilities requires about $5,000 per annual ton in capital costs (Ex. 476–122).

The primary copper industry employs about 10,000 production workers at smelters and refineries. The ratio of skilled to unskilled laborers has risen with increasing mechanization and large-scale operations have generated demand for mechanics, technicians, and machine operators. In 1971, employee hours per ton of copper averaged 20.3 hours; whereas in 1977, there were 18.2 employee hours per ton of copper (Ex. 476–122), indicating a slight increase in productivity.

Secondary copper producers are classified in SIC 3341. Total shipments in this SIC were valued at $719.2 million in 1977 (Ex. 476–20). Firms in this industry include Southwire, Cerro Copper, Chemetco, U.S. Metals Refining, Franklin Smelting and Refining, Reading Metals Refining, and Nassau Recycling (Ex. 475–32). These producers are located near their sources of scrap materials.

The low availability of scrap, a raw material for this industry, and the high cost of fuel have inhibited capital investments to increase plant capacity in the secondary production industry. The limited quantity of scrap increases the competition among secondary copper producers for sources of supply. The recent entry of Nassau Recycling into the secondary market increased the competitiveness of buyers in the scrap market by removing telephone scrap from available supplies. (Nassau Recycling is a subsidiary of Western Electric (Ex. 475–32), a major manufacturer of telephone equipment.)

While secondary producers are, at present, more energy efficient than primary producers, the threat of an oil embargo or fuel restrictions is sufficient to increase the reluctance of producers to expand operations. However, test results on a new experimental furnace designed for continuous smelting of copper-bearing scrap show that substantial energy savings and an increase in product quality can be realized (Ex. 476–124). On balance, however, the past volatility of the copper industry gives every incentive to delay expansion decisions.

The primary and secondary producers of scrap operate in the same market, because their products are generally perfect substitutes. Copper prices are set by the primary producers at the level that, in their estimation, will yield a reasonable profit without encouraging import competition or substitution. Copper demand is met first by the processing of scrap that can be done below the cost of primary production. Primary copper supplies the remaining demand. During shortages, rather than raise prices, primary producers may ration sales. When the demand and hence the price of scrap rises, the supply of copper scrap ultimately increases. This happens as lower quality, more dispersed scrap is gathered and processed at a price that purchasers are willing to pay to fill needs not met by primary producers. Although this market activity is limited by the cost of imported copper, this price is generally significantly higher than the domestic price during shortages (Ex. 475–32). Thus, the domestic market does not appear to face major import competition now or in the future. In addition, the secondary copper industry does not appear to be at a competitive disadvantage with the primary copper producers.

(iii) *Conclusion: Economic Feasibility.* The copper market has demonstrated past volatility and remains sensitive to the demand for durable goods. Thus, the demand for copper will fluctuate with swings in the national economy. However, on balance, the demand for copper is expected to grow at an annual rate of 3.6 percent.

Copper is produced and sold in a world market. The domestic industry has a demonstrated ability to compete successfully in this world market. Foreign price advantages no longer pose a threat to the domestic industry, and the stable political situation in the U.S., the existence of an advanced infrastructure, and the domestic scale of operations are expected to contribute to the continued viability of the domestic producers.

The primary copper industry, which produced shipments valued at almost $4 billion in 1977 (Ex. 476–20), will be required to spend a maximum of $3.2 million in annualized compliance costs. OSHA estimates that annualized compliance costs for the secondary copper industry, which produced shipments valued at $719.2 million in 1977 (Ex. 476–20), will not exceed $5.3 million. Therefore, OSHA concludes that the domestic copper industry will be able to comply with the lead standard within one year, and that compliance will not adversely affect the economic viability of the industry.

11. Cutlery

(a) *Process Description Exposure Areas*

Cutlery is produced by die manufacturing and casting (Ex. 22 p. 279). Decorative handles are soldered on and the products are packaged for sale.

A small amount of lead is used in the cutlery industry when handles are soldered (lead-tin solder), when a quick mold check in the die manufacturing and casting of knives is necessary, and when heat treatment of cutlery is necessary. (Ex. 22, p. 279)

The greatest sources of exposure occur in the soldering and heat treatment operations (Ex. 22, p. 279) Soldering of handles to knives is not usually done with lead; when it is however, the appropriate controls, such as local exhaust ventilation, are used (see soldering section for a complete discussion).

Heat treatment with lead is discussed in the section entitled "Wire Patenting and Annealing." In the heat treatment of cutlery, posts measuring 13 by 18 inches, are filled with lead and layers of sand, charcoal and fine steel and heated to high temperatures. The knives or blades are placed in the pot for about 5 minutes. As the blade is pulled out, the upper layers of sand, charcoal and steel remove all trace of lead. The blade is then quenched in oil. The layers of sand and charcoal help prevent the escape of lead fumes and maintain the temperature in the pot. Due to high prices, lead's use is diminishing in heat treating and is being replaced by salt. Also, heat treatment of cutlery and razor blades is often performed in furnaces rather than with molten lead.

(b) *Controls Currently Used*

Soldering operations in cutlery are comparable to other soldering operations, and may be done at benches or in soldering furnaces. Soldering done in furnaces may also use exhaust ventilation (see Soldering section for further discussion).

Heat treating operations are usually segregated from the rest of the workplace because of smoke from the oil, the intense heat, and fire danger. Lead pots are supplied with exhaust hooding. Almost all companies are believed to have exhaust fans and ventilation over the lead pots. (Ex. 22, p. 279) Ventilation methods will be heavily relied upon to achieve compliance in the heat treating rooms and solder areas. (Ex. 22, p. 279)

(c) *Exposure Levels*

No data were submitted indicating the levels of exposure to be found in soldering or heat treatment operations within the cutlery manufacturing process. Exposure levels can be estimated from comparable processes such as soldering of small components and parts, as well as other heat treating operations.

Soldering operations involving small components generally have minimal levels of lead exposure. Some studies have found levels ranging from 3–9 $\mu g/m^3$ (Ex. 476–401). Very little ventilation, if any, was available at these sites.

In heat treatment, lead is melted and heated to a certain temperature; where lead is also melted in melt pots, the company estimated that 50 $\mu g/m^3$ is usually achieved (Ex. 476–228).

It should be noted that lead baths used for heat treatment are covered with layers of sand and charcoal to maintain heat. These layers also tend to prevent the escape of dust and fumes from the process, whereas lead casting melt pots have no such internal controls.

(d) *Population Exposed*

It is estimated that of 11,000 employees in the cutlery industry, fewer than 65 persons are exposed to lead in the heat treatment process, with an additional 50 persons exposed through housekeeping, maintenance, etc. (Ex. 22, p. 279).

(e) *Additional Controls*

Additional engineering controls are not expected to be necessary to achieve compliance in this industry. Existing ventilation methods will be heavily relied upon to meet compliance in the heat treating rooms and solder areas. (Ex. 22, p. 279) The ventilation systems may require upgrading to produce desired flow rates, etc. Housekeeping will have to be improved to achieve compliance with 50 $\mu g/m^3$, with work practices and worker rotation being relied upon when companies choose not to implement engineering control changes.

(f) *Conclusion: Technological Feasibility*

Despite the fact that OSHA provided direct notice to at least one firm (W.P. Case and Sons of Bradford, Pennsylvania), concerning these special proceedings on the issue of the feasibility of the lead standard, no cutlery manufacturers participated in the public hearings, nor did any submit exposure or feasibility data to the Agency. Based upon the Short Report and analogies to comparable processes (such as soldering and smelting of lead), OSHA believes that attaining the 50 $\mu g/m^3$ PEL in this industry is feasible using the simplest of engineering controls. Employers who do not wish to upgrade existing ventilation systems may rely upon housekeeping, work practices, and worker rotation to achieve compliance with the 50 $\mu g/m^3$ limit within one year.

(g) *Economic Feasibility*

Neither compliance costs nor economic impact data were offered by any cutlery industry representatives. Based on the record evidence, it appears that, at most, employers may need to upgrade existing ventilation systems. Most probably, however, employers will need to rely only on the less costly, but equally effective alternatives, such as housekeeping, work practices and worker rotation, to achieve compliance. The costs of these controls are relatively small in comparison with engineering controls. The industry has stated that compliance poses no problems, therefore, no economic impact is expected as a result of the implementation of this standard (Ex. 22, p. 280).

12. Diamond Processing

(a) *Uses*

Lead is not used in the cutting, polishing or setting of diamonds (Ex. 22, p. 282). However, lapidary wheels having lead sheeting impregnated with powered diamonds are used to polish metal and rock surfaces (Ex. 22, p. 282). In 1977, it was estimated that about 100 such lapidary wheels were in use in this country. The record indicates, however, that the use of these wheels is rapidly declining because the soft lead wheels are not as durable as brass or cast iron wheels. (Ex. 22, p. 282)

(b) *Process Description and Exposure Areas*

An object, either metal or stone, is held against the lapidary wheel which turns and polishes the surface. Lead exposure results from the abrasion of the lead-diamond impregnated sheet surrounding the wheel.

(c) *Controls Currently Used*

The principal method presently used to control exposure during this operation is ventilation. A tight hood enclosure with minimum wheel-hood clearance is used to provide dust control at a minimum exhaust volume. Fixed operations may use conventional controls and portable units may require movable exhaust ventilation units. Some operations use no controls. Water may also be used to reduce dust, but does not eliminate the need for ventilation (Ex. 476–4B).

(d) *Exposure Levels*

OSHA is unaware of any available monitoring data (Ex. 22, p. 282). It is expected that little to no lead exposure results from this operation (Ex. 22, p. 282), although data were not furnished by any industry source.

(e) *Population Exposed*

It is believed that approximately 200 persons are exposed as a result of this operation (Ex. 22, p. 282). However, data were not available to indicate how many of these individuals are exposed above or below the 50 $\mu g/m^3$ PEL.

(f) *Additional Controls*

Because of the very limited nature of lead exposures in this industry, controls, other than those currently being used, are not necessary to comply with 50 $\mu g/m^3$.

(g) *Conclusion: Technological Feasibility*

The magnitude of lead exposures in this industry appears to be very slight. Thus, it appears that this industry is already in compliance with the 50 $\mu g/m^3$ limit. The controls needed to achieve the PEL are already being used effectively. In addition, the inadequacies of lead wheels have resulted in substitution of more durable wheels made of cast iron or bronze. These wheels will probably replace all lead lapidary wheels, thus eliminating the potential for lead exposure in excess of the 50 $\mu g/m^3$ standard. Based on these factors, OSHA concludes that compliance with the standard within one year is technologically feasible for this industry.

(h) *Economic Feasibility*

Since better substitutes have virtually replaced the lead lapidary wheel in this industry and, where the wheel remains in use, lead exposures are likely to be below the PEL, no costs of compliance and, thus, no significant economic impact will be incurred, and the standard will have no effect on the national economy.

13. Electroplating

(a) *Uses*

Plated lead is used primarily in battery parts and chemical construction when resistance to the corrosive effects of sulfuric acid is needed (Ex. 476–145). Lead plating is done for the electronics industry also (Ex. 476–150). The National Association of Metal Finishers indicated that electroplated lead is probably used in the electronics industry only for solder plating (lead-tin alloy plated on printed circuit boards) (Ex. 476–149). However, data from TRW indicate that copper wire plated with lead is used in electrical resistors (Ex. 476–148).

(b) *Process Description and Exposure Areas*

Electroplating consists of coating one metal with another metal by means of an electric current. The cathode, which holds the work, is negatively charged. The anode, made of the material to be coated, is positively charged. The anode and cathode are positioned in a solution and the plating is completed by anode material traveling through the solution and depositing on the cathode. (Ex. 476–145)

Many different materials can be plated using the electroplating process; lead and its alloys are among these. Lead is plated from a fluoroborate solution. At the temperatures involved, it is believed that no lead fumes or dusts are generated. Dr. Billings testified that lead exposures result primarily from lead emissions being given off from open-surface tanks during the electroplating process (Tr. 146), but that exposure to lead is insignificant (Ex. 22, p. 305).

(c) *Controls Currently Used*

The primary method of control involves the use of local exhaust ventilation. The *Industrial Ventilation Manual* recommends the use of local exhaust ventilation for this process and provides specific air-flow parameters sufficient to contain exposures in open surface tanks (Ex. 476–147). Dr. Billings also recommended total system enclosure (Tr. 146). Data indicating which controls are used in the electroplating processes were not made available by the industry, however, the industry feels that application of these control technologies as well as good housekeeping should maintain levels below the 50 $\mu g/m^3$ limit. In fact, only very low lead levels are found in the industry and industry representatives believe that airborne lead is not a significant problem (Ex. 22, p. 305).

(d) *Exposure Levels*

The only available data, collected at TRW, indicate that, in plating operations, airborne concentrations to lead were undetectable (Ex. 476–145).

(e) *Additional Controls*

The engineering controls and work practices currently being used by the industry will be sufficient to maintain levels below the 50 $\mu g/m^3$ standard. Additional controls, such as housekeeping and worker rotation, may be necessary, in some instances, to insure that compliance with the standard is achieved in all operations.

(g) *Conclusion: Technological Feasibility*

Very low exposure data and the industry's statement that lead levels are insignificant indicate that this industry is already in compliance with the standard and, thus, it is certainly feasible for this industry to achieve compliance within one year.

(h) *Economic Feasibility*

Because exposure levels are apparently well below 50 $\mu g/m^3$, no costs for compliance are anticipated nor is any economic impact expected. Compliance with the standards is, therefore, economically feasible.

14. Explosives Manufacture

(a) *Uses*

Explosives serve two main purposes. They serve as labor saving devices in dislodging rocks, coal and other minerals (industrial uses) and as destructive devices (military uses).

Explosives may be chemical, physical or nuclear in type. Chemical explosives are the most widely used, and involve use of lead in greater quantities than other types. Chemical explosives use initiating devices to ignite the explosive. Lead azide and lead styphnate are among some of the chemical compounds used for this purpose. These lead compounds are mixed with other materials to form the initiator (blasting cap or detonator). The amount of lead compound used is small.

Some uses of lead have been discontinued. For example, the addition of lead to rocket propellants to increase thrust has been replaced by more effective metals, such as aluminum (Ex. 476–152).

(b) *Process Description and Exposure Areas*

The manufacture of lead explosives involves the handling, mixing, precipitating, and drying of various lead compounds and the storing or packaging of the lead based explosives formed. In the case of lead azide, formation results from the mixing of sodium azide with lead acetate or lead nitrate. Lead styphnate is formed from lead acetate and magnesium styphnate (Ex. 476–TG).

Lead exposure results from the handling and mixing of lead compounds used in the preparation of the explosives themselves. Lead exposure may also result from the repair of lead flooring which is used by this industry when sparking dangers are present. Lead plates used to test blasting caps may also result in lead exposure, but only if the plates are melted, poured and cast by the explosives' manufacturer (Ex. 22, p. 308). Lead exposure does not result from the use of plates as detonating devices. Exposure to lead may also occur in the soldering operations, where lead solder is used to attach wires onto the initiators.

(c) *Controls Currently Used*

The handling and mixing of lead compounds is generally well controlled since dust accumulations generated by mixing explosive chemicals are undesirable (Ex. 22, p. 308). The process is usually automated, and the operator is separated from the mixing operation by a protective barrier (Id.).

A few companies indicated that they have an ongoing repair program for their lead flooring. The defective parts are cut away and new sheets of lead flooring are burned into place (Ex. 476, 151). Most others reported that the floor was replaced every five to ten years. Lead burning operations are used quite extensively to repair or replace lead flooring.

Soldering operations are usually ventilated and automated where possible. (See Soldering-Discussion of Control Technology). Lead floor repairing uses no ventilation controls. Blasting caps are now being detonated in water rather than on lead plates, mostly as a means of controlling noise exposure.

DuPont Chemical commented that the use of mechanical engineering controls such as mechanical ventilation would be an unsafe means of reducing employee exposure to 50 $\mu g/m^3$ of lead during the manufacture of two types of explosive initiators (Ex. 475–35). DuPont argued that the two compounds, lead azide and the complex lead salt of dinitro ortho cresol (lead DNOC), are extremely sensitive to impact and that subjecting them to the friction caused by the moving parts in mechanical ventilation systems could lead to detonation. DuPont also pointed out that insertion of a filter into the system ahead of the moving parts, would permit the accumulation of lead compounds that could detonate either on removal of the filter or on impact of moving particles in the air stream against particles held by the filter. In support of these arguments, DuPont submitted impact sensitivity test data for lead azide and lead DNOC. The data showed that a 0.5 inch diameter, 8.35 gram steel ball must fall from 20 to 26 inches to detonate a 0.013 inch thick layer of lead azide. A similar steel ball must fall 5 to 10 inches to detonate lead DNOC. Based on this data, lead particles of 30 microns in diameter which might enter a ventilation system and impact on a collection filter within the duct would have to impact with a velocity of over 55,000 miles per hour to impart enough energy to detonate a layer of lead azide and a velocity of similar magnitude would be required to detonate a layer of lead DNOC. Thus, the detonation hazard allegedly created by colliding particles in a ventilation duct appears to be highly unlikely.

The detonation hazard associated with filter removal could be minimized by wetting the filter before removal. In fact, wet methods to prevent detonation are employed by DuPont in its sieve room, where the employees entering the room to remove lead azide or DNOC products and reload the sieve is required to wet mop the floor ahead of him. Also consideration could be given to employing wet filtering methods (scrubbers, water curtains, etc.) upstream of the ventilation system's moving parts.

(d) *Exposure Levels*

Exposure data were not available for the manufacturing of lead initiators and the soldering of initiator wires. However, industry representatives indicated that exposure levels were well below the 50 $\mu g/m^3$ level (Ex. 22, p. 308). Representatives of Hercules, Inc., of Wilmington, Delaware, indicated that exposures are low because the lead azide cartridge primer prepared by the company is prepared in gram quantities and the process is kept wet throughout (including during the mixing of other compounds with explosives) (Ex. 476–152).

In lead floor repair, where lead burning may be done, exposure results have indicated lead levels 10 to 20 percent below 200 $\mu g/m^3$ (Ex. 22, p. 308). This would place the industry below the 50 $\mu g/m^3$ PEL. In addition, companies like Atlas Power Co. of Dallas, Texas (Ex. 476–151), have indicated that they only encounter lead exposures twice yearly during the repair of lead floors. Exposure to lead was not considered a problem even in these repair activities because of sophisticated ventilation systems already in place to control nitroglycerine vapors.

In operations using lead plate as a detonating device the lead discs used by Hercules to test low-intensity charges would not be expected to give rise to significant lead exposures since the test explosion deforms, but does not volatilize, the lead (Ex. 476–152). The thickness of the discs are measured before and after the explosion as a quality control check of the uniformity of the explosive charges. For testing ammunition charges, blasting caps, and other high-intensity charges, Hercules uses harder copper discs. Moreover, testing of blasting caps in water, instead of on lead plates, would minimize exposure problems (Ex. 22, p. 308).

(e) *Population Exposed*

Total employment in the explosives industry is estimated to be 30,000, of which 100 employees may be potentially exposed to lead (Ex. 22, p. 309).

It appears that most exposure areas are already in compliance using existing controls. Work practices and housekeeping are invaluable tools for this industry, and in many cases are emphasized due to the extreme explosion hazards. Also many of these lead-bead explosives are made in extremely small quantities (Hercules) and this also tends to minimize exposure hazards.

(f) *Conclusion: Technological Feasibility*

Compliance with the 50 μg/m³ standard has been achieved in the explosives industry through a series of compliance endeavors including the use of ventilation, careful adherence to strict work practices, and good housekeeping practices. The importance of striving for a dust free environment in explosives manufacture, revolves around the fact that poor work practices and sloppy housekeeping might result in an explosion. Because exposures are already below the PEL, compliance is feasible.

(g) *Economic Feasibility*

The explosive industry is made up of five major producers with several small firms. It is estimated that 9 or 10 firms manufacture 90 percent of the explosives produced in the United States (Ex. 22, p. 309).

Since this industry appears to be well below the 50 μg/m³ limit, there will be no cost for compliance with the lead standard, and the standard will have no effect on the national economy.

15. Gasoline Additives

(a) *Summary*

OSHA has interpreted the processes in this industry (in which lead wastes are recycled) as falling under the definition of "secondary lead production" (Ex. 476–7H). Table I of section (e)(1) of the standard gives this industry five years to comply with the 50 μg/m³ PEL. The Agency made this determination because several of the processes that occur at secondary smelters are functionally similar to the recycling processes used in the manufacture of gasoline additives and present the same exposure control problems. Gasoline additive manufacture involves the initial handling of lead sludge, the removal of moisture from the sludge by drying, the smelting of sludge in reverberatory furnaces, the transfer of lead to hold-up pots, the drossing of the lead, the melting and drossing of pig lead additions, and the alloying of lead including weighing, drossing and sodium addition. Since the feasibility of the standard has been upheld for secondary smelting and refining, the similar processes involved in this industry warrant a conclusion of technological and economic feasibility here. Ethyl Corporation's request for this interpretation, together with the absence of objections from any other manufacturers in the industry reinforces this conclusion.

16. Glass Manufacture

(a) *Primary Glass Manufacture*

(i) *Uses.* Glass is manufactured as flat glass, container glass, pressed and blown glass and fiberglass. In subsequent operations, these basic glass types are further processed to form window glass, wire glass, figured rolled glass, plate glass, slash blocks, health glass and special glasses (stained glass and glassware).

(ii) *Process Description and Exposure Areas.* Glass is manufactured by the high temperature conversion of raw materials into a homogeneous melt capable of fabrication into useful articles (Ex. 476–174). The process can be broken down into three subprocesses: raw material handling and mixing, melting and forming and finishing (Ex. 476–174).

Raw materials are received in packages or in bulk and are unloaded by hand, vibrator gravity, drag shovels, or vacuum systems. Raw materials are then weighed and mixed (Ex. 476–174).

Raw materials are delivered to the furnace where they are transformed into glass (Ex. 476–174). Glass is produced in day pots, day tanks, or continuous operating regenerative or recuperative furnaces (Ex. 476–174). Melters are charged either manually or automatically, usually through screw or reciprocating type feeders (Ex. 476–174).

Molten glass at the yellow-orange temperature is drawn quickly from the furnace and worked in forming machines to press, blow in molds, draw, roll or cast. Annealing is done to remove internal stress (Ex. 476–174).

Lead exposure in glass manufacturing can result from the general use of a lead litharge in some melting operations (Ex. 476–195), from the production of leaded glass, or from the production of colored glasses (Ex. 476–5G). Particular process points where lead exposure may occur include materials handling and mixing, charging areas, melting areas (fugitive emissions) and finishing processes (Ex. 476–174).

(iii) *Controls Currently Used.* Controls for materials handling include automated handling of materials by tote bins (Ex. 476–190). Bins may also be mechanized to discharge lead via pinch valves (Ex. 476–190). Buckets may be mechanically interconnected with mixers and automatically dumped, thereby minimizing employee exposure to dusts (Ex. 476–190). Exposures during manual handling can be controlled through the use of exhaust ventilation (Ex. 476–193). Where bags are dumped into barrels and the barrels are fork lifted to mixers, exhaust enclosures have been used successfully to control dust exposures (Ex. 476–193). General batch house controls can include the use of hoods over the weighing hoppers, the top of the mixer, the end of the belt and the whole of the mixer; the use of a vacuum system to maintain clean surfaces; and the use of batch wagons at feeding and dumping points (Ex. 476–189). Batch house operations that result in the highest exposures, such as ingredient weighing, have also required the use of worker rotation to achieve compliance with the 50 μg/m³ standard (Ex. 476–190).

Some companies minimize dust emissions by using an oil-base lead oxide (main constituent of glazing compound) (Ex. 476–193). Others perform the work wet (Ex. 476–195), while still others use pelletized or briquetted lead oxide (Ex. 476–190).

To maximize the effectiveness of dust collection systems, baghouses have been enclosed and exhausted to prevent the dispersal of dust into the workplace.

In melting operations, exposures have been controlled by installing continuous melters with dust collection systems (Ex. 476–193). When continuous melters are not used, exhaust ventilation has been used over day pots or tanks to control exposure (Ex. 476–174).

In finishing operations, such as hand blowing, local exhaust systems have been used (Ex. 476–190). Automated press production areas have also been exhaust ventilated (Ex. 476–190).

(iv) *Exposure Levels.* Exposure data for batch house operations were presented by Lenox Glass, Schott Glass, Fostoria Glass and Nuclear Pacific. Exposures at Lenox, Schott, and Fostoria ranged from 24 to 53 μg/m³, however, all companies reported average levels of 30 μg/m³ (Ex. 475–25; 476–189, 190 and 193). Nuclear Pacific indicated that exposures in its batch operations were in excess of 50 μg/m³ (Ex. 475–41, 476–181). Prior to installing a vacuum system, Fostoria indicated that dust levels ranged from 18 to 73 μg/m³ in this operation (Ex. 476–189).

An OSHA inspection of a glass manufacturing facility found levels of 44 μg/m³ prior to the implementation of engineering controls. After implementation, levels were below 30 μg/m³. Only ventilation was used. Another OSHA inspection of a company making television face plates (WB–1) found that batch attendants were exposed to levels of 740 μg/m³, prior to the implementation of controls, and 30 $\mu g/m^3$ after the implementation of a totally enclosed materials handling system.

Exposures in melting operations were reported to be 6 to 25 $\mu g/m^3$ by Fostoria Glass (Ex. 476–189) and less than 8 $\mu g/m^3$ by Schott Glass (Ex. 476–189). Lenox indicated that the 50 $\mu g/m^3$ PEL was achievable (Ex. 476–193). At Nuclear Pacific, exposures were reported to be in excess of 50 $\mu g/m^3$ (Ex. 475–41, 476–181).

In its glass blowing areas, Fostoria indicated that exposures ranged from 20 to 50 $\mu g/m^3$ for employees involved in the melting process and less than 10 $\mu g/m^3$ in the melting pot areas (Ex. 476–189). Nuclear Pacific reported exposures to be below 50 $\mu g/m^3$ in this area (Ex. 476–181). Lenox indicated that 50 $\mu g/m^3$ is achievable (Ex. 475–25, 475–41, 476–193).

(v) *Population Exposed.* The Short Report estimated that about 1500 glass workers are potentially exposed to lead (Ex. 22, p. 248). Exposure data presented by representative companies indicated that in only one instance were workers exposed to levels in excess of 50 $\mu g/m^3$ (three workers at the Nuclear Pacific Company) (Ex. 475–41, 476–181). No definitive estimate of the number of exposed workers can be made, but it can be reasonably assumed that only a small percentage is exposed to levels in excess of 50 $\mu g/m^3$.

(vi) *Additional Controls.* In most instances, existing engineering controls have proven effective in controlling exposures to lead in glass manufacturing (Ex. 475–25, 475–41, 476–189, 190, 193). Engineering controls and administrative controls (worker rotation) have been used to achieve compliance in even the more difficult areas (Ex. 475–25, 475–41, 476–190–193). Exposure levels are, by and large, below 30 $\mu g/m^3$, although in some operations exposures approach 50 $\mu g/m^3$ (Ex. 476–193). Consequently, controls in addition to those existing and in use by most firms are probably not needed. Improved housekeeping may be helpful in those areas where exposures are near 50 $\mu g/m^3$ (Ex. 476–189).

(b) *Secondary Glass Operations*

Secondary operations include grinding, spinning and polishing of glass to produce final products; the remelting of glass for coloring prior to product formation; and the glazing or painting of finished glass surfaces.

Commercial uses include lamp tubing, iron sealing ware, solder sealing, tungsten sealing electron tubes, radiation shielding, capacitors, and television tubes (Ex. 476–5G).

(i) *Process Description and Exposure Areas.—(a) Grinding and Polishing.* Grinding is done with sand, garnet, carborundum, silicon carbide, boron carbide or diamond (Ex. 476–5G). These materials may be used loose, as is done in plate glass grinding (Ex. 476–5G), or grinding may be done by machine. In general, the same machines used for metal grinding may be used to grind glass (Ex. 476–5G). Polishing is similar to grinding, but the polishing compound is finer (felt pads with rouge (iron oxide)) (Ex. 476–4B). Acid polishing and fire polishing are also done (Ex. 476–5G).

Exposure results from ground up lead glass emitted from the process or from lead fumes emitted during chemical or heat polishing. Mechanical grinding operations are generally performed under water mists to suppress dusts (Ex. 22, p. 271).$\mu g/m^3$

(b) Spinning. Fiberglass is produced by throwing a thread of glass pulled from a heated glass rod over a rapidly revolving drum which draws the glass out into fibers resembling wool or silk (Ex. 476–5G). The potential for lead exposure exists when leaded glass is being spun.

(c) Glazing. Glazing is used to color and to increase the strength, durability and abrasion resistance of glass. A water suspension of the glaze forming ingredients is applied through spraying, dipping or screening (Ex. 476–5G). Exposures occur when lead-based glazes are applied to surfaces.

(d) Staining. The staining process involves ion exchange and migration (Id.). When the potash-lead glass is melted down, the colorant is added. The glass is cooled and then often reheated to produce the correct color (Id.). Lead exposure may result from the melting of lead-based glass.

(e) Painting. Lead paint resembling a crayon is melted at low temperatures and poured over a screen onto the glass and then annealed for several hours in an oven. Exposure results from the use of a lead-based paint.

(f) Soldering. Solder glass is a highly leaded glass that melts easily at low temperatures. It is commonly used to seal the various components of television tubes and comes in paste or powder form. Exposure results from the use of lead solder glass.

(ii) *Controls Currently Used.—(a) Grinding and Polishing.* Water mists are used to suppress dusts generated by this process (Ex. 22, p. 271). Local exhaust ventilation has also been used successfully to contain dusts as well as to capture fumes in chemical or heat polishing operations. A detailed discussion of the appropriate design, ventilation rates, etc. is available in the *Industrial Ventilation Manual* (Ex. 487) and the NIOSH criteria document entitled, "Grinding, Buffing, and Polishing Operations" (Ex. 476–40). Companies have reported no problem with controlling exposures in the operation (Ex. 22, p. 475).

(b) Spinning. Local exhaust ventilation applied to the drawing stage of the operation and the glass pulling operations is often used to control exposures.

(c) Glazing Operations. Data were not furnished which indicated the kinds of controls used in glazing operations. However, glazing of glass can be compared to pottery glazing where automated or manual spraying in booths may be done. (See the section on pottery glazing for more details.)

(d) Staining Operations. Data were also not provided indicating the specific controls needed for staining processes. However exposure results from the melting of potash-lead glass and, thus, the controls needed for any melting operation are applicable here also (see glass manufacture).

(e) Painting Operations. Data were not provided for glass painting. However, local exhaust ventilation may apparently be used in areas where lead crayons are melted and poured over the screens. Proper ventilation can also be used in the annealing process to control lead exposures. Ovens are generally enclosed and exhausted (Ex. 476–355).

(f) Soldering. The same controls needed for any soldering operation (i.e., local exhaust ventilation) must be used here.

(iii) *Exposure Levels.—(a) Grinding/Polishing Operations.* Exposure data were not provided by any industry. However, many industry representatives indicated that lead exposure posed little problem (Ex. 22, p. 271). The plate glass industry had replaced grinding to finish the glass surfaces with a flotation process (Ex. 476–172).

(b) Spinning. There appears to be no data available on lead levels associated with fiberglass production, although there are some data indicating exposure levels for fiberglass particulates (Ex. 476–200). Dr. Konzan, of Owens-Corning, stated that in 13 years with the company he has only known of two occasions in which lead was even mixed with fiberglass (Ex. 476–195).

(c) Other Processes. Exposure data for other processes were not provided.

(iv) *Population Exposed.* There are no data indicating the number of workers who may be exposed to lead in secondary glass operations.

(v) *Additional Controls.* No additional controls are anticipated to be necessary to achieve compliance with the 50 $\mu g/m^3$ level. The use of local exhaust ventilation, improved housekeeping and worker rotation should be sufficient.

(c) *Conclusion: Technological Feasibility (Primary and Secondary Processes)*

Primary and secondary glass operations can achieve the 50 $\mu g/m^3$ PEL. Primary operations will have to make use of engineering controls, to the extent feasible, and supplement them with worker rotation (as the industry is currently doing) to bring areas of high or intermittent peak exposures into compliance with the standard. In addition, improved housekeeping and maintenance operations will be necessary. Compliance with the lead standard will probably also bring about a significant reduction in employee exposure to silica.

Secondary glass operations appear to require minimal controls such as local exhaust ventilation (movable or stationary). Extensive control technology does not appear to be necessary and only in a few instances will worker rotation be necessary.

Representatives of the glass industry emphasized in their submissions that compliance with the 50 $\mu g/m^3$ standard was not possible through engineering controls alone. Based on the evidence submitted, OSHA agrees that the success experienced by this industry in meeting the 50 $\mu g/m^3$ limit has been based on multi-faceted control strategies that include enhancement of existing controls, automation of many processes, stringent work practice programs, improved housekeeping and maintenance and worker rotation. This approach avoids the more costly strategy of relying solely upon engineering controls to achieve compliance. OSHA believes that the use of such balanced controls strategies, rather than reliance upon a single method of control, is perfectly consistent with the lead standard since the Agency's ultimate goal in regulating worker exposure to lead is to reduce workers' exposures through the combined use of engineering controls, work practices, housekeeping, and some worker rotation. The industry did not dispute the feasibility of achieving compliance using this combination of controls.

(d) *Economic Feasibility*

(i) *Costs of Compliance.* Most of the establishments affected by this regulation are currently required to comply with OSHA's standard for silica, and some must also comply with the arsenic standard. Therefore, to the extent that compliance activities simultaneously control other toxic substances, the costs attributable to lead are overstated.

Only three firms submitted cost data to OSHA and none of them documented the derivation of their estimates. Bausch and Lomb estimated that $500,000 would be required to bring its very old optical glass operation into compliance (Ex. 476-171). Owens-Illinois stated that in excess of $1,800,000 has been spent to achieve the 200 $\mu g/m^3$ standards (Ex. 475-195). Nuclear Pacific stated, without supporting data, that it had invested $44,000 in controls for lead (Ex. 475-181).

On the basis of OSHA's assessment of additional controls necessary and the submissions of glass manufacturers, OSHA estimates that costs will range from $10.4 to $26.6 million. Annualized costs, therefore, will range from $1.9 to $4.8 million.

(ii) *Industry Profile.* There are four separate and distinct Standard Industrial Classification codes for glass products. The industries affected by the standard are primarily classified in 3229, Pressed and Blown Glass, Not Elsewhere Classified. While there are a total of 382 establishments employing 38,600 production workers in this SIC, most of these establishments are not engaged in the manufacture of lead-bearing products (Ex. 476-20). Lead-bearing products include radiation shielding glass, television glass parts, optical glass and lead crystal.

Only two domestic firms, Nuclear Pacific and Schott Glass, produce radiation shielding glass. Because of high transportation costs for this specialty product, it is unlikely that the secure market position of these firms would be threatened by foreign products as a result of regulation under the lead standard. In addition, there do not appear to be substitutes for lead in this application, with the possible exception of cadmium (Ex. 476-181). However, cadmium is much more expensive than lead and is also toxic.

Schott Glass, a relatively new facility built in 1969, has invested in control technology and produces several product lines in addition to radiation shielding glass (Ex. 476-190). Nuclear Pacific's radiation shielding glass operation comprises a small part of its business and employs only three workers. Nuclear Pacific reported that OSHA-related expenditures constitute 20 percent of the firm's total machinery and equipment investment, but did not substantiate this claim (Ex. 476-181).

Five firms (RCA, Owens-Illinois, Schott Glass, Lancaster Glass, and Corning Glass) manufacture leaded glass television parts, such as surface plates, funnels and television tube necks (Ex. 476-170). As with other luxury items, the demand for televisions is generally elastic and fluctuates with the general state of the economy. In addition, foreign imports have been a major influence on this market because television sets produced abroad are often perfect substitutes for domestic sets. In fact, Owens-Illinois Television Products Division contends that, as a result of "unrelenting pressure from foreign competition," the industry now has an overcapacity problem (Ex. 475-195). Although a 1977 agreement between the U.S. and Japan limited imports of Japanese color television sets for three years, foreign competition continues to make inroads into the domestic market (Ex. 476-26).

Nevertheless, the effect of the lead standard on the glass parts firms should be relatively small because the economics of the domestic manufacture of these sets will be largely determined by the volume of foreign imports permitted into the country. If domestic production remains viable, the demand for glass parts will be sustained because there are no direct substitutes for these parts, and they comprise only a minor portion of the value of the final product (Ex. 476-174). If foreign competition brings about a sharp decline in the domestic production of television sets, the glass parts firms could probably expand into other product lines with existing plant and equipment because these firms can also manufacture other glasswares.

Three firms produce optical glass in the U.S. They are Schott Glass, Corning Glass, and Bausch and Lomb (Ex. 476-180). Thus, a high degree of concentration exists in the domestic optical glass market. Bausch and Lomb has indicated that allocating resources to comply with the standard in its plant will present a serious dilemma for three reasons: (1) The plant is very old, (2) its output of glass is small, and (3) only seven people are involved in the glass operations (Ex. 476-171). However, the cost estimated by Bausch and Lomb is unsupported. Moreover, given the age of the plant, the firm would increase production efficiency and control lead exposures simultaneously with the advent of new equipment. In addition, there is no evidence to indicate that international competition is occurring, or would occur, in this market as a result of this regulation. Therefore, because there primary uses are considered medical necessities and because the are no suitable substitutes for the product, the demand for optical glass should remain relatively constant with most of the costs of compliance with the OSHA lead standard passed forward to consumers.

Although there are seven domestic producers of crystal (Lenox, Fostoria, Viking, Fenton Art Glass, Rainbow, Pilgrim, and Seneca), Lenox and Fostoria produce the majority of domestic crystal (Ex. 476–170). Lenox submitted a detailed statement on the problems of complying in its china operations, however, no similar material was presented with respect to the manufacture of crystal (Ex. 475–25). Therefore, OSHA assumes that exposure problems in this area are much less severe. Lenox crystal is produced exclusively by hand (Ex. 476–180) whereas Fostoria also uses automatic processes for some of its product lines (Ex. 476–189).

There has always been strong foreign competition in certain quality ranges of the crystal products market. Foreign products may enjoy the advantage of lower labor costs. However, leaded crystal products are valued by the consumer for their quality and craftsmanship. These are luxury items for which many consumers will defer purchase in times of economic uncertainty, but because of the unique aesthetic quality of these products, will generally not substitute lower cost imports, even if they are functionally equivalent.

Both the domestic wool and textile fibergalss markets are highly concentrated, with no prospects for competition from foreign producers (Ex. 476–191). Given the high demand for insulation materials, rising energy costs and the oligopolistic nature of the industry, any cost increases incurred as a result of the lead standard would likely be passed on to consumers. Since specialty orders requesting the addition of lead in these products appear to be extremely infrequent, no significant economic impact is anticipated for this industry.

The record shows that there is little potential for exposure to lead in the production of fiberglass and other insulating materials. Minimal compliance costs may be incurred by companies that intermittently accept special order jobs that might require the addition of lead to their products (Ex. 476–201).

(iii) *Conclusion: Economic Feasibility.* None of the industries or firms within the industries presented financial data to OSHA for consideration. However, the annualized costs of compliance are expected to comprise, at most, 0.8 percent of the total value of shipments ($505.6 million in 1977) (Ex. 476–20). This information and the apparent stability of the lead glass industries lead the Agency to conclude that no major economic impact will occur.

17. Gold, Silver and Platinum Smelting

(a) *Primary Gold Smelting and Refining*

(i) *Uses.* The oldest and the most important commercial use of gold is in jewelry. It is also used in dental devices such as inlays, crowns, bridges and orthodontic appliances (Ex. 476–204). The most important industrial use of gold is in electronic devices, especially printed circuit boards, connectors, keyboard contactors and miniaturized circuitry. Gold containing brazing alloys are also important to the aerospace industry, especially in jet engine assembly. Gold is used as a reflector of infrared radiation in radiant heating and drying devices and heat-insulating windows for large buildings (Id.).

In the United States, 60 percent (Id.) of the domestically produced gold is obtained by recovering natural gold from gold-bearing ores or placer deposits or as a byproduct of lead and copper smelting (Ex. 481 p. 20). The total domestic output of mined gold comes from approximately 225 mines. Three mines accounted for 63 percent, and 25 mines for about 95 percent, of domestic output in 1977 (Ex. 476–204). Eighty-five percent of the gold ore in the U.S. comes from South Dakota, Nevada, Utah, and Arizona. The leading producer, Homestake Mining Company, provides about one-third of domestic output from deep underground mines in South Dakota. The Kennecott Copper Corporation, a major copper producer that produces gold as a by-product of its extensive copper smelting operations, is the second largest gold producer (Id.). The third largest producer, the Carlin Gold Mining Company, has an open pit mine in north-central Nevada. Due to increased gold prices, other mines are now being refurbished (Id.).

(ii) *Process Description and Exposure Areas.—(a) Smelting.* Except for certain alluvial deposits, the first step in recovering gold from ore to is crush it very finely with water in a ball mill to liberate the gold. At the Homestake Mines in Lead, South Dakota, good milling practices have resulted in the recovery of 96 percent of the gold contained in the ore. The remaining gold is removed by amalgamation and cyanidation (Ex. 476–4B).

For some ores (tellurides), a preliminary roasting step may be required prior to amalgamation (Id.). Ores which are to undergo amalgamation are crushed, concentrated, and sorted before the concentrates are passed over mercury-treated (amalgamated) copper plates, to which the gold particles adhere. The discharge from the plates is then extracted with a cyanide solution. Mercury may also be added during the crushing stage to achieve direct amalgamation. The crushed ore may be treated directly with a cyanide solution, thereby making the entire process described above unnecessary.

During cyanidation, the ore is placed in large vats and treated with a dilute solution of sodium cyanide or an equivalent amount of calcium cyanide plus a little lime. Air is bubbled through the mixture to provide oxygen. Cyanide will dissolve any silver present as well as some of the base metals in the ore, further reducing impurities. The cyanide slurry is then filter pressed. This process allows gold to be extracted, without roasting, after fine grinding (Ex. 476–4B). The gold and other metals dissolved by the cyanide are recovered by treatment with zinc dust or, occasionally, with aluminum, that precipitates the gold out of the solution. Frequently, lead acetate is used to assist in the precipitation (Ex. 481).

(*b*) *Refining.* The impure gold recovered from amalgamation or cyanidation is melted under oxidizing conditions to remove most of the copper and the base metals, leaving gold and silver. A cupel, or an open-hearth furnace with a hearth of special construction, furnishes a refractory base of noncontaminating materials to absorb a portion of the fused litharge (a lead solution which is added to the precious metals to formulate the fine metal blends). The litharge is run through a trough and collected for future use. The process requires a blast of air directed at the metals in the hearth while at red heat. The process is complete when the last film of oxide is removed, and the gold flashes out brightly. This process removes all trace metals, including lead (Ex. 476–5G). However, the gold must be further refined to produce a final product.

The gold product can usually be recovered by electrolysis in a chloride solution. In this process, developed by Wohlwill, the gold in the anode is dissolved and deposited in pure form on the cathode. Any remaining silver is converted to chloride, which tends to coat the anode, however, superimposing alternating current on the system will sharply reduce this problem. The resulting cathode deposit should contain 99.95 percent pure gold after melting (Ex. 476–4B).

Electrolytic recovery of gold from impure gold may also be accomplished through the Miller process in which chlorine is bubbled through the molten metal and converts the base metals into volatile chlorides, which then can be poured off and further refined. The remaining gold is less pure and may require additional treatment (Id.).

Lead exposure occurs in the initial stages of material handling such as crushing, grinding and conveying of the ores. Preconditioning of ores which requires pyrometallurgical treatment may also result in exposures. Cyanidation processes are another potential area for lead exposure. In refining operations, exposures can occur during furnace charging when litharge is being added, from the furnaces' fugitive emissions, and from handling litharge for reprocessing. During the electrolytic processes, very little lead exposure should occur because most impurities have been removed. In the casting areas, very little lead exposure occurs; although trace amounts of lead may remain in bars of silver, gold, or platinum, the lead is in alloy form and does not present an exposure hazard (Ex. 22, p. 236).

(iii) *Controls Currently Used.* The ores are mechanically conveyed to the grinding areas and grinding is done at a ball mill with water (Ex. 476–4B). The companies are very careful about dust collection so as not to lose the noble metals (Ex. 22, p. 235). Materials are stored in bins with chutes and are conveyed by screw conveyors. Belt wipes, dead drops, conveyor curtains or skirts and local exhaust ventilation at material transfer points can also be used to control dust. Dust suppression is accomplished by keeping the materials moist and, on many lines, liquid sprays or chemical dust suppressants are added to ores being handled. Vacuuming (preferably wet) minimizes the reentry of settled dusts into the air. In some instances, clean air pulpits are used in automated operations in very dusty handling processes (Ex. 481).

Controls in cyanidation processes may consist of enclosed materials conveying systems, exhaust ventilation of cyanidation tanks and the automated or mechanical addition of chemical precipitators.

Controls used during pyrometallurgical processes consist of maintaining negative pressure in the furnaces and providing ventilation to capture fugitive furnace emissions or enclosure of the source of contamination. In addition, materials handling systems, such as ladles, pots, kettles and launders, are provided with exhaust hooding, as are tapping and skimming pots (Ex. 481).

In refining operations, exposure control involves the application of pressure differentials to furnaces, ventilation to capture fugitive emissions from furnaces, total or partial enclosure of units and the use of materials handling systems with ventilation of tapping and skimming pots. In addition, electrolytic precipitatory processes are ventilated.

The casting areas utilize exhaust ventilation.

(iv) *Exposure Levels.* Exposure data in ore handling operations were provided. One gold processor reported that the percentage of lead present in gold ore was so low as to preclude any problems in meeting the standard (Ex. 22, p. 235). William Wagner, an expert witness on smelting, agreed that the 50 $\mu g/m^3$ limit was achievable in material handling operations (Ex. 481). Data on lead levels resulting for pre-treatment of telluride ores were not available. However, companies stated that lead exposure from this operation presented no problems (Ex. 22, p. 235). Exposure data were also unavailable for lead exposures resulting from cyanidation, although Wagner stated that he was unaware of any data indicating that lead levels exceed 50 $\mu g/m^3$ in this operation (Ex. 481, p. 20).

A NIOSH survey of the Homestake Gold Refinery (Ex. 476–210) indicated that lead exposures can range from 50 to 13,800 $\mu g/m^3$ in gold refinery operations. Wagner stated that exposures ranged from nondetectable to a few hundred $\mu g/m^3$ at plants that he had sampled (Ex. 481). The broad range of exposure levels is due to a lack of engineering controls at some facilities (Ex. 481). No exposure data were submitted by industry representatives.

(v) *Population Exposed.* The exact number of workers exposed to lead in this industry is probably less than 100. Short estimated that 100 workers in silver and gold smelting (both primary and secondary) are exposed to lead (Ex. 22, p. 237). Wagner stated that approximately 2000 workers are engaged in the gold, silver and platinum industries, but that only 200 are exposed to lead (Ex. 481). No data are available which indicate the numbers of workers exposed to lead above and below 50 $\mu g/m^3$.

(vi) *Additional Controls.* Wagner testified that "all areas associated with the processing and refining of gold, silver and platinum could be brought into compliance with the OSHA lead standard by the application of generally available controls" (Ex. 481).

The selection of the appropriate control, or combination of controls will depend on the material handled, the extent of the dust problem, the process involved, and the extent to which engineering controls are already in place.

Mr. Wagner stated that:

> Materials handling problems occur when bins and chutes become plugged, at transfer points, and when dry or hot materials must be conveyed. Standard engineering solutions for all of these problems exist, especially since materials handling is a problem common to many industries, not just the smelting and refining industries (Ex. 481).

Basically, all commenters agreed that, depending upon the particular condition of a plant, different plans for achieving compliance with the 50 $\mu g/m^3$ standard might be necessary (Ex. 481; 475–38; 479; 487). Applying exhaust hoods and fans to capture and contain fugitive emissions at tapping holes, troughs and charging areas and use of worker observation booths may be necessary in cases where exposure levels are extremely high. Where exposures are intermediate, the use of local exhaust ventilation in specified areas in conjunction with an enhanced housekeeping and worker rotation program may be sufficient. Where levels are slightly above 50 $\mu g/m^3$, employee rotation alone may suffice.

The best controls available will not be effective, however, unless they are properly designed, fabricated, installed, and conscientiously operated and maintained. Ventilation hoods and ducts permitted to deteriorate beyond use; conveyor skirtings that are remove or improperly adjusted; inspection doors that have been removed, left open or replaced by screens; and new systems that are simply tacked onto existing ones with little or no thought to proper air flow balancing will counteract any effort to achieve the 50 $\mu g/m^3$ limit (Ex. 481). Ducts that are not attached to the associated hood or that are completely detached from the ventilation system are also insufficient (Ex. 479). The necessity for enhanced maintenance cannot be stressed enough in this particular industy.

(vii) *Conclusion: Technological Feasibility.* Compliance for primary gold production and refining appears feasible through the use of the conventional control techniques discussed by William Wagner (Ex. 481), Melvin First (Ex. 270), and Charles Billings (Ex. 487). Materials handling systems, pyrometallurgical controls and controls for chemical processes all involve either containment of the source of exposure or worker isolation (Ex. 270). In all areas except for gold refining, compliance with the PEL appears to have been achieved. In refining, levels of exposure are high but, as Wagner testified, the plant he observed with the highest exposures had virtually no controls. Therefore, using the controls methods discussed herein, OSHA concludes that compliance with 50 $\mu g/m^3$ is feasible in one year in gold smelting and refining.

(b) *Primary Silver Smelting and Refining*

(i) *Uses.* In 1977, domestic use of silver amounted to 154 million ounces. Major consuming areas were photography, silverware, and electrical equipment (Ex. 476–205). Chemicals are produced from about one-third of the silver.

Refineries normally ship silver in the form of ingots. These go largely to several principal producers or fabricators of semi-manufactured products, such as rolled and extruded bars, rods, wire, sheet, foil and powdered or pelleted silver. These semi-manufactured forms go, in turn, to about 5,000 manufacturers of silver products. New scrap, resulting from the manufacture of finished products, is reprocessed internally or returned to one of a number of refiners for reprocessing (Ex. 476–205).

(ii) *Process Description and Exposure Areas.—(a) Primary Ore Recovery.* Silver is recovered from ores almost entirely by a flotation process that recovers silver from intermediate products of lead, zinc or copper smelting. Silver is carried down with the lead in smelting and separated from it by the Parkes process. This process requires the addition of zinc to the molten silver-lead mixture. The mixture is allowed to cool, and the virtually insoluble silver-zinc alloy separates from the molten lead and rises to the surface, where it is skimmed. This first crust contains much lead, more than 2,000 ounces of silver per ton, and all of the gold in the original bullion. By use of a retort, the zinc is distilled for reuse. The retort residue is cupelled to recover the gold and silver as dore metal, and the lead as litharge (Ex. 476–205).

(b) Refining. Silver found in association with gold from gold-placer or lode-gold mining is recovered in the electrolytic refining of gold bullion and was discussed in the primary gold smelting and refining section.

Crude silver bullion, which usually contains small quantities of gold or other metals and old scrap silver, may be treated at a copper refinery. The electrolytic refining process is commonly used, that consists of an electrolyte of silver nitrate and nitric acid. Fine silver crystals are produced and remelted into commercial bullion bars. Commercial silver is guaranteed to be a minimum of 99 fine and may range from 99.4 to 99.9 fine purity, with copper or gold the usual impurity (Ex. 476–205).

(iii) *Controls Currently Used.* Materials handling control technology for silver smelting is comparable to that used in gold, lead and copper smelting, and generally requires the use of storage and mixing bins; belt, screw or mobile conveyors; pneumatic conveyance; and enclosure and hooding of conveying systems, etc. (Ex. 481). The controls for the electrolytic processes and refining are also comparable to gold smelting and include ventilation of pyrometallurgical equipment and electrolytic processes.

The areas of exposure are essentially the same as in the copper and gold smelting industries, and consist of materials handling, pyrometallurgical processes, and chemical processes (Ex. 481). The Bunker Hill Company stated that the greatest potential for exposure occurred during the handling of silver concentrates when they are transferred to holding bins via an overhead conveyor system, and when carts are used to transfer the concentrates from the bin to the refining furnace (Ex. 475–38B). Specific sources of exposure include spillage of concentrate, dust from shoveling, fuming furnaces and skimming molten metals from furnaces (*Id.*).

(iv) *Exposure Levels.* The Short Report estimated that in gold and silver smelting combined the 100 workers were exposed to low to medium concentrations of lead. Low was defined as 70 percent below 50 $\mu g/m^3$, 20 percent above 50 but below 100 $\mu g/m^3$, and 10 percent above 100 $\mu g/m^3$. In the medium category, the percentages were 40, 30, and 30 respectively (Ex. 22, pp. 239, 124). Lead exposure estimates by the Bunker Hill Company indicate that 20 percent of all employees are exposed below 30 $\mu g/m^3$ and 80 percent are above 50 $\mu g/m^3$ (*Id.*) Exposures were significantly higher than 50 $\mu g/m^3$ in certain of the areas the company labeled as high exposure areas (Ex. 475–38B, p. 2). This inconsistency with the Short estimate suggests that Bunker Hill's levels may be higher and, therefore, are not representative of the rest of the industry.

(v) *Population Exposed.* As stated for the gold smelting and refining industry, the number of workers exposed to lead in silver smelting alone is not known, but is probably below 100. William Wagner estimated that about 200 workers are exposed to lead in the silver, gold and platinum smelting industries combined (Ex. 481).

(vi) *Additional Controls.* Wagner concluded that the application of generally available controls can bring the silver industry into compliance in those areas where compliance has not yet been achieved (Ex. 481). These controls were discussed extensively in the section above. In the case of Bunker Hill, additional efforts may be required, such as upgrading existing dust collection systems. For example, Bunker Hill provided data which indicated that the handling of the concentrate presents the most difficult control situation (Ex. 475–38B). Overhead conveyor systems are used, as are carts, to transfer the concentrate to refining furnaces. A detailed description of the existing technology was not provided, thus, it is not clear whether the conveyance system is totally enclosed, whether long material drops are used, whether protective curtains or barriers can be applied, etc. However, as Wagner stated, materials handling is a problem for most industries and existing, already tested, workable controls are available. Bunker Hill must assess the controls it has in place and determine their effectiveness. The extent to which upgrading or additional controls will be required depends upon the characteristics of the ores being handled, the extent of the dust problem, the exposure levels of the workers (eight-hour time-weighted averages) and the design of existing equipment.

In areas where exposure levels are high, improvements to existing ventilation systems may be necessary and, perhaps, the addition of worker observation booths. Where exposures moderately exceed 50 $\mu g/m^3$, proper ventilation, enhanced housekeeping and worker rotation may be sufficient to achieve compliance. Where levels are only slightly above 50 $\mu g/m^3$, worker rotation may suffice (Ex. 481).

(vii) *Conclusion: Technological Feasibility.* Compliance with the 50 $\mu g/m^3$ PEL within one year appears to be feasible for the silver smelting and refining industry, in most cases, simply by upgrading existing control technologies, using effective work practices and using worker rotation. Since silver smelting is, for the most part, a by-product of primary lead and copper smelting, the controls needed to achieve compliance with a 50 $\mu g/m^3$ PEL in these operations will also control lead exposure during silver recovery processes. In the refining of silver, improvements in the areas of material handling should bring the industry into compliance with the standard.

(c) *Platinum Smelting*

(i) *Uses.* Platinum is used as a catalyst in synthetic organic chemistry, in contacts for relays and switch gears, in resistors and capacitors, electro-chemical electrodes, spacts electrodes, grids for power tubes and radar tubes, fuel cells, thermocouples, retardants, and as an ingredient in corrosion resistant substances, hardening agents, medical or dental uses, jewelry, reflecting ornamental surfaces, and brazing alloys (Ex. 476, 4L). Of the platinum metal refined in the U.S., new metal either as a placer or by-product from gold and copper refining accounts for a very small portion of the production, whereas attainment of the precious metal from recycling accounts for the largest production (Id.).

(ii) *Process Description and Exposure Areas.* There are two principal stages in the isolation of reasonably pure platinum metals from raw materials. One is the extraction of a concentrate of precious metals from a large body of ore. The other is the refining of the precious metals, which involves the separation of the concentrates from each other and, ultimately, their purification (Id.).

In one process most of the platinum metal is separated from the bulk of the copper and nickel during slow cooling of a Bessemer matte. During this cooling, the oxidation of sulfur is regulated and produces small amounts of metallic nickel and copper. The latter serve as collectors of the precious metals from the original ore, and separation of the metallic phase is facilitated because the phase is magnetic. The separated material can be concentrated to an even richer alloy, the electrolytic refining of which yields a rich concentrate in the anodic slimes. Smaller amounts of the precious metals are also recovered during refining of nickel either electrolytically or by the Mond carbonyl process. The separation from placer gold ores is also done electrolytically.

Areas of exposure are similar to those in gold and silver smelting (Ex. 481), exposure can occur at materials handling stages, during pyrometallurgical processes, and possibly during electrolytic precipitation.

(iii) *Controls Currently Used.* The controls necessary to achieve the 50 $\mu g/m^3$ standard in gold, nickel, silver and copper smelting would be the same controls necessary to achieve 50 $\mu g/m^3$ limit for platinum, since platinum is recovered as a by-product of the smelting of gold, lead, silver, copper, and nickel.

(iv) *Exposure Levels.* No data on levels of exposure were presented by any witnesses nor as part of any written submissions. Levels are assumed to be the same as those in gold and silver operations and to depend entirely upon the percent of lead in the ore (Ex. 481).

(v) *Population Exposed.* Approximately two hundred workers are exposed to lead in gold, silver, and platinum smelting combined (Ex. 481). The number potentially exposed in platinum operations alone is not known.

(vi) *Additional Controls.* Controls are not necessary to control lead exposure occurring as a result of platinum recovery, since platinum is recovered exclusively as a by-product of a gold, silver, copper, lead or nickel smelting process.

(vii) *Conclusion: Technological Feasibility.* Since platinum is recovered almost exclusively as a byproduct of the smelting of another ore, the controls needed to achieve 50 $\mu g/m^3$ lead exposure for the recovery of primary ore will also achieve 50 $\mu g/m^3$ in the recovery of platinum.

(d) *Secondary Smelting of Gold, Silver, and Platinum*

(i) *Uses.* The uses of silver, gold and platinum obtained from secondary operations are the same as for metals produced through primary production operations.

(ii) *Process Description and Exposure Areas.*—(*a*) *Sampling of Scrap.* Sampling is done to determine the content of materials so that the correct treatment for extracting the impurities may be selected. There are three major forms in which materials are sampled; (1) Sweep, which are the residues from jewelry and dental laboratories; (2) bullion, which are materials received in pigs or bars; and (3) slimes, which are the dried residues from electro-refining or electrowinning processes (Ex. 475–31).

Materials for sweep sampling are received in 55-gallon drums. The powder is mixed in double cone blenders, repackaged in the drums, the thiefed for sampling. Bullion bars must be melted, prior to processing, for sampling. Kaplan described AMAX as having a bullion room containing with five furnaces, four oil-fired and one electric to melt bars prior to sampling (Ex. 475–31). Sampling of slimes is accomplished by dumping the materials onto the floor and quartering and coning (Id.). The operation has already been enclosed in a separate isolated room, with that room placed under suction to a dust collector, in order to localize the problem (Id.).

(*b*) *Pyrometallurgical, Wet Chemistry, or Electrowinning Processes.* Following sampling, materials are fed either to the Dore furnace for pyrometallurgical treatment, or to the wet chemistry and electrowinning sections of the precious metals process (Id.).

The dore furnace is a special type of reverberatory furnace (Id.). Pyrometallurgical treatment is comparable to treatment performed in primary operations and basically involves the melting of the materials, separation, and skimming or raking. Chemical separation is also done quite often, of pyrometallurgical separation.

Sweeps and related materials containing nonmetallic particles can be treated by adding the appropriate flux to produce a low-melting slag. Litharge (PbO) should be present in the mixture and some of this is reduced to produce metallic lead, which dissolves the fine precious-metal particles. The resulting noble metal-lead alloy, which should contain a reasonable amount of silver, is oxidized in a later step to produce litharge, which is poured off, and the residual dore is treated electrolytically (Ex. 476–5G).

(*c*) *Refining.* A number of special problems arise in the treatment of precious metal wastes of various types, such as "sweeps" and in treating scrap containing copper, nickel, zinc, and possibly some iron, tin, and lead, plus gold and silver. Dilution of the zinc can be fumed off as zinc oxide, and iron, lead, and some of the tin may be slagged off. The precious metals remain with the copper and most of the nickel. This product can be made at the anode in a sulfate solution and most of the copper and nickel removed, the precious metals remaining as an anode slime or mud, which is further recovered through electrolysis (Id.).

In refining precious metal scrap and some concentrates, the gold is converted to its chloride by treatment with aqua regia. After heating to remove nitrogen oxide, gold is precipitated from this solution by reduction with sulfur dioxide or ferrous sulfate. Any platinum metals can be recovered from this solution after the complete precipitation of the gold. (Id.)

Silver also can be removed from dore metal by treatment with hot sulfuric acid. The gold remains undissolved but is lower in purity than that resulting from most other processes. (Id.)

Dore containing moderate amounts of gold can be treated by electrolysis in a nitrate solution. The gold does not dissovle but is retained in canvas anode bags. The silver deposits are very pure. (Id.)

Exposures may occur in sampling operations, in the dore furnace areas, and in chemical processing and electrostatic precipitation processes.

(iii) *Exposure Levels.* Typical exposure levels are not known, but Short's statement that "companies anticipate no difficulties or costs involved with compliance with the proposed standard" (Ex. 22, p. 235) indicates exposure level must be below 100 $\mu g/m^3$ as a general matter. At one site for which exposre levels were obtained, exposure in sweep sampling range from 15 to 5290 $\mu g/m^3$ (Ex. 475–

31). Typically, four workers are involved per shift. No information was given which indicated if these were personal samples or area samples, or if they were peak exposures or 8-hour time-weighted averages. The bullion furnace operations create exposures ranging from 17 to 530 $\mu g/m^3$ (Id.) These numbers also have not been characterized to determine accurately what environmental conditions are at this site. No exposure data were given concerning lead concentrations in the dore furnace areas.

(iv) *Population Exposed.* The Short Report did not separate the number of employees in primary recovery of gold and silver from secondary recovery (Ex. 22, p. 237), but the number is less than the total amount of 100.

(v) *Additional Controls.* Improvement of existing technology may be necessary for some plants; use of work practices, housekeeping, and worker rotation may also be necessary to achieve compliance with 50 $\mu g/m^3$.

Materials handling operations involving the sampling of sweeps pose some problems as a result of trade customs which dictate the methods and size of shipments (Ex. 475–31). While it may be true that this particular operation may require improved ventilation to recover lost precious metals from the ambient air as a result of these customs, an economic incentive for implementing such improvements is created by rising prices for precious metals (Ex. 22). Of course, one should also consider that the recovery of these precious metals is economically advantageous to the company (Ex. 481). However, where ventilation cannot be used to reduce levels to 50 $\mu g/m^3$, worker rotation can be used as a supplement to achieve compliance with the intent of the standard, to control worker exposure.

The electric furnace is amenable greater fume control with a lesser air volume than are oil-fired furnances (Ex. 475–31), thus, Kaplan suggests converting to all electric furnaces. This certainly is the most costly alternative; however, less expensive and technologically less drastic changes such, as the use of local exhaust ventilation, containment, etc., as suggested by Wagner, could also be utilized (Ex. 481).

Current trade practice dictates that only one method of slime sampling is acceptable, and Kaplan testitied that this is the method AMAX uses and that no further mechanization is possible under present circumstances (Ex. 475–31). In this case, stringent adherence to work practices, effective maintenance and housekeeping plans and worker rotation should be sufficient to reduce levels to 50 $\mu g/m^3$.

Improved ventilation of the dore furnaces may also be necessary. In Kaplan's example, improved ventilation was applied to prevent strong air currents from disrupting the air flow of exhaust hoods and to prevent contaminated air from being carried to other portions of the precious metals department. (Id.)

The importance of plant maintenance cannot be overstated. Repairing floors, leaking pipes, etc., can reduce or eliminate exposures in many instances. One example presented by Mr. Kaplan involved lead exposure in a leach room which resulted from lead emissions from the dore furnace area. It appeared that the leach room was located above and generally downwind of the dore furnace room, and the lead concentrations in the leach room were due to contaminated air rising from the dore furnaces. Kaplan felt that repairing the leach room floor, keeping the stairway opening closed, and installing a make-up air system to pressurize the room slightly would resolve this problem. (Id.)

(vi) *Conclusion: Technological Feasibility.* The most difficult areas to control appear to be in the materials handling processes. As Bill Wagner testified, the materials handling problems are common to many industries, and standard engineering controls do exist to reduce exposures in these areas (Ex. 481).

Controls for pyrometallurgical processes are also available and used extensively in primary operations and include hooding of tapping and skimming ports, ladles, pots, kettles, launders, etc. (Ex. 481) and are also applicable to secondary processes.

Even though there may be areas for which engineering controls *alone* may not be able to reduce exposures below 50 $\mu g/m^3$ (i.e., sweep sampling and slime sampling), effective work practices, worker rotation, and housekeeping can be used to control exposures to the 50 $\mu g/m^3$ level. The industry is, therefore, capable of compliance within one year.

(e) *Gold, Silver, and Platinum as By-Products of Lead or Copper Smelting Operations*

(i) *Uses.* The uses of these precious metals are the same as those discussed in the primary smelting of gold, silver, or platinum ores.

(ii) *Process Description and Exposure Areas.* The precious metal may also be recovered from the smelting of base metals such as lead and copper by the cupellation method. Subsequent processing to remove precious metals may involve chemical treatment to precipitate one or more precious metals or an electrolytic method.

The electrolytic method is the preferred means of separating precious metals from base metals in the U.S. One process uses anodes of dore silver, with the cathode being a movable silver belt with a light coating of oil. The belt moves in a trough of redwood coated with acid-resisting paint. The bath is silver nitrate, kept slightly acidic with nitric acid. The belt moves under the cathode, is brushed off automatically at the turn, and delivers silver powder. The anode is hung in a fabric basket in which the gold slime deposits. The slimes are collected, washed with sulfuric acid, and melted to recover gold metal (Ex. 476–4B).

The composition of the anode and cathode determines which precious metals will be precipitated electrolytically.

When precious metals are recovered as a by-product of the primary smelting of a lead or copper ore, the greatest exposure to lead occurs in the initial stages of the base metal processing. The feasibility of the standard in these operations has been established. The final electrolytic processing to remove the precious metals involves very little lead exposure.

(iii) *Controls Currently Used.* The technology necessary to achieve compliance with a 50 $\mu g/m^3$ standard in primary lead smelting and copper smelting will suffice to control lead exposure in the recovery of by-products such as gold, silver and platinum, since the lead in all cases is separated from the precious metals prior to electrolytic treatment.

(iv) *Exposure Levels.* Exposure levels during primary lead refining were discussed in the initial preamble (43 FR 54481–82). Exposure levels during primary copper smelting and refining is discussed in the primary copper smelting section. Data on lead exposure in electrolytic processes were not available.

(v) *Population Exposed.* Data were not provided indicating the populations exposed to lead as a result of the recovery of precious metals as a by-product. However, one can assume that the same population exposed in primary lead and copper smelting would also be potentially exposed in these refining processes.

(vi) *Conclusion: Technological Feasibility.* Since gold, silver, and platinum are recovered electrolytically as by-products of primary lead and copper smelting operations, the controls necessary to achieve compliance in primary operations would suffice to control by-product emissions.

(f) *Economic Feasibility: Precious Metals*

(i) *Cost of Compliance (Gold and Silver).* Industry submitted no cost data relevant to the recovery of precious metals as by-products from zinc and copper smelting. Although both ASARCO and Bunker Hill presented comments that referred to precious metal recovery, they submitted no data on controlling lead exposures in these areas (Ex. 475–28 and Ex. 475–38).

OSHA estimates that the cost of compliance in these areas will be between $500,000 and $1,500,000 (Ex. 481). These estimates were entered into the record and presented during the hearings. At no time did industry submit any data which would counter this estimate.

(ii) *Industry Profile.—(a) Gold.* In 1977, production of domestic gold was 1,100,000 troy ounces. Total value of shipments was $163,197,000 (Ex. 476–206). About 60 percent of gold is obtained from predominantly gold ores, while the balance (40 percent) is a coproduct primarily of copper and partly of other base metal productions. Of this base metal production, seven percent of the total gold mined involved lead ores (Ex. 476–206).

Three major smelting and refining companies produce 65 percent of domestic primary gold. These companies are Homestake Mining Co., Kennecott Copper Corporation, and Carlin Gold Mining Corporation. Three individual mines produce 63 percent of domestic primary gold.

Major uses of gold include jewelry and arts, dental supplies, industrial uses and investment. In 1977, 55 percent of U.S. demand for gold was for jewelry and arts, 15 percent for dental supplies, 25 percent for industrial uses and 5 percent for investment. There are no major individual demanders for gold in the U.S. With respect to the elasticity of these demands for gold, the demand for gold in jewelry and arts and in dental supplies is inelastic. There are very few acceptable substitutes for gold in these industries. However, with respect to industrial demand for gold, this appears to be much more elastic. As evidence, the industrial demand for gold in troy ounces fell by one-half between 1975 and 1977. Taking the place of the industrial demand for gold has been the investment demand for gold.

Traditionally, gold has been considered to be a hedge against inflation because of its limited supply and its resistance to tarnish and corrosion. Expectations of inflation lead to this increase in the demand for gold and this component of demand becomes a larger and larger component over time as inflation remains unabated. Thus, minor cost increases in the production of gold are not likely to have a significant impact upon the gold market.

As relatively little gold is produced as a by-product of other metal refining and, as 92 percent of that by-product gold is currently recovered, other metals markets will have little impact upon total gold production. Recent gold price fluctuations simply illustrate the volatile nature of investor expectations and their impact upon the price of gold. These price increases have also shown that the secondary gold supply is extremely responsive to prices.

(*b*) *Silver.* In 1977, five primary and 17 secondary producers in SICs 3339535, 3341531, and 3341571 produced 111,623,000 troy ounces of silver and silver-based alloys. Total value of shipments was $388,300,000 (Ex. 476–20). Nearly one-third of silver is obtained from predominantly silver ores, while the balance is produced as a coproduct of copper, lead, zinc, and other mineral production. Nineteen of 25 mines from which silver was obtained were copper, lead, lead-zinc, and copper-lead-zinc-gold mines (Ex. 476–205).

Four major smelting and refining companies produce the bulk of domestic primary silver. They are ASARCO, the largest, and Bunker Hill, Kennecott, and U.S. Metals Refining Company (a division of AMAX). Three silver processing and fabricating firms consume nearly two-thirds of all domestic unmanufactured silver. They are Eastman-Kodak, Handy and Harman, and Engelhard Minerals and Chemicals (Id.).

Major uses of silver include photography, silverware, and electrical and electronic equipment. In photography, demand for silver is relatively inelastic since there are no suitable substitutes. The relatively low value of silver content in electronics applications in comparison to the high unit value of the end product, leads to an inelastic demand for silver in this use as well (Id.). Thus, price increases are not expected to adversely affect the firms in this industry.

However, since production is dependent on other metals, silver output also responds to economic factors other than the price of silver. Recent silver price fluctuations have been attributed more to speculation than to the gap between supply and demand (Id.). Future increases in market price will probably result in an increase in the supply of secondary silver.

(iii) *Conclusion: Economic Feasibility.—(a) Gold.* Over the past few years, the price of gold has risen dramatically. Mines that were previously closed because it was not economically profitable to work them have been reopened. Because of the relatively low compliance costs that gold producers may incur and the high rates of profitability in the industry, OSHA concludes that the standard will clearly not be financially burdensome in this industry.

(*b*) *Silver.* There has been a pronounced increase in the profitability of producing silver and other precious metals in the past few years. Given the relatively small compliance costs in this industry, OSHA concludes that the standard will not be financially burdensome to the silver producers and will not have an adverse effect on the economy as a whole.

(*c*) *Platinum.* There are no additional costs attributable to platinum smelting beyond those required to achieve compliance in the smelting of the primary ore.

18. Jewelry Manufacture

(a) *Uses*

Jewelry manufacture does not use lead in the actual production of pieces of jewelry, but lead solder is used in the laminating of two metals or in construction of items such as service emblems. The technological discussion relates to the soldering of jewelry.

(b) *Process Description and Exposure Areas*

Manual jewelry soldering is a typical soldering operation. Workers may solder at "bench type" operations where a soldering iron is used to mèlt solder to individual work pieces.

One large costume jewelry company reported that most costume jewelry soldering is done in furnaces (Ex. 22, p. 287). In one company having 500 employees, a total of one pound or less of lead solder is used per year (Id.).

(c) *Controls Currently Used*

One industry contact felt that 50 percent of the companies have well ventilated facilities at present (Id.). Local exhaust ventilation (see discussion in soldering section) and housekeeping can be relied upon to maintain levels below 50 $\mu g/m^3$ (Id.). Where furnaces are used to melt solder, proper ventilation, consisting of fugitive emission capture hoodings, is used.

(d) *Exposure Levels*

Data were not furnished by jewelry manufacturers. However, in comparable soldering operations (Ex. 476–404), breathing zone samples were less than 3 $\mu g/m^3$. One operation surveyed had mostly nondetectable levels, except for one which was .018 μg/m³ (Ex. 476–400). All levels in manual soldering were less than the 30 μg/m³ action level (Id.).

(e) *Population Exposed*

Data indicating the number of workers exposed to lead in jewelry manufacturing were not available.

(f) *Additional Controls*

None are needed other than those already being used.

(g) *Conclusion: Technological Feasibility*

One company stated that if there was any lead exposure, its insurance company would know about it and would have made recommendations for corrections (Ex. 22, p. 287). A trade association representative stated that lead use in jewelry soldering has been studied at length by State and local officials, and that lead exposure was not found to be a problem (Id.).

Based on the data from comparable soldering operations, it would appear that companies in this industry are correct in stating that lead exposure poses no feasibility problem. Levels are less than 30 μg/m³, which signifies that compliance with the standard is currently being achieved (Id.).

(h) *Economic Feasibility*

Since existing control technology will be sufficient to keep levels below 50 μg/m³, there will be no compliance costs nor economic impact as a result of this standard.

19. Lamp Manufacturing

(a) *Uses*

Lead is used in the manufacture of incandescent lamps, either in the remelting of leaded glass to form specific parts or in the soldering together of parts (Ex. 22, p. 312).

(b) *Process Description and Exposure Areas*

Operations have been described quite differently at various locations. At the Quoizel Plant, glass patterns are set, copper foil is wrapped around the edges of the glass and lead flux is poured around the glass to glass interface (Ex. 476–215). At the General Electric lamp making facility, lead compounds are used primarily in the application of solder, in some lamp types, to seal the wires to the metal bases, and in lead glass, in flares at the base of lime glass bulbs (Ex. 476–214). While the specific manufacture of a product is variable, the exposure to lead results from either the reworking of a lead glass or a soldering process.

(c) *Controls Currently Used*

The basic controls include the use of local exhaust ventilation at points of exposure, such as melting, pouring and soldering areas.

(d) *Exposure Levels*

Exposure monitoring performed at the Quoizel Plant indicates no exposure to lead (Ex. 476–215). General Electric also has indicated that air levels are below 50 μg/m³ (Ex. 476–214).

The three major lamp producers suggested that compliance with the 50 μg/m³ PEL was achievable (Ex. 22, p. 312). General Electric also indicated that the 50 μg/m³ limit had been achieved in soldering processes (Ex. 476–214).

(e) *Additional Controls*

No additional ventilation controls are needed. In fact local exhaust ventilation was not being used by the Quoizel Company and compliance was being achieved (Ex. 476–215). Soldering processes are already well ventilated and automated (Ex. 22, p. 312). It appears that existing technology, when coupled with good housekeeping, will enable these companies to remain in compliance with the 50 μg/m³ standard.

(f) *Conclusion: Technological Feasibility*

Indications are that compliance has been achieved in the manufacture of lamps either through the use of engineering controls or by housekeeping and worker rotation. Companies have indicated that the 50 μg/m³ PEL is achievable and, where monitoring data were compiled, levels were shown to be below 50 μg/m³ and, in fact, they were nondetectable (Ex. 476–215).

(g) *Economic Feasibility*

Since compliance with the standard apparently has been achieved, there are no estimated costs for compliance, nor is any economic impact anticipated.

20. Lead Burning, Brazing, Welding and Surface Preparation

(a) *Uses.*—(i) *Burning, Brazing, and Welding.* Welding is a term applied to various processes that join pieces of metal by heat, pressure, or both (Ex. 476–5G). There are over 80 different types of welding and allied processes in commercial use; those allied processes include brazing and thermal cutting. Welding, brazing, and thermal cutting are widely applied in all industries where metals are used in construction, repair, and manufacture (Ex. 476–39).

Brazing is a process that produces fusion by using a nonferrous filler material having a melting point above 450° C but below that of the base metals. The filler metal is distributed between the closely fitted surfaces of a joint by capillary action. Thermal cutting (commonly referred to as burning) severs or removes metals by using welding heat sources. Thermal cutting processes include gouging, burning, and scarfing.

Recent technological advances have introduced new and more efficient welding and allied processes. The magnitude of these changes is shown by the change in materials used. In 1976, for the first time, stick electrodes constituted less than 60 percent of the electrode market. Ten years earlier, stick electrodes accounted for 75 percent of the filler metal used. The decrease in stick electrode production in 1976 indicated the trend towards automatic and semiautomatic welding methods using a continuous wire instead of rods (Ex. 476–39).

Many of the recently introduced processes are finding only limited application. Electron beam welding has found application in the aerospace and automobile industry; laser welding in automobile manufacture; and plasma arc, an extremely high temperature process, in cutting processes. (Id.)

(ii) *Abrasive Blasting.* This process entails use of an abrasive media such as sand, steel shot, or grit to remove a surface coating prior to painting. The construction industry has been exempt from the lead standard, however, the industry has not been exempt from complying with the provisions in 29 CFR 1926 which regulate abrasive blasting operations. So while some of the exposure data was compiled from abrasive blasting at construction sites, the exposures are comparable to abrasive blasting exposures found elsewhere.

(b) *Process Description and Exposure Areas*

Exposure to lead can occur in a variety of situations where any of these operations are performed and lead sheet or a lead containing product is being used. Specifically lead exposure results when workers must handle and weld, lead sheets and pipes for waterproofing, chemical resistance lining (this use has declined with the increased use of either specialty coatings or plastics, although a recent increase in lead sheeting for lining pollution control ductwork has been reported (Ex. 22, p. 244), non-sparking electrical bonding (i.e., lead floors for explosives manufacturers), when workers perform lead burning or braze leaded materials, or when lead surfaces are cleaned with an abrasive.

(i) *Welding.* Welding processes differ in the way heat is created and applied to the parts being joined. In arc welding, the most frequently used process, heat is created as electricity flows across a gap between the top of the welding electrode and the metal. In gas welding, the heat from burning gas melts the metal. As part of any welding process, filler materials, including welding rods, stick electrodes, or welding wire, are melted and added to the joint to give it greater strength. Lead exposure results from the welding of lead materials (Ex. 476–56).

(ii) *Burning (Cutting).* The fabrication or burning of joints previously formed or shaped is accomplished by utilizing a small torch (oxygen-acetylene), to heat a surface to a red color. Flame size is intentionally kept small, liquefying the smallest possible area. Lead exposure at burning operations results from the melting of the lead and the accompanying emission of fumes from this process (Ex. 22, p. 244).

(iii) *Brazing.* A nonferrous alloy is introduced in the liquid state between the pieces of metal to be formed. Four methods are used to heat the metal, (1) dipping the parts in a bath of molten metal; (2) furnace brazing; (3) torch brazing; or (4) electric brazing (Ex. 476–5G).

Exposures in all cases may occur at stationary places (such as in anode manufacture) or may involve movable sites (such as in the shipbuilding industry), or may simply be part of maintenance activities (such as repairing lead flooring in explosives manufacture) (Ex. 476–5G).

(iv) *Abrasive Blasting.* An abrasive substance is used to clean a surface prior to painting, or to remove dust and scale. This is usually accomplished by using compressed air to propel the abrasive. Exposure results from lead-containing abraded materials.

(c) *Controls Currently Used*

(i) *General Controls.—(a) Welding, Burning, Brazing Operations.* The reduction of fume concentrations within the breathing zone of a welder, brazer, or cutter can be accomplished by using either of two ventilation methods. The fume can be dispersed by diluting fume-laden air with uncontaminated air, or the fume can be captured by a hood collector connected to an exhaust system (Ex. 476–39).

Dilution ventilation can be provided either naturally or mechanically. Natural ventilation relies on wind currents or vertical temperature gradients to move the air. General mechanical ventilation uses fans to exhaust contaminated air and to provide clean make-up air in order to dilute the concentration of contaminants in the workplace air.

The use of local exhaust ventilation has been shown to be a practicable means of controlling the exposure of welders, brazers, and thermal cutters from fumes (which may contain lead) produced in their work. Compared with general ventilation, local exhaust ventilation can control fumes more effectively and is the preferred means of ventilation, provided the exhaust hood can be positioned close enough to the process to capture air contaminants.

In addition to ventilation, another method of lowering total emitted fume is the use of operating procedures that minimize the fume generation rate. The techniques identified in one report (Ex. 476–39) include using lower currents than those recommended by the manufacturer, using larger diameter electrodes, and positioning the electrode for minimum arc length, minimum contact tube-to-work distance, and maximum angle from the work. Slower speeds not only decrease the fume generated per unit of time but also per unit of length, because a lower temperature may be used (Id.).

Enclosure can also be effective in limiting airborne levels of fume. Electron beam welding, brazing, and cutting performed in a partial vacuum exemplify this practice. Dust emissions can be reduced by storing and dispensing powders in closed containers, (e.g., fluxes in submerged arc welding and filler metals in furnace brazing and thermal welding). Substitution of cleaner welding processes such as dip-arc and foil seam welding or the use of redesigned equipment such as the welding torch, can lower fume production. Proper selection of consumable welding electrodes can also lower total fume emission. Because of their widespread use, covered stick electrodes have been tested and reformulated to reduce fume generation. (Id.)

In the welding, brazing, and thermal cutting of metals, control of lead exposures also requires the use of well-designed work practices. Such practices, together with engineering controls, can minimize worker exposures to airborne lead. In open work areas, exposure to lead may be controlled by ventilation, but in confined spaces, the application of safe work practices becomes essential.

However, under some circumstances, respiratory protection may be necessary to adequately protect workers. Concentrations of a lead within a worker's breathing zone may reach an unsafe level because work is being performed in an area too confined to provide adequate ventilation, or because the quantity of emissions is quite high.

(*b*) *Abrasive Blasting.* The NIOSH criteria document entitled "Abrasive Blasting Operations Control Manual", provides a detailed discussion of the controls necessary to protect workers from the hazards of abrasive blasting, including lead hazards. In addition, OSHA's general industry standard for ventilation 29 CFR 1910.94(a) establishes requirements for abrasive blasting operations, some of which include the use of supplied air respirators when using certain abrasives or when blasting under certain conditions. Currently, the operations are controlled by using local exhaust ventilation in confined or enclosed areas in addition to supplied-air respirators.

(ii) *Specific Application of Controls to Work Operations.—(a) Welding/Burning/Brazing.* Lead burning operations are used quite extensively to repair or replace lead flooring. The lead flooring is approximately ⅜ inch thick and thus a relatively small flame is required for the burning of the lead (Ex. 475–37). This results in very few lead fumes being generated and thus low exposure. Lead emissions occur where the torch melts the surface. Local exhaust ventilation at the point of emission is often used to control exposure. Respirators are also used.

Republic Lead is primarily engaged in the manufacture of lead anodes used in the electroplating industry. Each of eight lead burning stations has local exhaust ventilation and the workers wear respirators while burning (Ex. 476–222). After evaluation, NIOSH concluded that Republic's ventilation system should be revamped and recommended the installation of local exhaust for the hook coating and the specialty casting process, stressed the importance of assuring that local exhaust ventilation hoods be maintained close to the point of contaminant generation, suggested that the temperatures of the small lead pots be thermostatically controlled, and recommended improving housekeeping within the plant since it was believed that fugitive dust contributes significantly to air lead levels and employee exposures. Finally, NIOSH noted that in two instances where lead burning hoods were being operated, air movement from an open door created air turbulence sufficient to override the capture velocity of the exhaust system, thus rendering the engineering controls ineffective. (Ex. 476–222).

NIOSH also surveyed Texaco Incorporated's Casper, Wyoming welding facility (Ex. 476–223). NIOSH's measurements and calculations for this plant indicate that the new ventilation systems had (lead burning hoods) adequate capacity, but modifications would increase air flows through the system. These modifications include (1) decreasing the amount of flexible duct since it has a high resistance, (2) keeping bends, in the flexible ducts to a minimum, and (3) using a more conventional type of hood in the place of the present hoods whose slot lengths of 2 to 4 feet are not ideal. Keeping the hoods close to the point of contaminant generation would assist in assuring a minimum capture velocity of 200 fpm, since the capture velocity at the point of contaminant generation decreases with distance from the hood. Lead exposures resulted from: (1) Lead aerosols generated from the lead burning processes, and (2) re-entrainment of lead-containing dusts into the air caused by foot traffic, air currents, fork lift usage.

In one instance, engineering controls at a lead burning operation consisted of large floor fans designed to blow fumes away from employees, but when the fans were mispositioned they blew fumes into other work areas. (Ex. 476–221)

(*b*) *Abrasive Blasting.* A 1975 NIOSH health hazard of demolition and reconstruction activities performed at seven missile silo sites in the Minot, North Dakota, area discovered that sandblast helmets were being used by workers performing sandblast operations (Ex. 476–220).

(d) *Exposure Levels*

(i) *Welding/Burning/Brazing.* One company reported that airborne lead exposure for workers performing lead floor burning is 10 percent to 25 percent of the previous T.L.V. of 200 $\mu g/m^3$ with no local ventilation (Ex. 476–37), thus exposure levels are at or below 50 $\mu g/m^3$ PEL.

Other air samples, both personal and fixed location, were taken to indicate exposures to, and general ambient levels of, lead. The personal air sample results for lead ranged from 60 $\mu g/m^3$ to 1,180 $\mu g/m^3$ with a mean of 300 $\mu g/m^3$. The fixed location samples ranged from 20 $\mu g/m^3$ to 150 $\mu g/m^3$ with a mean value of 100 $\mu g/m^3$.

Specific personal sampling results reflected the following lead exposures: lead burning of hooks to anodes, 60 $\mu g/m^3$ and 1,180 $\mu g/m^3$; lead burning involving coating of hooks, 150 $\mu g/m^3$; grinding and miscellaneous work, 170 $\mu g/m^3$; and plastisol coating and crating, 60 $\mu g/m^3$. Area samples indicated the following lead concentrations: Adjacent to burning station, 20 $\mu g/m^3$; 3 feet from lead casting pot, 150 $\mu g/m^3$ and adjacent to lunch room table, 90 $\mu g/m^3$.

Lead levels were measured in several areas of the plant. In the thermal spraying area, lead levels were reported to be less than 111 $\mu g/m^3$; in the torch brazing shop, described as a 20x20 foot enclosed room with local exhaust, 330 $\mu g/m^3$ of lead were found; and in an unenclosed but locally exhausted torch brazing area, 550 $\mu g/m^3$ of lead were found. (Ex. 476–222)

(ii) *Abrasive Blasting.* Results of data collected at four different missile sites where abrasive blasting was being done were reported by NIOSH. Ten measurements taken at one site ranged from 0.8 to 5,300 $\mu g/m^3$ with a mean of 1,470 $\mu g/m^3$. At a second site, nine measurements ranged from 8 to 620 $\mu g/m^3$ with a mean of 230 $\mu g/m^3$. For a third site, nine samples ranged from 20 to 19,000 $\mu g/m^3$, with a mean of 4,340 $\mu g/m^3$. At the fourth site, two samples indicated lead levels of 210 and 200 $\mu g/m^3$. Respirators were being used.

(e) *Additional Controls*

The controls needed to comply with a 50 $\mu g/m^3$ standard consist of simple straight forward portable or fixed local exhaust ventilation. However, some operations or locations are not amenable to engineering solutions, and respirators may also be necessary. Less reliance on respirators may, however, be accomplished by employers relying upon worker rotation. In fact, OSHA expects that employers will use existing ventilation equipment, maintain this equipment in optimum order, and rotate workers, in an effort to comply with 50 $\mu g/m^3$ in difficult compliance situations.

Fred Mabry of the United Steelworkers described one situation where engineering controls were effectively utilized in reducing lead exposures during lead burning operations (TR 533–525).

Mr. Mabry testified:

> When lead burning is done in a stationary location adequate ventilation can be used. At other times, there are other devices that perhaps could be available. One of those devices could be a welding suction device which is not that expensive; in this case it cost them less than $1,000 each for two complete units, which consisted of two 4-inch suction hoses with a magnetic pick-up head so that it would stick to the iron wherever they needed it. This was sufficient to remove all the welding fume including the lead from all four welding stations completely.

Charles Billings of Johns Hopkins University, also testified on exposure control technology (TR 140–141).

> But there is no reason why control technology that is presently developed cannot be applied to that. The problem here is an infrastructure problem, an implementation problem. For example, there are small, portable control devices which can be applied to any welding application. They simply have to buy it, instruct the welder how to use it, and make sure that the welder does use that. Now, you argue that involves participation on the part of the welder, and I think it does. But for the case where you are welding, and the material that you are welding, you have to move, your control technology has to move with it, and it isn't the same situation as a fixed location might be.

(g) *Conclusion: Technological Feasibility*

Inexpensive ventilation can be employed in most cases to effectively control fumes generated during welding, burning, and brazing operations. In some limited operations or locations engineering controls alone may not be effective in reducing exposures to below the PEL and supplemental respirators will be required.

21. Lead Casting

(a) *Uses*

Lead casting, as discussed in this section, relates to casting of finished special order or routinely manufactured products. The type of casting used to form pigs, ingots or billets by primary or secondary lead smelters and refineries is not covered here, but instead is discussed as part of primary and secondary lead processes.

The American Die Casting Institute states that only a few of its members continue to cast lead, and this is done only upon special customer request (Ex. 22, p. 291). Castings are most often made of aluminum, zinc and magnesium, since those metals are lighter, cheaper and have better mechanical properties than lead. Lead is used when greater corrosion resistance and weight are needed. In fact, lead has generally been replaced by plastics and lighter metals. One establishment reported that lead is cast only as a customer service and is not a money-making proposition. Also, in this instance, lead is cast in a separate facility to prevent contamination of the aluminum and magnesium casting processes. Lead casting is still used, to some extent, in making weights used balancing automobile wheels, in fishing weights and in industrial size expansion shields (Ex. 22, p. 291).

(b) *Process Description and Exposure Areas*

When lead is cast, it is melted to a barely fluid state and poured. One company described its process as having 17 pots, ranging from 1 to 10 tons with a 3–5 ton average, and a gas furnace melting lead for casting. Metal is either hand ladled or pumped into molds. The hardened castings may then require further finishing prior to sale. Exposure results from the melting, pouring, casting and finishing of lead castings (Ex. 22, p. 291).

(c) *Controls Currently Used*

Melting pots are equipped with exhaust ventilation. Material conveying systems may also be hooded and ventilation hoods are often placed over the casts. Of course, any grinding, buffing or polishing would require the use of local exhaust ventilation also (Ex. 476-228).

(d) *Exposure Levels*

The company estimates that 50 $\mu g/m^3$ is usually achieved but occasionally exposures do go above 50 $\mu g/m^3$. Data were not submitted which indicate whether these were personal or area exposures (Ex. 476-228).

(e) *Population Exposed*

No data are available on the number of employees exposed above 50 $\mu g/m^3$, although based on data which indicate that lead specialty casting is being replaced by substitutes, the number is expected to be very low (Ex. 22).

(f) *Additional Controls*

Housekeeping and worker rotation may be necessary to ensure that levels remain below 50 $\mu g/m^3$.

(g) *Conclusion: Technological Feasibility*

Conclusion. The data suggest that levels are presently at or very near 50 $\mu g/m^3$ in this industry, although exposures occasionally exceed 50 $\mu g/m^3$. Existing engineering controls appear to be sufficient for maintaining levels at 50 $\mu g/m^3$, in general, with intermittent exposures being controlled by worker rotation. Housekeeping and maintenance may need upgrading since controlling general exposures to the lowest limits will allow occasional excursions to be accommodated with minimal effort.

(h) *Economic Feasibility*

Compliance costs were not furnished by the industry. However, since compliance is generally being achieved through the use of existing ventilation controls and work practices (except for occasional excursions) any additional compliance costs should be minimal and should be for the less costly controls, such as improved housekeeping or worker rotation.

22. Lead Chemical Manufacture

(a) *Uses*

Lead based chemicals may have many uses some of which are plasticizers, stabilizers, catalysts, oxidants, soaps, and colorants. Some common lead chemicals are: red lead, a rust-inhibitor and a component in positive storage battery blends and in ceramics; lead dioxide, used as a powerful oxidizing agent in the dyeing and chemical industry; lead silicates, used as a stabilizer or inhibitor; lead oxide, which has many uses as an ingredient to form other lead compounds and as a litharge in numerous chemical processes; and the lead soaps, which are used extensively in the polyvinyl chloride (PVC) industry as stabilizers, as driers in paints and varnishes, and in lubricating greases. (Ex. 476-4B).

Lead Stearates and lead 2-ethylhexoate are stabilizers for vinyl and other plastics. Lead stearate is used in the metal powder and molding industries. Other lead soaps include the following:

lead caprate
lead undecylenate
lead laurate
lead myristate
lead palmitate
lead dibasic stearate
lead resinate
lead neodecanoate
lead lignocerate
lead cerolate
lead melissate
lead hydrocarpate
lead chaulmoograte
lead linoleate
lead 2-ethylhexoate
lead tallate [7]

(b) *Process Description and Exposure Areas*

(i) *Lead Pigments (includes lead oxides).* The primary metal, lead, is fed to a smaller melting pot at approximately 900 degrees F. Following an air/stream oxidation and separation process, the oxides of lead are produced (Ex. 476-235). See Pigment section.

(ii) *Lead Soaps.* Lead soaps are produced mainly by *chemical* specialty companies in a batch process in a *partially* closed kettle. The powdered lead litharge is added to the kettle under a slight negative pressure so as to draw the lead dust into the pot. This process takes about 15 minutes, and generally is not performed more than once a day. Precautions are taken to reduce lead litharge dust and the empty shipping bag is sealed in plastic for disposal. Companies monitor employee air-lead exposures by urine and blood sampling.

Only employees involved in dumping and mixing the lead litharge could be generally exposed to inorganic lead. These employees wear respirators and protective equipment (Ex. 22, p. 316).

(c) *Controls Currently Used.*

Most exposures result from handling and mixing lead containing materials. (Id.). As discussed in lead pigment manufacture and plastics manufacture, automated or mechanized materials handling systems, hooding and enclosure of mixing operations, and worker control booths have been used successfully in some plants to control exposures. (See these sections for a complete discussion.)

Cyanamid (Ex. 475-30) submitted data on the compliance activities at their plant. This company manufactures litharge (lead oxide) and from the lead oxide produces other lead chemicals. The process here basically involves acquiring the raw lead, melting, oxygenating and separating out oxide. As a result of several OSHA inspections it was determined that lead levels were in excess of the PEL and after negotiation an abatement plan was devised. This plan would include, many changes, some of which are: Local exhausting of the screening station, dryer, and drossing door; enclosing the screw conveyor feeding the pre-oxidizer; replacement of one mill with an enclosed mill which does not require routine mill screen examination; modifying the drumming station by lengthening the feed chute to reduce dust generation and the hopper by flanging the hood to improve dust collection efficiency; enclosing four dust collector dumping stations; balancing ventilation systems; and improving maintenance by applying new seals; reducing leakage from screw conveyor seals and gaskets, etc.

Blood lead levels prior to 1971 were very high at this plant with 5 employees having levels above 100 ug/100g of blood. Recent levels average at 42 ug/100g. Cyanamid attributes this to stringent management of employee practices (work practices), improved respiratory protection, and engineering modifications.

(d) *Exposure Levels*

(i) *Lead Oxides.* Data was not submitted by the companies indicating the levels to which workers are exposed. OSHA is aware that Cyanamid (cite to 475-2 or 475-30) had levels in excess of 50 $\mu g/m^3$; however, compliance with the abatement plan should reduce levels to below 50 $\mu g/m^3$. On follow-up OSHA found that levels in some part of the process were in compliance with 50 $\mu g/m^3$. (Ex. 476-16).

(ii) *Lead Soaps.* Due to precautions now taken, exposures to inorganic lead are low. (Ex. 22)

(e) *Population Exposed*

(i) *Lead Oxides.* Data on the numbers of workers exposed to lead oxide as a result of its manufacture was not available.

(ii) *Lead Soaps.* In one establishment that produces thousands of specialty chemicals, 12 employees out of 240 production employees are potentially exposed to inorganic lead. (Ex. 22, p. 317). A total of 12 companies are reported to make lead soaps with an estimated total of 240 employees nationwide being potentially exposed to lead. (Ex. 22)

(f) *Additional Controls*

Controls already in place or soon anticipated to be in place are expected to achieve compliance with the 50 $\mu g/m^3$ standard. Clearly, in some cases, enhancement of existing controls will be necessary. In the survey done on the N.L. Industries plant, recommendations were made to improve local exhaust ventilation, isolate and enclose dusty operations, and improve housekeeping. (Ex. 476–309). Cyanamid has an abatement plan which includes many ventilation improvements. In addition, housekeeping and worker rotation will be necessary in difficult to control areas.

(g) *Conclusion: Technological Feasibility*

Although exact exposure levels were not available, the Agency knows that lead exposure may be a problem in this industry due in part to the similarity in processes between this industry and the lead pigment industry. Exposure may be high in some cases, due to the failure on the part of the industry to automate, mechanize, etc. This same failure puts the industry at a competitive disadvantage with regard to more modernized foreign competitors. Compliance is achievable even in the most difficult of situations such as that faced by Cyanamid. Controls exist for materials handling problems, and enclosure of mixing operations has been done successfully by many plastics firms. This industry may, however, need an amount of time for compliance comparable to that given the pigments industry, not because the technology is not available, but because the industry has been laggard in some cases in keeping up with control technology.

23. Lead Pigments Manufacture

(a) *Uses*

Pigments are used as the colorants for linoleum, plastics, paints, rubber, pottery, glass, and other products. They also serve as plastics stabilizers. Pigment products include lead chromate-lead molybdate (molybdate orange), red lead, lead sulfates, lead carbonates, lead silicates, lead oxides, and lead chromates. Lead chromate is by far the most commonly used.

(b) *Process Description and Exposure Areas*

The manufacture of pigments involves a number of different processes. Only pulverizing and grinding processes for reducing the particle size are common to all members in the class. Inorganic pigment manufacture is a combination of chemical-physical processes involving both wet and dry reactions and including precipitation, filtering, washing, fusing, calcining, etc. The processes may be carried out as a batch system, as continuous production, or as a combination of the two.

Pig lead is often the basic raw material in inorganic lead pigment; litharge and other lead forms, however, are sometimes used. Because litharge is a powder, it presents the potential for lead exposures at every transfer point. Filtering, drying, grinding, sizing, grading, blending, and bagging are all considered to be areas of potential exposure to lead. Cross contamination between operations also occurs.

DuPont (Ex. 476–269) manufactures, among others, yellow lead chromate, orange lead chromate (molybdate orange), and "Krolor," a silica-encapsulated lead chromate containing pigment. The pigments are made by both batch and continuous processes. In the initial stages of the batch process for the manufacture of yellow lead chromate, an aqueous sodium chromate solution is reacted with a lead nitrate solution. To make the orange pigment, some of the sodium chromate solution would be replaced by a sodium molybdate solution at this stage. From there, the pigment slurry is dewatered in a filter press, then dried, ground, blended, and packaged.

To make Krolor, bags of dried lead chromate pigment are manually dumped into tanks and slurried in water. This water pigment dispersion is then silica coated in a strike tank. All operations after the silica strike are identical to the molybdate orange batch process.

Manual handling operations of the batch process for all of these pigments involve loading wet presscake from the filter press onto dryer trays, transporting and dumping dryer cars, dumping dried material into grinders or blenders, packing pigment out of the blenders into bags, and dumping dry pigment into dispersion vats for processing Krolor. All of these operations require manual handling of dry pigment and result in exposure to lead.

Contamination between colors and even between shade grades is detrimental to product quality. Consequently equipment is dedicated to specific product groups; there are five separate tank/press units for the "Krolor" operation and three tank/press units for molybdate orange. The equipment is spread over four separate buildings.

Sodium chromate (or sodium chromate/molybdate solution) and lead nitrate are continuously reacted to produce a pigment slurry. The slurry is continuously dewatered and washed in centrifuges, then discharged to a belt dryer. The dried pigment is automatically conveyed to a grinder and the packing system where bags are manually filled.

The unit is operated on a campaign basis with cleanouts between color grades. The campaign cycle consists of the manufacture of zinc chromate, followed by a major cleanout; primrose shade lead chromate cleanout; light shade lead chromate, cleanout; medium shade lead chromate, followed by a major cleanout; and molybdate orange, followed by a major cleanout.

The most significant dust exposure sources in the continuous unit include: packing the finished product into bags; attending the dryer and grinder operations, which requires entering their enclosures; and cleaning operations for the centrifuges, belt dryers, and grinders.

Cleaning operations are performed about once every 2 weeks and take 28 to 48 hours to complete. This operation involves high pressure water cleaning of about 10 process tanks, opening of the continuous belt dryer for vacuuming and washout, opening material transfer equipment including five screw conveyors and bucket elevators for vacuum cleanout, and cleaning of storage bins, product collectors and packing equipment. Each of these cleaning operations presents a lead exposure problem for employees performing the cleaning and introduces airborne lead into surrounding work areas.

(c) Controls Currently Used

DuPont described engineering controls to reduce pigment dust exposures which are presently in place or contemplated for installation (Ex. 475–37).

In the early 1970's, enclosures were installed in the continuous unit at the dryer and grinding equipment locations. Special gaskets and seals were added to the material transfer equipment to reduce dusting. In a typical day, an employee will fill over 500 bags. To pack these products, a pressured, air flow packer is used. The packer is susceptible to dust generation if slight seal problems occur or as the filling air pressure is relieved to take the bag off the packer. In 1977, a simple exhaust hood was installed at the packer. DuPont reports that operator exposure (95 percent value) is 266 to 2,921 $\mu g/m^3$, as an 8-hour TWA. An improved exhaust hooding system was installed at the bag packing station with levels being reduced to 127–182 $\mu g/m^3$. This system included:

—Digital check weigh scale enclosed in a hood with 250 feet per minute face velocity;
—Catch pan and partial enclosure under and around the packer filling spout to catch any spills;
—High velocity exhaust from around the filling spout to control leaks during bag filling and puffs of color when the bag is removed;
—Exhausting all hoods to an existing scrubber system used primarily to service the dryer;

In 1974, DuPont installed a new system to control dust during the unloading of tray dryers into drums during batch processing. Facilities included:

—Separate building area for the unloading operation;
—Two tray dryer dumping stations with exhaust hoods pulling 250 feet per minute face velocity with a hoist system to raise or lower cars so dumping only occurs at waist to shoulder height;
—Monorail system for moving and staging dryer cars;
—Conveyor system for removing full pigment drums;
—Hooding and ventilating (H & V) system for the dump hoods and staging areas;
—Portable vacuum floor scrubber;

DuPont reports the dry room operator's (95 percent value) 8-hour time-weighted average exposure is 1,100 $\mu g/m^3$. DuPont has also indicated that they have in progress work to increase the laminar flow fresh air supply which will provide a slight reduction in dust levels.

In 1975, a completely new inorganic finishing area was constructed for dust control. The new facilities included:

—Three separate grinding lines dedicated to different product groups to reduce cleanout; and
—Two large blending lines with wet packers.

Dust control features included:

—Enclosure of grinding equipment in separate rooms;
—Isolation of equipment where possible;
—Exhaust hoods at all pigment dumping locations;
—Specially developed packers that reduce dust generation and which are equipped with exhaust hoods.
—Tote bin filling and unloading equipment; Tote bins are used in place of drums for interim storage between grinding and blending;
—Separate tote bin storage area;
—Automatic bag dumping machine. (This proved to be unsatisfactory and did not live up to the vendor's claims);
—Central vacuum clean-up system;
—Portable vacuum floor scrubber;
—Central exhaust system and dust collector (36,000 CFM);
—Central H & V system;

With completion of this project, DuPont reports that dust levels were significantly reduced. The 95-percent, 8-hour time-weighted average values for employees assigned to this area were stated to be 428–1,122 $\mu g/m^3$.

New dumping hoods were installed in the "Krolor" manufacturing process in late 1979. The new facilities included:

—Two dumping hoods with very small open areas and 250 feet/minute hood face velocity. One hood is used for yellow, and one hood for orange;
—Unit dust collectors mounted directly over the hoods which can recycle captured dust;
—Side slot inside the hood for transferring empty bags directly into a plastic bag for disposal. Before this, empty bags were placed inside a plastic bag which was kept outside the hood;

Since the installation of the new dumping hoods, 13 8-hour time-weighted average personal breathing zone samples reported by DuPont showed employee exposure when making "Krolor" to range from 1 to 119 $\mu g/m^3$ and to average 26 $\mu g/m^3$.

Engineering controls considered by DuPont to reduce exposure levels in the continuous process include replacement of grinding and packing systems, installation of flash or spray dryers and dust collection H & V systems. For the batch process DuPont is considering installing packing area air-sweep rooms, automating drumming and bag dumping operations, and utilizing ultrasonic, dryer car cleaning, and additional hoods and dust collectors.

With the installation of these controls, DuPont estimates that dust levels in lead chromate pigment manufacture could be consistently (95 percent value) controlled to 200 $\mu g/m^3$ (8-hour TWA) and optimistically as low as 100 $\mu g/m^3$, (8-hour TWA). Additionally, DuPont states that regardless of the extent of engineering controls, the need for respirators during the following operations will always be necessary:

—Equipment cleanout for color grade changes,
—Equipment malfunction repairs such as cleaning jammed mill air lock (1,830 $\mu g/m^3$, 8-hour TWA measured 5/13/80), unjamming mill chute (1,975 $\mu g/m^3$, 8-hour TWA measured 5/12/80), cleaning air ducts (3,882 $\mu g/m^3$, 8-hour TWA measured 9/4/80);
—Equipment servicing requiring work in the blender pit (640 $\mu g/m^3$, 8-hour TWA measured 8/21/80);
—Changing dust collector or product collector bags;
—Mechanical work inside grinding equipment enclosures;
—Unloading tray dryer cars. During this operation, the employee can accidentally drop the tray causing dust or the tray may get stuck in the car and have to be forced out;
—Packing pigment bags can break, usually at the seam, during bag filling.

The project to automate drum and bag dumping to reduce dust levels in the batch finishing area is underway and, according to DuPont, the use of additional technological controls that will give significant reductions at reasonable cost will be undertaken. DuPont did not specify when the additional controls would be available nor did they indicate to what extent "significant reductions" might be achieved.

Information on pigment production at the Harshaw Chemical Company was also provided to the record (Ex. 476–244). The number of employees exposed at the Harshaw plant is small, since the process is not labor intensive. At Harshaw only two or three workers are required at one time at each stage of the process, i.e., precipitation, filtering, spray drying, milling, and packaging.

This company has replaced some equipment in their plant and has eliminated some processes, such as press filtering and tray drying, which were the source of high employee exposures. The process has been modified so that pigment precipitate slurry is now pumped from batch tanks through a continuous filter, then the wet precipitate is conveyed to a spray dryer after which the dry pigment is conveyed to a mill, and then to the bagging operation. Exposures at the bagging operations are reported to be the most difficult to control. Some exposure may also occur at the milling operation. Most Harshaw production line workers are estimated to have 8-hour TWA exposures below 100 $\mu g/m^3$ of lead and some are below 50 $\mu g/m^3$ of lead, according to a Harshaw spokesman. Enclosure and local exhaust ventilation have yielded the best results in lowering exposures.

Changes of production from one color to another at Harshaw were not reported to be a serious source of lead exposure. The company employs separate production lines for dark shades, light shades, etc., of lead chromates and a separate line for molybdate orange. Color changes are made from one shade to a slightly different shade, resulting in the need for less frequent equipment cleaning. Thus it appears that installing separate production lines for different colors and graduating slightly from shade to shade during the runs could reduce equipment breakdown and resulting release of lead into the surrounding work area.

Hercules, Inc., of Wilmington, Delaware, manufactured lead-containing pigments until recently. A company source familiar with Hercules' process when in operation provided the following information on lead chromate pigment manufacture. (Ex. 476–245).

Solubilization of the lead before reaction with a chromate solution was mentioned as a possible source of employee exposure, particularly if pig lead is the raw material used. The lead is melted and poured into a stream of rapidly moving water to "feather" and increase surface area. The feathered lead is partially dissolved in acetic acid, using a series of tanks in which there is a continuous counter current flow of the acid over the lead particles. Lead which does not dissolve in the acetic acid is then dissolved in similar tanks using nitric acid. The employee lead hazard is exposure to the acid mists containing soluble lead acetate or nitrate.

The Hercules spokesman stated that some companies now buy litharge for a raw material and dissolve it in nitric acid, so the process can more readily be enclosed.

Various shades of chrome pigments can be obtained by coprecipitating lead sulfate with lead chromate. A high proportion of lead sulfate gives a light lemon color, while very little lead sulfate gives orange to primrose colors.

The Hercules representative felt that the degree of difficulty and the available technology for controlling lead exposures is about the same for lead chromate pigments and other lead pigments (such as litharge, red lead, lead carbonate, lead sulfate, lead silicate, etc.). All involve handling a dry, fluffy powder with small particle size. Bagging is a problem for all lead pigments. The ultimate control technique in bagging involves automation of the process so that the operator can control it from within an enclosure.

The Hercules pigment facility has been purchased by the Ciba-Geigy Corporation. A company representative for Ciba-Geigy indicated that they were presently in the process of planning and implementing engineering modifications to reduce exposures during the pigment manufacturing process. Though no details were provided by Ciba-Geigy, the company source indicated that they felt they could achieve compliance with a 50 $\mu g/m^3$ exposure limit by March 1, 1984. (Ex. 476–262).

Finally, Kikuchi Color and Chemicals, Paterson, N.J., provided details on their operations. (Ex. 476–264). Kikuchi Color and Chemicals is a subsidiary of a Japanese company of the same name, headquartered in Tokyo. The Paterson, N.J., plant makes a single product, a lead chromate pigment. The color is constant, except for minor adjustments to achieve the desired hue.

Mixing of chemicals to form the lead chromate precipitate is done by a batch process where no significant lead exposures are reported. All other steps are automated and enclosed. These steps include washing, centrifuging, conveying to the oven dryer, conveying to the bagger, and bagging.

The plant is entirely new. It has been in operation for 11 months. The plant employs nine people. Pigment is produced in batch tanks, and pumped to a washer. From the washer, the pigment is pumped as a slurry to the centrifuge. From the centrifuge, a concentrated slurry is pumped to the feed tank for the oven dryer. The dry pigment is conveyed pneumatically to the bagging station. No grinding is required.

The Paterson plant produces a medium chrome yellow pigment. The hue is carefully controlled by sampling the pigment at the washer and analyzing it in the lab. Color adjustment is made as needed by pumping the contents of one batch tank into another batch tank. All blending is done by pumping slurries. No blending is done at the "dry end."

Under the present bagging system, pigment is poured into open top bags, and the bagging operator then sews the top of each bag. The new equipment being sent from Japan in November will allow Kikuchi to convert to valve-type filling. That new equipment will consist of a conveyor line which will carry an empty bag with the top already sewn, to a scale. A filling spout will introduce pigment into the bag through an opening on the side near the top of the bag. Air will be sucked from the bag as pigment enters it. The pigment feeder will be automatically stopped at 50 pounds, and the bagger will remove the filling spout and close the bag manually.

The new ventilation system for the bagging station will be mounted above the bagging station, with the bagging operator external to it. It does not involve any new technology, and according to Kikuchi, similar systems could be easily developed by other companies. The unique features are multiple points for dust pickup and dust control equipment inside the enclosure so that the unit is self-contained.

Even with their present equipment, Kikuchi stated that there is very little dust on the outside of the filled bags and they have had no problem with bags breaking. Thus, warehousing involves little lead exposure.

The New Jersey Department of Labor and Industry inspected the facility and found that the only lead exposure in excess of 50 $\mu g/m^3$ was at the bagger. Eight-hour TWA lead levels included: Bagger operator—66 $\mu g/m^3$; Centrifuge operator—45 $\mu g/m^3$. The two operators sampled spent the entire workday at their respective work stations. Following advice offered by the New Jersey Department of Labor, ventilation was improved at the centrifuge and the bagger. The exhaust system at the centrifuge was modified to vent directly to the outside. The exhaust system at the bagger was upgraded to achieve better capture of the pigment. Kikuchi is hopeful that lead exposure of the bagger operator is now below 50 $\mu g/m^3$ and that lead concentrations at the centrifuge are significantly lower. A vacuum clearner is used at the bagger for spills, and the entire plant is kept as clean as possible and is now being repainted.

In summary, Kikuchi reports that no new technology was required to achieve their present, relatively low air lead levels in the plant and that the key elements to exposure control are good enclosure of processes and good ventilation.

(d) *Exposure Levels*

Exposure levels vary greatly in this industry from highs reported at DuPont's pigment facility in maintenance operations where levels of 1,830, 1,975, 3,882, 640 $\mu g/m^3$ were reported (Ex. 475-37), to a low at Kikuchi Color and Chemicals (Ex. 476–264) at which all levels in the plant were below 50 $\mu g/m^3$. Harshaw (Ex. 476–244) reported levels of most production line workers to be below 100 μg/m³ with some levels being above 50 μg/m³.

(e) *Population Exposed*

The number of production employees in lead pigment manufacturing is estimated to be 2,000. DBA's survey of several plants indicated that 90 percent of the workers were exposed to levels of lead above 100 μg/m³. (Ex. 26, p. 5–93)

(f) *Additional Controls*

DuPont predicted that the additional, conventional controls, exposure could be controlled at least to 200 μg/m³ and possibly to 100 μg/m³. (Ex. 475–37). Kikuchi and Ciba-Geigy suggest that there appear to be controls available to achieve compliance with the 50 μg/m³ standard (Ex. 476–262, 478–2). However, most pigment plants appear to be rather old structures which were originally built with no consideration given to dust control. Subsequent additions of control equipment have required great capital expenditures because of the antiquity of plant design and the difficulty of retrofitting equipment with controls. This lack of modernization is also reflected in the stiff competition experienced by American firms with more modernized foreign competitors.

Even though the technology exists, continual retrofitting of equipment in this industry poses problems and in some cases firms could be required to make major changes.

(g) *Conclusion: Technological Feasibility*

The Court of Appeals rejected OSHA's original conclusion that compliance could be achieved if employers undertook major renovations and redesign of outmoded plants and equipment. It objected not to the notion that OSHA had the authority to require major rebuilding in an industry (if it were economically feasible), but to the lack of "logic and supporting evidence" (Slip opinion, p. 210). The Court cited the absence of descriptions of the technology that could be used and rejected OSHA's reliance on a "casual" statement by DBA and Dr. First's generalizations as central evidence on feasibility (Id.).

OSHA now confirms its earlier conclusion on the feasibility of the standard in this industry, but supplements the conclusion with specific detailed discussion of a pigment plant which has, in fact, used conventional control technology to already achieve compliance with the standard. The Kikuchi plant has applied the basic control principles discussed by Dr. First, Dr. Billings, and others and stands as a concrete example of what can be achieved by other pigment manufacturing firms. The company reported that no new technology was required in achieving these low air lead levels in the plant and that the elements of exposure control are good enclosure of processes and good ventilation. There is no reason why these controls cannot be employed by other pigment manufacturers to achieve the PEL in the time allowed under the standard. As the Court of Appeals stated:

> At the very least, * * * OSHA can impose a standard which only the most technologically advanced plants in an industry have been able to achieve—even if only in some of their operations some of the time * * *. But under this view OSHA can also force industry to develop and diffuse new technology. (Slip opinion, p. 142)

For this industry, it is not a matter of the diffusion of *new* technology, but simply a matter of permitting firms sufficient time to utilize *conventional* technology already demonstrated to be technologically feasible (Kikuchi) or expected to be in four years (Ciba-Geigy). After careful reevaluation of the 5 year period for compliance with the PEL, OSHA has concluded that 5 years is adequate for firms in this industry to make the necessary changes if economic resources permit.

The interim level has, however, been deleted for this industry. Most plants are old and retrofitting may not be effective in many cases. The industry, *as a whole*, is not close to compliance with either the PEL or the interim level in most operations and will require major renovation in plant and equipment to achieve either 100 or 50 μg/m³.

(h) *Costs of Compliance*

One producer of lead chromate pigments, the lead chromate producers' trade association, one producer of lead frit, and one producer of other lead pigments submitted written comments to OSHA on the feasibility of the 50 μg/m³ standard. In addition, OSHA has estimated the compliance costs that may be incurred by producers in this industry.

The Dry Color Manufacturers Association (DCMA) contends that the lead standard will necessitate the expenditure of "very significant amounts of money" with no assurance that compliance can in fact be achieved (Ex. 475–23). However, the DCMA did not provide a more specific estimate of the magnitude of the costs for the industry or for any firms within the industry. Furthermore, details on the types of controls that may be necessary have not been provided.

DuPont states that expenditures of more than $5,000,000 from 1971–1979 have not guaranteed compliance with the lead standard. In the early 1970's, more than $140,000 was invested in controls, enclosures, and hoods. A new system for unloading tray dryers was installed at a total cost of $280,000 in 1974. In 1975, $4,300,000 was invested in a completely new inorganic finishing area. DuPont considers this project a failure, because design control dust levels (not specified in the company's submission) were not achieved. In 1979, $20,000 was invested in new dumping hoods in another part of the plant. Levels in most areas are still significantly greater than the previous 200 μg/m³ lead standard (Ex. 475–37).

DuPont suggests that additional, new controls including another continuous unit at a cost of $3,740,000, air-sweep rooms, automation of dumping, ultrasonic dryer car cleaning, and additional hoods at a cost of $1,505,000, might reduce levels. DuPont estimates the total capital cost of these controls to be $5,245,000 plus $1,300,000 in increased annual operating costs. Thus, capital expenditures on controls since 1971 would total $9,945,000. DuPont estimates optimistically that levels of 100 μg/m³ might be achieved with these controls in place (Ex. 475–37).

The large control costs that have already been expended and that DuPont estimates would still be required include the high costs of building new structures and replacing entire product lines or processes. As demonstrated by the DuPont case, this is certainly a more efficient and cost-effective method of reducing levels than retrofitting old plants and equipment. However, it is probable that an industry with relatively old plants and equipment would incur many of these expenses for modernization even in the absence of the lead standard. Therefore, OSHA regards these figures as overestimates of actual costs of controlling lead exposure, since some replacement of equipment and expansion would be occurring in response to market stimuli other than regulation. In addition, companies are able to deduct expenses incurred in coming into compliance with a regulation as costs of doing business. Therefore, the after-tax financial impact on the firm will be reduced as it deducts costs of coming into compliance.

Harshaw Chemical has reduced lead levels by modifying its processes to limit handling of pigment. The company has separate automated product lines for various colors produced. Harshaw provided neither costs of current controls nor estimates of additional costs of achieving the 50 μg/m³ standard (Ex. 476–263). Similarly, Ciba-Geigy, which acquired two Hercules facilties, is currently planning to install engineering controls in these plants. The company stated that expenditures would be large, but did not provide specific figures (Ex. 476–262). Anticipated controls include continuous equipment, preferably enclosed systems, product packaging modifications and increased local exhaust ventilation (Ex. 478–2).

Kikuchi Chemicals appears to be substantially in compliance now. The company is also planning to install new equipment from the parent company in Japan to reduce lead levels in the bagging area. The company stated that the unit represents a "substantial investment." However, a dollar cost for the unit was not provided (476–264).

The Ferro Corporation manufactures lead frit and has spent about $300,000 to control exposures to lead. A combination of automation, exhaust ventilation, and use of pelletized litharge have contributed to reductions in lead levels (Ex. 476–241). No costs of compliance for additional controls, which may not be necessary, were provided.

Eagle-Picher produces white lead pigments. In its submission, engineering controls such as containment, isolation, ventilation, and bagroom collectors are described as "perhaps available" and expensive (Ex. 475–13). OSHA knows that these methods of control are indeed available and have been successful in controlling dust exposures and does not dispute that controls may be expensive. However, Eagle-Picher's qualitative assessment of burden is difficult to evaluate without a supporting quantitative estimate of the cost of compliance.

Eagle-Picher also does not offer data on the controls currently in place and installed "at great cost over the past five years." This information would be of substantial use in determining the additional costs necessary to continue the reduction in levels that the company currently reports. (Ex. 475–13). Furthermore, the company states that "minor" improvements in levels owing to better ventilation and better housekeeping have yielded commercial benefits by reducing cross-contamination of products and consequently reducing the costs of rectifying contamination problems (Ex. 475–13). To the extent that these cost-savings offset control costs, they should be subtracted from the costs of compliance.

All of the pigment producers mentioned bagging operations as a particularly troublesome and expensive process to control. However, there are substitute forms in which to package and ship pigments, such as slurries and pastes. In addition, dust suppressants could be added to the dry product. This would reduce control problems at bagging operations as well as contamination of other plant areas and exposure potential for downstream users (except spray painters). The adoption of these alternatives would offset to some extent increases in cost of transporting products in wet forms, which are heavier than dry pigment.

DBA estimated the costs of compliance for three pigment producers and derived costs per ton of pigment produced and costs per employee. The estimates were based on retrofit technology in two of the plants and the cost of substantially rebuilding a third plant. Initially, DBA estimated that the upper bound on compliance costs was $109 million. This appears to assume, however, that the firm from which they received data was representative of every other firm and that each firm would rebuild at a cost of $7.1 million. Clearly, there is substantial variation in the degree of current compliance for pigment producers, hence, this upper bound estimate is excessive.

On the basis of the estimated unit cost estimates, DBA then extrapolated the compliance costs to the lead pigment industry as a whole to yield a range of potential compliance costs. The total capital cost of compliance for the pigment industry ranged from $4,451,000 to $43,817,000 using costs per ton as a basis for extrapolation. Using costs per employee, the total capital costs for the entire industry ranged from $15,820,000 to $80,226,000 (Ex. 474–26).

These upper bound estimates overstate the costs of compliance. First, as DBA states, the costs do not reflect the simultaneous reduction of other toxic substances, such as hexavalent chromium. Second, the costs associated with complete rebuilding in an industry already in need of modernization should not be attributed in their entirety to OSHA regulation. Rather, the cost attributable to the lead standard is the difference in expenditures between rebuilding to comply with the standard and rebuilding in the absence of the standard. In addition, economic benefits gained by modernization further offset these compliance costs. Examples of offsetting benefits include increases in product quality, increases in capacity, and increases in labor productivity stemming from reduced absenteeism and lower labor turnover.

OSHA concludes that the costs of compliance in this industry are best represented by an average of the extrapolated costs calculated by DBA. Averaging the costs expected for a large and small firm adjusts the costs to reflect more accurately the variation between large and small producers, and reduces the distortion created by extrapolating on the basis of either extreme. Thus, the estimated capital costs would then range between $21.5 and $41 million. Annualized over the life of the equipment, these costs range between $3.8 and $7.3 million.

(i) *Industry Profile*

There are 71 companies operating 106 establishments and employing 8,000 workers in the manufacture of inorganic pigments (SIC 2816). New capital expenditures for the industry totalled $20,800,000 in 1967 and rose to $124,300,000 in 1977. Average hourly wages of production workers in the industry rose from $3.57 in 1967 to $6.72 in 1977 (Ex. 476–20).

Within the industry, it is estimated that about 15 companies produce pigments or frit that contain lead (Ex. 476–248, Ex. 475–37, and Ex. 478–2). The product lines manufactured by these companies include chrome green (2816311), chrome yellow and orange (2816315), molybdate chrome orange (2816317), red lead (2816341), litharge (2816345), basic carbonate and sulfate white lead (2816213), and leaded zinc oxide (2816225). Quantity of litharge produced has dropped significantly since 1972, while the quantities of lead chromate pigments produced rose very slightly between 1972 and 1977. The value of product shipments of lead chromates doubled in this same period. Total value of shipments of all lead pigments in 1977 exceeded $170,000,000 (Ex. 476–20).

Twelve companies produce lead chromate pigments. They are F.D. Davis, DuPont, Harshaw, Ciba-Geigy, Reichold, National Lead, Chemetron, Bordon Chemical, Kikuchi Chemical, Nichem, Wayne Chemical, and Industrial Color (Ex. 476–250). Lead chromate pigments are considered to possess a versatility superior to all other inorganic pigments. In addition, white lead pigments are dual purpose products that can serve as vinyl stabilizers in the plastics industry. Lead pigments are used in a myriad of formulations destined for numerous end uses including paints, inks, vinyl, rubber, and paper colorants.

There are technical substitutes for the chrome yellows and oranges in most of their uses, but, most of these substitutes are not price competitive and do not offer the combination of properties that make lead chromates so attractive. One exception to this lack of substitutes is the chrome green pigments. Between 1955 and 1965, the rate of production of chrome green pigments was almost halved as a result of two factors. First, mandatory "lead-free" legislation specifying a low lead content in interior paints has excluded chrome green from this market and restricted its use to exterior and industrial applications. Second, its market dominance has been effectively challenged by phthalocyanine green, even though it is more than five times as expensive as chrome green (Ex. 476–249). To avoid disclosure of company operations, current production figures on chrome green have not been published by the Department of Commerce (Ex. 476–20).

The industry has been characterized by a substantial degree of concentration. In 1972, the top four producers of chrome colors and other inorganic pigments manufactured 47 percent of the industry output and the top eight firms produced 64 percent of the industry output (Ex. 474–26). Current estimates indicate that the top four firms manufacture close to 80 percent of the lead chromate pigment industry output (Ex. 475–37), and that the top eight firms produce close to 95 percent of the industry output of lead chromate pigments (Ex. 475–23).

Foreign imports do not appear to be a significant source of competition at this time in the lead chromate market. (Ex. 476–26). In fact, between 1973 and 1977, imports of chrome yellows and oranges have fallen from 9,000,000 pounds to 5,700,000 pounds, and imports of molybdate orange have fallen from 1,100,000 pounds to 500,000 pounds (Ex. 476–409).

No significant export activity for lead chromate pigments exists for U.S. producers (Ex. 478–2), except for DuPont. Since 1977, DuPont's exports have risen from 2,900,000 to 4,000,000 pounds (Ex. 475–37).

Hercules has expressed concern that domestic producers may leave the market because foreign producers can produce the lead pigments products at lower cost. However, neither the foreign producers nor their competitive advantages were identified. Cost advantages for foreign producers may be maintained because transportation costs for dry pigment are not prohibitive in relation to the value of the product (Ex. 476–245). Moreover, the influence of foreign interests is evidenced by the fact that Hercules is now a subsidiary of a foreign-owned (Swiss) corporation, which has plans to revamp the production process in its newly-acquired facility and to achieve compliance with the 50 $\mu g/m^3$ standard by 1984 (Ex. 476–262). Furthermore, a Japanese firm recently built a new facility in this country because raw material costs are rising faster abroad than in the U.S. and foreign exchange rates favor production in the U.S. The company does not import lead chromates into the American market from Japan (Ex. 476–264).

One submission states that the trend in the demand for lead chromate pigments is declining. In 1979, demand was 70 percent of the pre-1974 demand for lead chromate pigments (Ex. 475–37). However, these figures are significantly influenced by demand fluctuations stemming from the general business cycle. Comparison of the demand for these two years is not an accurate indicator of the health of the market. The DCMA argues that there are no cost-effective substitutes for lead pigments and that substitution would require significant production and process changes. Hence, many customers would not be able to afford a switch to other pigments (Ex. 475–23). While there does not appear to be growth in the industry in excess of 2 percent, according to census data (Ex. 476–26), the market is not contracting.

The DCMA also forecasts "massive dislocation which threatens the competitive stability" of the industry and devastating effects including the "complete discontinuance of manufacture" of lead chromate pigments by many firms (Ex. 475–23). Given the degree of market concentration apparent among producers, the standard may indeed have differential impacts on smaller versus larger producers. However, other factors may mitigate the severity of such an effect. First, the pigment industry in general tends to be regionally oriented (Ex. 474–26). Production and distribution are closely tied to regional markets. Therefore, the geographic location of a small firm may be its largest competitive advantage.

Second, large producers have no monopoly on successful control of lead exposure. In fact, the largest producer with the best access to capital has invested in controls which it considers to be, on balance, a disappointing failure. By contrast, other large producers and at least one smaller producer appear to be having more success reducing lead exposures (Ex. 476–244 and Ex. 476–264). Third, because of the batch nature of the processes in most of the older plants, economies of scale do not appear to be significant (Ex. 474–26).

Pigment products are intermediate or industrial inputs into final products. Thus, general economic conditions will be a significant determinant of the demand for pigments. The demand for pigments is derived from the demand for paint, ink, plastics, rubber, and ceramics, demand for all of which is derived in turn from the demand for final durable goods such as construction equipment, farm equipment, trucks, school buses, and automobiles (Ex. 474–26). The market for pigments can be characterized as a bilateral monopoly with a competitive fringe of small sellers and small buyers existing in conjunction with the large sellers and large buyers (Ex. 474–26). The price of pigments, therefore, is set within a range bounded by the cost of production and the value to the user of the pigment. To the extent that the large and small sellers and buyers perceive one another as alternative sources of the product, some downward pressure exists on the prices of lead pigments (Ex. 474–26).

Large producers may pass costs of compliance with the lead standard to consumers with no effect on output (Ex. 474–26), but some contraction may occur in the output of small producers. If the small producers were identical, perfectly competitive and substitute products were unavailable, then each producer would cut output by an equal quantity. However, DBA suggests that it is more likely that there are marginal firms in the industry that will exit the market, thereby reducing total output of some of the small producers. On the basis of evidence gathered to date, however, there is no reason to believe that small producers are necessarily at a competitive disadvantage with large producers. In fact, small producers may be at a competitive advantage over large producers because of geographic location, and the inability of large producers to comply may ultimately lead to less concentration in the industry.

The market for white lead pigments is much smaller than the market for lead chromates. White lead pigments, primarily basic carbonate and sulfate and leaded zinc oxide, are expected to disappear from the market partly as a result of the 1971 Lead-Base Paint Poisoning Prevention Act (42 U.S.C. 4831) but more importantly due to the superiority of water-based titanium dioxide paints for residential and commercial applications (Ex. 474–26). One producer of white pigments, Eagle-Picher, claims that it will be forced out of business by the lead standard. Eagle-Picher is currently operating a plant that was built 105 years ago (Ex. 475–13).

One domestic firm produces pigment grade dibasic lead phosphate and basic lead silica sulfate. One domestic firm produces basic lead silicate and basic lead sulfate. Five domestic producers manufacture basic lead carbonate (Ex. 476–250). One of the five is now a subsidiary of a foreign firm (Ex. 476–247). Sales of this firm and one of the lead chromate companies to European firms indicate the increasing cost and diminishing profits of the facilities (Ex. 476–26), which are usually quite old. On the other hand, takeovers by other producers also forecast a good market for the products.

The market for corrosion-inhibiting lead pigments refers primarily to red lead, a lead oxide. A small quantity of litharge, an input into the production of pigments and red lead, is used directly as a paint additive (Ex. 476–409). In 1972, product shipments were 26,300 short tons of red lead valued at $9,900,000 and 157,200 short tons of litharge valued at $45,000,000. In 1977, product shipments of red lead had declined to 9,300 short tons valued at $7,800,000 and litharge fell to 97,200 short tons valued at $67,300,000 (Ex. 476–20). Imports of red lead rose from 1,200,000 pounds in 1973 to 2,500,000 pounds in 1977 while litharge imports rose from 28,000,000 pounds to 36,000,000 pounds (Ex. 476–409). Exports for red lead and litharge combined fell from 4,500,000 pounds to 3,500,000 pounds between 1973 and 1977, with peaks in 1974 and 1975 of 6,800,000 pounds and 5,200,000 pounds, respectively (Ex. 476–409).

These corrosion-inhibiting lead pigments are used in resistant primers with the largest volumes in industrial maintenance and marine finishes. However, there are nunerous suitable substitutes in these applications. Lead pigments comprise only 20,300,000 out of 861,400,000 pounds (or 2 percent) of corrosion inhibitors used in industrial settings. In marine environments, 40,800,000 pounds of corrosion inhibitors were used, but only 3,000,000 pounds (or 7 percent) were lead-based (Ex. 476–409).

Production of lead frit (SIC 2899, Miscellaneous Chemical Products), colorants used in the ceramics industry may be in a temporarily depressed state with output as much as 40 percent lower than normal (Ex. 476–242). Frit is used in products such as glass bottles, glass-lined vessels and pipes, hot water heaters, household crockery, tile, and piezoelectric products (Ex. 476–241).

The number of producers of leaded frit is now known but it is estimated to be small. Some users may produce their own frit by mixing lead oxide and silicates. One producer stated that it has a plant in Mexico that is not yet capable of producing frit of acceptable quality. However, the entire operation would be shifted to Mexico if quality were not a problem (Ex. 476–241).

(j) *Conclusion: Economic Feasibility*

OSHA recognizes that the pigment industry consists of many firms that operate plant and equipment built more than 50 and even 100 years ago. For these firms, retrofit controls would be expensive and, as demonstrated by the experience of DuPont, may be ineffective in achieving compliance. While OSHA cannot require the construction of new plants, it encourages affected firms to consider this means of compliance, especially in light of the many other benefits of modernization in addition to the benefits of a healthier work force.

Given a compliance period of 5 years, pigment producers would face annualized costs ranging approximately between $3.8 and $7.3 million dollars. The costs are reasonable and feasible in an industry that produces total shipments valued at $170 million per year. Compliance costs range between .025 and .048 percent of total value of shipments. OSHA requested data on profitability of potentially affected firms. However, pigment producers did not submit financial data to the Agency for its consideration.

Market changes may occur as a result of compliance with the standard. First, there may be a slight shift in demand in favor of substitute products. Some downstream users may decide to use a different pigment rather than incur their own compliance costs. Others, responding to changes in relative prices, may switch to substitute pigments. However, given the present wide difference between the prices of lead chromates and substitutes currently characterizing the industry, a significant shift is not likely. Furthermore, lead pigments are not closely rivaled in technical properties by substitute pigments. Therefore, the stability of the market even in the face of an increase in price is enhanced. The relatively inelastic demand for lead pigments will also allow producers to pass forward the increases in costs to consumers in the long-run.

The domestic market for lead chromates is not facing competition from foreign producers. However, a recent increase in imports of litharge could signal the onset of foreign competition in this market. The industry did not raise this as an issue. Therefore, OSHA infers that domestic producers will not be placed at a competitive disadvantage relative to foreign producers as a result of the standard.

OSHA anticipates that the standard will generate changes in market structure. However, the impact of compliance with the standard on the relative market position of small firms and large firms is uncertain. Smaller firms with compliance costs which are large in relation to total costs of production may no longer be able to compete with large firms. But the regional orientation of the pigments market may mitigate to some extent the reduction of a small firm's competitive edge. But more importantly, it appears that small lead chromate producers will not necessarily be at a competitive disadvantage because of the standard. On the contrary, if some small firms are relatively close to compliance now, their costs may be proportionately smaller than a large firm's costs. In fact, if larger producers, which currently dominate the lead chromate market leave the market, then several smaller firms might enter the market thereby reducing industry concentration and enchancing competition.

24. Lead Sheet Metal Manufacture

(a) *Summary*

Lead sheet metal is used in roofing, flashing and sheeting for radiation protection (Ex. 22, p. 144). The manufacture of lead sheet metal is a secondary lead smelting operation (Ex. 22). A discussion of this process and the accompanying exposure areas can be found in the feasibility section of the final lead standard. The feasibility of the standard in secondary smelters has already been established. Slip Op., at 181–97.

The use of lead sheets may also result in exposure in that sheets must be cut, welded, brazed, or burned into place. A discussion of these operations and accompanying exposure problems can be found in the section of this document entitled Lead Burning (Brazing/Welding).

25. Leather Manufacture

(a) *Uses*

Leather is a skin permanently combined with a tanning agent so that its principal fibrous protein is rendered resistant to decay while the fibrous structure and desirable physical properties of the skin are retained.

Leather must be cured, soaked, dehaired, delimed, baited, pickled, tanned, and dyed (post-tanning operation).

Lead chemicals are no longer used in the tanning of leather so exposure to lead only occurs when lead chromate dyes are used.

(b) *Process Description and Exposure Areas*

The only data on the application of lead based dyes to leather indicates that dyes are swabbed on (Ex. 22, p. 207).

(c) *Controls Currently Used*

Local exhaust ventilation may be used in some cases, in operations involving the swabbing of materials onto the finished hides, protective gloves may be used. Further data concerning current use of controls was not available.

(d) *Exposure Levels*

The only data available indicated that solid waste residues could contain as high as 0.3 percent lead (Ex. 22, p. 207). No data was available on ambient levels.

(e) *Population Exposed*

The actual number of exposed employees was not available. Industry contacts indicated that the number exposed is not appreciable (Ex. 22, p. 207).

(f) *Additional Controls*

Since finishes containing lead chromates are swabbed on, no fumes or dust are generated and exposures are low. Moreover, the total elimination of lead-base pigments would have no adverse impact on the industry (Id.).

(g) *Conclusion: Technological Feasibility*

The data indicates that no exposures to lead in excess of the 50 $\mu g/m^3$ level occur in this industry. Where exposures may occur they could be eliminated entirely by eliminating use of lead-based pigments.

(h) *Cost of Compliance*

It appears that potential exposures to lead in the finishing of leather have already been controlled to 50 $\mu g/m^3$. Therefore, there are no costs attributed to this regulatory action and no economic impact is anticipated.

(i) *Industry Profile*

In the past, patent leather workers were on occasion exposed to inorganic lead. However, lead-free urethanes have been substituted for the lead salt driers that caused past exposures. The only current source of exposure to lead in the industry is in the dyeing of leather with lead chromate pigments (Ex. 22, p. 207) however, use of lead chromate based dyes in declining (Ex. 476–278).

Tanneries (SIC 3111–11) employ 14,300 production workers in 315 establishments and contract tanneries employ only 4,500 production workers in 107 establishments. (1977 Census of Manufacturers Industry Services MC77–1–31A). A very small percentage of these workers are in finishing departments and no workers are directly exposed to dry lead-based pigments or to spray mist. Application of finishes occurs in specialized, mechanized operations. (Ex. 476–278)

26. Machining

(a) *Uses*

Machining and milling serve to cut away excess metals from product edges and to finish a surface by the grinding or polishing action of a machine.

(b) *Process Description and Exposure Areas*

The process may be like the one used at Schulmerich Carillons, Inc. where rough cast bronze belts are machined to achieve predetermined pitch (Ex. 476–298) or at Raybestos-Manhattan, Inc. (Ex. 476–299) where sintered metals are machined into gears and clutch plates.

Only machining or milling of lead metals or lead-based alloys poses any lead exposure problem. The points of exposure are at the machines being used.

(c) *Exposure Levels*

Exposure data from Raybestos-Manhattan (Ex. 476–299) indicated that lead exposures were below 35 $\mu g/m^3$. In fact, all sample groups except for one were below 30 $\mu g/m^3$. Exposure data from Schulmerich Carillon Inc. consisting of five samples taken at the machining operations showed no detectable levels of lead. (Ex. 476–298). Samples taken at the Western Gear Corp. were also below the limits of detection (Ex. 476–300).

(d) *Controls Currently Used*

Control technology in each of these establishments consists of local exhaust ventilation over the source exposure points (Ex. 476–299, 300), the use of a water-soluble cutting fluid (Ex. 476–300), and housekeeping (Ex. 476–298, 299, 300). At Raybestos-Manhattan, which had detectable lead levels, it was recommended that the use of compressed air for cleaning be restricted and consideration be given to the use of a vacuum cleaning system in lieu of forced air hoses (Ex. 476–299).

(e) *Additional Controls*

Controls other than those already being used are not needed since compliance is being achieved.

(f) *Conclusion: Technology Feasibility*

Exposure levels are below the 50 $\mu g/m^3$ PEL thus, compliance is being achieved.

(g) *Economic Feasibility*

There will be no cost of compliance nor any economic impact because the industry is well below the 50 $\mu g/m^3$ standard already.

27. Miscellaneous Lead Products

(a) *Uses*

There are many other products that use or contain lead. Only those for which data was submitted to the Agency are discussed here.

Collapsible tubes that are used for glue packaging, often contain lead, as does lead caulking used by plumbers and certain specialty lubricants.

The use of lead in the collapsible tube industry has dropped considerably. One explanation for this is the adoption of aluminum and plastic collapsible tubes. However, this replacement is limited by the compatibility of the product and the container. It is doubtful that lead will be totally replaced by other materials.

(b) *Process Description and Exposure Areas*

(i) *Lead Tubes.* A survey of several companies (Ex. 22, p. 315) indicated that lead tubes are made in much the same way from company to company. Lead is purchased in billets, melted and then poured or rolled into shapes for further processing. When rolled or poured, the end result is a slug (the shape of a coin). It is then impact-extruded into the tube shape. Further processes involve capping one end and possibly lining the tube with a wax or some other type of sealer.

Potential exposure exists during all processes of fabrication. The highest exposure probably exists in the melting area. All sources indicated these processes are ventilated and that lead is brought just to the melting temperature (less than 1,000°F) which decreases the probability of significant lead fumes being created.

(ii) *Petrochemical Industry.* The only data that was available involves the manufacture of specialty lubricants from crude oil. (Ex. 476–305)

Oil is filtered through bauxite to remove impurities, material is conveyed to a multi-stage burner and impurities are burned off.

Lead is the pyrolysis product from the combustion of the impurities from the oil. Air monitoring indicates that all levels are less than 5 $\mu g/m^3$.

(iii) *Lead Caulking Used by Plumbers in Forming Lead and Oakum Joints.* Much of the caulking lead is manufactured as part of secondary lead operations. (Ex. 22, p. 316). This section covers those operations that primarily take large lead ingots and melt them down and cast them into smaller ingots. Melting is accomplished in a large pot (typically, 3,000 pound capacity). Some melting pots are vented, others are not.

(d) *Exposure Levels*

(i) *Lead Tubes.* Although no data is available for any operations making collapsible lead tubes, it is felt that exposure is not excessively high. With ventilation in existence, exposure of employees in the melting areas is estimated to be 50–200 $\mu g/m^3$ (Ex. 22, p. 305).

(ii) *Petrochemical Industry.* Air monitoring indicates that all levels are less than 5 $\mu g/m^3$ (Ex. 476–305).

(iii) *Lead Caulking.* Data was not available indicating exposures in caulking operations.

(e) *Population Exposed*

Using an estimate of 5 percent to 15 percent of total employees as representing those potentially exposed, a range of 250 to 750 potentially exposed employees is derived. Assuming one person per pot and 100 pots, an estimated 100 potentially exposed employees for the small shop manufacturing of lead caulking is obtained. Data on other exposed groups was not available. (Ex. 22, p. 316–317).

(f) *Additional Controls*

Manufacturers and shops fabricating collapsible tubes and lead caulking will probably have to add to or improve their present local ventilation. Improved housekeeping will also be required. Definite compliance methods are difficult to determine without better exposure data and site visits.

(g) *Conclusion: Technological Feasibility*

Very little information was furnished by companies indicating what exposure levels were or what problems exist with achieving the 50 $\mu g/m^3$ PEL. The Short Report was the only source of information which the Agency had to rely on. (Ex. 22, p. 215). Based on the information in this report, it appears that compliance is feasible with improved ventilation and housekeeping. In addition, the companies can rely upon worker rotation to achieve compliance with a 50 $\mu g/m^3$ standard in this industry.

(h) *Economic Feasibility*

The cost of compliance is assumed to be minimal in that inexpensive ventilation controls, housekeeping, and worker rotation will be relied upon to meet the 50 $\mu g/m^3$ PEL.

28. Nickel Smelting

(a) *Uses*

Nickel and nickel alloys are used for the fabrication of equipment to resist corrosion. Nickel is also used chemically to form catalysts. It is also used extensively as a plating medium.

There are only two nickel smelting operations in the United States. One of these, the Hanna Nickel Co. located in Riddle, Oregon operates the only nickel mine in the United States (Ex. 476–212). Trace amounts of lead in ores result in worker exposures.

(b) *Process Description and Exposure Areas*

The first step in processing the ore is to screen and crush it prior to transportation either by tramway or by some other automated method to the smelter (Id.).

Ore is reclaimed from the stockpile by rubber-tired front end loaders and is conveyed to dryers, where the moisture content is reduced. After drying, the ore is conveyed to the screening, crushing, and sampling plant. The ore is properly screened and sent to a storage bin.

From the storage bins, the coarse ore is fed to two natural gas or oil fired rotary calciners, while the fines are fed to two natural gas or diesel fired multiple hearth roasters (Ex. 476–212).

After calcining, the ore discharged from both the calciners and roasters is transported by automatic skips to hot ore bins above four electric melting furnaces in the smelter building (Ex. 476–212).

The ore is charged to the melting furnaces by gravity. Molten ore is poured from the melting furnaces into ladles for the reduction process (Ex. 476–212).

Reduction of nickel and iron is accomplished by the Ugine process, which consists of adding a reducing agent containing metallic silicon to an oxide ore in the presence of molten ferrous metals and using vigorous mixing action for good contact of reductant and ore (Ex. 476–212). After the vigorous mixing cycle, the ferronickel is allowed to settle to the bottom of the ladle. The slag is skimmed off and granulated with high pressure water jets.

As the reducing reactions continue, ferronickel accumulates in the ladle. At regular intervals, a portion of this product is removed, or "thieved," and transported to one of two identical small electric steel furnaces. Here the impurities, predominantly phosphorous, are removed by suitable refining slags, after which the ferronickel is cast into pigs. (Id.).

(c) *Controls Currently Used*

Control of dust emissions from the plant was recognized as a substantial technological problem during the initial design phase prior to 1954 because of the nature of the ore to be handled (Id.). Fabric filters were considered to be the best equipment available, for dust control and were installed on the melting furnaces, crusher house and storage bins ventilations systems. Electrostatic precipitators were installed on the calciner and wet scrubbers were installed on the dryers and furnace. This equipment operated at 98.3 percent efficiency (Id.).

In 1970, new State air quality standards again made it necessary to upgrade the system's efficiency, to 99.8 percent. Large cloth dust filters on the crusher house, ore melting furnaces, and a ferrosilicon furnace, handling a total of 720,000 actual cubic feet of gas per minute, were required. Improvements to existing equipment on the calciners, roasters, dryers, and storage bins were made (Id.). The system was completed in July, 1974, and now meets State air quality standards.

(d) *Exposure Levels*

Exposure data made available from the NIOSH survey of this smelting operation indicate that lead levels are well below the 30 $\mu g/m^3$ action level. In fact, of 81 samples analyzed for lead, the highest exposure was 0.013 $\mu g/m^3$. The company presented no data at the hearings, presumably because compliance with the lead standard poses no problem. There is no reason to suspect that the other nickel smelter has appreciably different environmental conditions.

(e) *Population Exposed*

No workers are believed to be exposed above 30 $\mu g/m^3$.

(f) *Additional Controls*

No additional controls are necessary, since the industry is already in compliance.

(g) *Conclusion: Technological Feasibility*

Levels of exposure are below 30 $\mu g/m^3$ and thus compliance with the 50 $\mu g/m^3$ lead standard is already being achieved.

(h) *Economic Feasibility*

There will be no cost of compliance nor any economic impact as a result of this regulation.

29. Nonferrous Foundries

(a) *Uses*

There are currently 1,620 foundries in the United States which do some casting of brass and bronze. Copper-based alloys are the primary raw materials at approximately 900 of these foundries. Lead is used in this industry in the form of ingots or scrap metals and may vary in amount from less than 1 percent to 20 percent of the brass or bronze casting (Ex. 26, p. 5–73; Ex. 475–33D; Ex. 479).

(b) *Process Description and Exposure Areas*

The processes found in nonferrous foundries are similar to most foundry operations, and consist of coremaking, molding, melting, pouring, shake-out, and cleaning of castings. Cores are produced by chemical reaction or by baking a resin coated mixture. (Ex. 476–331, 337, 339).

The molding process consists of compacting a prepared sand layer around a pattern; the cores are set in position within the opening left by the patterns; the two mold sections are then joined together. (Ex. 476–331, 337, 339).

Lead exposures in the molding area come either from the reuse of sand in which lead has condensed or from cross-contamination from other operations of the plant (Ex. 479; Ex. 22, p. 172). Usually this area is located near the pouring area, so that spills often contribute to the exposures. (Ex. 22, p. 172).

Solid metal is melted in an electrical induction, reverberatory, or gas or oil-fired crucible furnace (Ex. 476–317; Ex. 22, p. 172). When the metal is ready for pouring, dross is skimmed off the surface of the molten metal, increasing the amount of fumes released. (Ex. 479; Ex. 476–339, 337, 331; Ex. 475–10). Emissions at the melting operation come primarily from the furnace during charging the cupola launder leading to the forehearth; and the tapping of the ladles.

Pouring is performed at the transfer of metal from the furnace to the ladle and from the ladle to the mold. (Ex. 476–331, 339; Ex. 22, p. 172). Lead fumes may be released during each pouring (Ex. 22, p. 172; Ex. 479; Ex. 475–33C).

After a cooling period, the castings are removed and transported to the shake-out and/or the wheelabrator which rids the castings of any remaining sand. (Ex. 479; Ex. 476–331, 339). Castings are then cleaned by grinding, cutting or buffing. (Id.).

There are two important sources of lead in the finishing department: the dust generated from the finishing operation and background dust. Final processing may include plating with gold, brass or silver (Ex. 476–317). Lead exposures may also occur during baghouse operations from the melting of lead the pouring of lead into casts and shakeout and cleaning. (Ex. 22, p. 172).

(c) *Controls Currently Used*

Engineering controls in the foundry industry range from general ventilation to numerous local exhaust systems. The most frequent control in the melting department is a hood over the furnace. (Ex. 476–332). In one foundry, each furnace was equipped with a mechanical exhaust canopy hood to collect fugitive lead emissions (Ex. 479).

Another foundry had totally enclosed the furnace (Ex. 479). Some foundries have provided tightly enclosed exhaust ventilation around their furnaces, local exhaust ventilation on the ladles and side draft exhaust ventilation in the pouring stations (Id.). These additions have sufficiently reduced the lead emissions (Id.). Several of these hoods were portable, allowing better access (Ex. 476–317, 332). The American Foundrymen's Society agreed, noting that canopy hoods are generally ineffective and that using a close capture, high velocity hood performs more effectively (Ex. 476–332). Total enclosure of the furnace was also recommended as a means for reducing exposures (Ex. 479; Ex. 476–323). Enclosure allowed Allis Chalmers to reduce lead exposures from 280 $\mu g/m^3$ to 30 $\mu g/m^3$. (Id.). NIOSH observed a movable side-draft hood on an arc furnace which reduced the furnace operator's lead levels to 20 $\mu g/m^3$; on the melting deck similar background levels were found. (Ex. 476–332). One company isolated the operator from the furnace by enclosing him in a positive-pressured booth, and the charging operation was totally automated and controlled from the booth (Ex. 476–332); these controls substantially reduced lead exposures.

Other methods of control included: proper control of charge materials and furnace operations, charge bucket filling and preheating stations with local exhaust, use of a charge bucket cover during loading and unloading of charge materials into the furnace, control of charge door emissions by local exhaust, and use of a charge bucket only slightly smaller than the opening. The charging and tapping operations can be exhausted by using a hood with an air volume of 19,000 cfm (Ex. 476–319, 332). Other suggestions include keeping the furnace covered, minimizing overheating and wing deoxidizers or alloying agents while the crucible is still in the furnace shell (Ex. 476–319). By replacing a crucible furnace with an electrical induction furnace, George Butler, OSHA's expert witness reported lead levels were reduced from 325 $\mu g/m^3$ to 200 $\mu g/m^3$; coupled with isolation of the melting area with a barrier was recommended (Ex. 479). One foundry reported that installation of an induction furnace resulted in a cleaner metal.

NIOSH recommended several methods for reducing lead emissions at the slagging station. They included: a side-draft hood exhausting 25,000 cfm, a fresh air supply directed past the worker, rollers to ease the use of long slagging poles used on large ladles and "rosat slagger" used to isolate the worker during slagging on large ladles. (Ex. 476–329). DBA suggested that the dross be disposed of in barrels with a mobile ventilation system (Ex. 26, p. 5–80).

The most effective method for controlling lead in the pouring area was the use of a mobile ladle hood which exhausts the ladle at the source and is connected by flexible ducting to a traveling exhaust carriage which moves along a stationary plenum extending the entire length of the pouring area. Air volumes ranged from 2,000–7,000 cfm (Ex. 475–3; Ex. 479; Ex. 476–330, 329, 323, 339, 337, 317). Using this technology, Allis Chalmers reported a drop in lead levels from 600 to 40 $\mu g/m^3$ (Ex. 476–323). NIOSH reported levels of 100–140 $\mu g/m^3$ for the molten and 52–100 $\mu g/m^3$ for the metal pourer (Ex. 476–329).

One company visited by NIOSH had an automatic transfer system for metal from the melting area to holding furnaces through a launder, and then automatic pouring from the holding furnace (Id.). Ladle covers were also suggested as a means of reducing emissions (Id.; Ex. 317). In addition, careful work practices to reduce spills as much as possible (Ex. 22, p. 174) or pouring in a remote area would reduce lead levels. (Ex. 476–319).

Butler and Marion Bronze suggested other methods to control lead levels. Butler suggested changing the type of alloys cast to reduce the lead content (Ex. 479). Marion Bronze has developed a patented process where metal is continuously cast and then finished while cold. The idea is not new, but it has not been applied in nonferrous foundries. (Ex. 475–18). Marion Bronze has achieved compliance with these controls.

One of the most frequently used and least effective methods of reducing lead exposures is the use of roof fans. The fans have a tendency to allow air currents to bring the emissions back into the plant. This can be prevented by increasing the height of the stack (Ex. 476–317).

The molding area is generally ventilated, primarily to control silica (Ex. 479). Rigorous housekeeping in this area is mandatory. (Ex. 22, p. 173). Cast Metals Federation (CMF) found that cooling fans, so often used in this area, can disrupt the calculated air flows.

The finishing department includes grinders, chippers, buffers, cut-off saws, torch cut-offs, and air ranging and cutting, all of which can be exhausted locally (Ex. 476–339, 331, 332, 317; Ex. 22, p. 174; Ex. 479). Low-volume, high-velocity exhaust systems were used by one company (Ex. 476–337). Down draft tables were found at the chipping, grinding and buffing operations (Ex. 476–332), and enclosures or booths have also been used. (Ex. 475–3; Ex. 22, p. 174; Ex. 479; Ex. 476–339, 332, 317). NIOSH found a company using an air-supplied booth exhausting 16,000 cfm on a torch cut-off operation. Lead levels were less than 1 $\mu g/m^3$. (Ex. 476–332). In an air operation for small castings, NIOSH also noted a backdraft hood on a bench exhausting 8,300 cfm and an air supply of 1,500 cfm. For large castings there was a ventilated booth with supplied air and a materialized turntable for positioning the castings. The air volume exhausted was 8,500 cfm; the air supplied was 3,600 cfm. Booth curtains were used to separate this area from other areas (Ex. 476–337). CMF suggested the use of kiss gating for the casting area which would reduce, if not eliminate, some cut-off operations. Cosmetic grinding might also be eliminated (Ex. 475–33).

Nearly all of the foundries utilized local exhaust ventilation for capturing lead-containing dust in the cleaning rooms when dust is generated from grinding operations. However, the high-speed rotation of the grinding wheel interferes with the effectiveness of capturing the grinding dust (Ex. 479). Grinding dust containing lead can be satisfactorily controlled with an exhausted booth (Id.).

Vacuum cleaning also must be regularly performed. (Id.; Ex. 22, p. 174). Preventive maintenance is a major part of any ventilation system and must be done regularly to maintain effective control of emissions (Ex. 476–332).

Finally, crane operations can use fresh air cabs. One company had lead levels of 300 $\mu g/m^3$ outside the cab and 30 $\mu g/m^3$ inside (Id.).

In the small foundries, rotation of employees occurs out of necessity and therefore, individual exposure is reduced. Another inherent control in the brass and bronze foundry industry is the variability of lead content in the metal. However, this exposure reduction may be offset by a lack of housekeeping, resulting in accumulations of lead from fugitive emissions from past formulations. (Ex. 479) Air filtering respirators are also sometimes used by the workers.

(d) *Exposure Levels*

The job classifications in a foundry include core maker, muller, molder, furnace operator, pourer, shake-out operator, wheelabrator operator, chippers, grinders, and other maintenance personnel (Ex. 476–317). In the very small foundries, one worker may be responsible for several of these jobs. Of these jobs, the furnace operator, pourer, and cleaner are exposed to the highest lead levels. These operations account for approximately 60 percent of the workforce (Ex. 479).

Exposure levels within foundries are quite variable. Levels at Hersey Products were: 50–222 $\mu g/m^3$ at melting operations with a mean value of 118 $\mu g/m^3$; 100–280 $\mu g/m^3$ at pouring operations with a mean value of 190 $\mu g/m^3$; 10–660 $\mu g/m^3$ at cleaning operations with a mean value of 228 $\mu g/m^3$ (Ex. 476–337). At another Hersey Products site, levels for melting were 25 $\mu g/m^3$; less than 7 $\mu g/m^3$ in pouring operations; and 242 $\mu g/m^3$ in cleaning operations. (Ex. 479). Gorsuch Foundry had levels with a mean value of 88 $\mu g/m^3$ at melting operations; 123 $\mu g/m^3$ at pouring operations; 102 at cleaning operations; and 85 at molding operations. (Ex. 476–336). Other plants had considerably lower levels in melting, less than 40 $\mu g/m^3$; in pouring less than 40 $\mu g/m^3$; and higher levels in cleaning 165 $\mu g/m^3$ mean value. (Ex. 476–317).

When all the data submitted for the record is compiled the range of exposure levels found were: molders ranged from 3–250 $\mu g/m^3$; melters and helpers from nondetectable to 2,000 $\mu g/m^3$; pourer's and helpers from nondetectable to 820 $\mu g/m^3$; shake-out from 2–300 $\mu g/m^3$; finishing department from nondetectable to 4,400 $\mu g/m^3$; miller was from 32–180 $\mu g/m^3$, wheelabrator operator was from nondetectable to 160 $\mu g/m^3$. (See, Ex. 476–337, 339, 331, 343, 328, 336, 317; Ex. 22, p. 178; Ex. 26, p. 5–78; Ex. 475–33I)

Although the exposure data varies greatly, it should be noted that many of these establishments were, in fact, in compliance with the 50 $\mu g/m^3$ lead standard in some operations. As Butler testified, 6 of the 12 foundries he surveyed were either in compliance in the melting areas or could easily be brought into compliance; 4 were in compliance in cleaning operations; and 3 foundries were in compliance in finishing operations. (Ex. 479)

OSHA compliance activities indicate that in a foundry making red brass (5% lead) workers time-weighted exposure were 20 $\mu g/m^3$ for the floor man, 10 $\mu g/m^3$ for the squeeze molder, 20 $\mu g/m^3$ for the share-out furnace tender, 10 $\mu g/m^3$ for grinders and share-out, 50 $\mu g/m^3$ for cut-off men, and 116 $\mu g/m^3$ for ferrous furnace tenders. (Ex. 476–317). This plant has a Hawley monorail traveling exhaust hooding system, an induction furnace, down draft ventilation of grinding areas, and good use of general and local exhaust ventilation.

(f) *Additional Controls*

The engineering controls and work practices to achieve compliance with a 50 $\mu g/m^3$ standard are available and have been used by some of the firms in this industry to achieve compliance. Some foundries have used isolation to separate areas of high exposure from areas of low lead exposure. Fossil fueled crucible furnaces have been replaced with electric induction furnaces. Foundries not in compliance with the standard may find it necessary to upgrade existing ventilation systems, upgrade housekeeping practices and rotate workers to meet the 50 $\mu g/m^3$ standard. Many of the facilities are not in compliance simply because of a reluctance on the part of the industry to invest in health and safety controls. Thus while current technology will enable this industry to comply with the standard, the absence of existing controls in some plants and inadequate design of controls in others indicates that compliance activities will take careful planning and time. OSHA has incorporated these considerations into its implementation schedule. The five years provided for compliance allowed the industry a sufficient planning horizon to install efficient, well designed, cost-effective ventilation systems or new processes.

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(g) *Conclusion: Technology Feasibility*

The Court of Appeals remanded the standard for this industry because the preamble did not explain OSHA's basis for extrapolating the feasibility of the proposed 100 $\mu g/m^3$ PEL and did not describe technological developments that might be utilized (Slip opinion, pp. 205–207). In this analysis, OSHA has presented direct evidence of the technological feasibility of the 50 $\mu g/m^3$ PEL. Exposure data for several foundries demonstrated that foundries which have utilized state-of-the-art controls have in fact already achieved compliance.

However, in the foundry industry, the use of effective engineering controls and work practices is not uniformly applied. Some firms have achieved compliance throughout, others have achieved amazing success in controlling lead exposures in some processes but lack controls in others areas necessary to achieve compliance, and other have done virtually nothing.

Many firms believe that it is not possible to bring all operations in the foundry in compliance with the permissible exposure level of 50 $\mu g/m^3$ (Ex. 479; Ex. 475–334, 33H, 33F, 33A, 3). Billard Pattern and Brass Foundry stated that even with the latest technology in use, in the most critical areas such as melting, levels remain in the 50–100 $\mu g/m^3$ range. (Id., at 33D). Another company said that at best they could meet the 200 $\mu g/m^3$ standard (Id., at 33D). The industry contends that the lead standard is not feasible and presented the Ford Motor Company as an example of a state-of-the-art foundry which is not in compliance with 50 $\mu g/m^3$. However, this state-of-the-art foundry appears to suffer from the lack of "common sense" in achieving control. As Gary Mosher from the American Foundrymen's Society observed: "Smoke tube testing done in the foundry at the same time as the air sampling indicated that there seemed to be no unifors air flow patterns in the foundry. A significant problem in the foundry is the use of man cooling fans. These fans are doing a fine job disrupting air flow patterns around exhaust hoods." It appears that a common sense approach to design and maintenance of ventilation controls would facilitate the ability of this industry to comply with the standard. Foundries that modify their processes and adopted those used by the Marion Bronze Company could easily come into compliance. This process in which alloys are continuously cast and then cold finished greatly minimizes the lead which becomes airborne. This process is readily adaptable to the industry (Ex. 475–18).

The American Foundrymen's Society (Ex. 503) discussed problems with the data relied upon by Butler in determining feasibility. They maintain that the exposure data was not representative of foundries doing casting of brass and bronze in that either low percentages of lead were involved or casting of non-lead substances was done, but provide no documentation of this claim. OSHA has no reason to believe that the data upon which it relied was not the representative, and in fact it was the best available data. OSHA made every attempt to get the best information, but industry has failed to provide adequate data.

(h) *Costs of Compliance*

The record contains a substantial amount of cost data on reducing exposures to lead in nonferrous foundries. The cost estimates for individual foundries vary widely for at least three reasons. First, some estimates were based upon a nonlinear relationship between compliance costs and exposure levels, whereas other estimates assumed a linear relationship. However, OSHA believes that documentation is available to support a linear relationship between costs of compliance and levels of exposure above 25 $\mu g/m^3$ (Tr. p. 85–86). Further evidence has been provided to corroborate the linearity relationship (Ex. 270, p. 25). Second, different methodologies were used to estimate the cost of these controls. Third, the baseline of current exposure levels varied from foundry to foundry over a wide range. Whereas some foundries were close to or in compliance with 50 $\mu g/m^3$, others were in excess of the previous 200 $\mu g/m^3$ standard.

One foundry reported that it had purchased and installed two induction furnaces with mechanical exhaust ventilation hoods. Each furnace cost between $10,000 and $11,000, and a $40,000 control panel for the furnaces was also installed. No other ventilation was installed. This represents a major undertaking by the foundry. However, the costs of reducing workplace emissions will be partially offset by savings stemming from a cleaner metal product (Ex. 476–314).

Another foundry reported the expenditure of $15,000 for increased ventilation of 6,000 to 7,000 cfm over pouring stations, and $3,000 for an increase of 10,000 cfm to ventilate furnaces (Ex. 476–330). Since the system is not yet operational, no exposure levels were reported by the firm. However, contaminant emissions are expected to be substantially reduced, and all fumes over the pouring stations should be captured by the hoods (Ex. 476–330). Thus, these two foundries indicate that measures can be taken to control exposures to toxic substances in foundries. Furthermore, because foundry workers are exposed to a multitude of hazardous substances, these controls are simultaneously effective in affording protection to workers against other metals, silica and other toxic substances.

A number of foundries submitted provision-by-provision cost estimates through their trade association, the Cast Metals Federation (CMF). Eight firms provided cost data ranging from capital expenditures of $111,190 to $4,000,000 per foundry to reach 50 $\mu g/m^3$ lead (Ex. 475–33). Total costs for these foundries were $14,446,429, and the average cost per foundry was $1,805,804. In addition, one firm estimated the cost of constructing a new, fully-automated foundry with the latest technology at $6,275,000 (Ex. 475–33(I)). The foundry was to be located in a warm climate, thereby eliminating costs associated with heating make-up air.

These cost estimates were not supported by engineering studies and appear to be speculative in nature. For instance, one respondent wrote that the installation of a ventilation system "would probably cost about $60,000" (Ex. 475–33(c)), while another submitted that it was "led to believe that (it would) be required to spend up to $4,000,000 more if this standard is upheld, with no guarantees of success" (Ex. 475–33(E)) in achieving compliance. One foundry estimated a cost of $23,000 for "removing partial moisture from brass chips" without an explanation of the reason for this process and its relationship to the revised lead standard (Ex. 475–33(A)).

The variation among the cost estimates also indicates that not all of the costs presented are reasonable. For example, one foundry with 24 employees estimates the cost of a shower/change/locker room at $70,000 (Ex. 475–33(A)); one with 12 employees estimates a cost of $5,000 for a change room and showers (Ex. 475–33(C)), another with 600 employees estimates the cost of change rooms and showers to be $30,000 (Ex. 475–33(E)); and still another with about 100 employees claims that change rooms, showers, a lunchroom, and lavatory modifications will cost $750,000 (Ex. 475–33(H)). With respect to costs of housekeeping, most foundries estimated that costs would be in the vicinity of $20,000 per year. However, one firm estimated much larger annual housekeeping costs of $180,000 (Ex. 475–33(T)) with no apparent explanation for this deviation.

All of the foundries forecast large decreases in productivity as a result of "nonproductive" hours spent by employees in compliance activities, such as housekeeping and showering. However, the firms did not explain the derivation of the productivity loss estimates, nor did they attempt to calculate offsetting gains in productivity that may be realized through modernization and a cleaner work environment. Furthermore, classification of work practices as "nonproductive" fails to depict accurately the purpose and effects of safety and health in the workplace. While work practices may not necessarily be perceived as contributing to the conventional product output of the firm, utilization of these resources does contribute to the health of employees and, therefore, may reduce worker turnover and absenteeism.

At least one foundry claims that it will incur large costs of training new employees because a certain percentage of its workforce would switch to other jobs as a result of "loss of personal freedom" at work (Ex. 475–33(F)). The firm claims that the calculation of the 8-hour TWA would require rescheduling shifts such that many employees would seek other employment. On the contrary, OSHA believes that providing cleaner and safer foundries would be likely to reduce worker turnover. Workers who were previously dissatisfied with the workplace, as exemplified by high rates of turnover and absenteeism, would be more likely to remain in current positions and attend with greater reliability. This would be of substantial benefit to the firm, because retraining costs associated with new workers would be reduced. In addition, overstaffing in the face of high absenteeism, to ensure an adequate workforce on any particular day, could be reduced.

In contrast to the relatively high compliance costs provided by some members of the CMF, other data indicate that compliance costs may be considerably lower. These data are estimates of the cost of complying with the 200 $\mu g/m^3$ lead standard. Bolt, Beranek, and Newman (BBN), a consulting firm that conducted a program of on-site consultations in the foundry industry as part of an OSHA National Emphasis Program, made estimates of the specific costs of controlling metal fumes in participating foundries. The reports also included separate cost estimates for controls recommended to reduce exposures to free silica, noise, binders, and safety hazards. A total of 282 firms sought BBN's consultative services. For all these foundries, including steel foundries, gray iron foundries, malleable iron foundries and nonferrous foundries, total control costs for all hazards were estimated to be $6,200,000. In other words, on average, each foundry needed to spend about $22,000. However, BBN pointed out that costs for individual foundries varied widely (Ex. 476–317).

OSHA reviewed the BBN reports pertaining to nonferrous foundries, especially those establishments in which brass and bronze were cast. The compliance costs and the estimated time necessary for implementation of control measures ranged from a minimum of $75 and one month to $95,000 and one year. Three establishments were advised that immediate actions, that bore *no* costs, such as moving a hood or a worker's position, could be taken to achieve compliance (Ex. 476–317).

BBN estimated the total costs for coming into compliance with the 200 $\mu g/m^3$ lead standard and all simultaneous exposures to metal fumes at $364,100 for the nonferrous foundries participating in the consultation program. The average cost per foundry was only $6,300. Excluding those foundries that were in compliance and that therefore incurred no costs, the average cost per firm rose slightly to $8,500. The average length of time required for implementation of controls was 4.5 months.

For their estimates, BBN used an integrated cost-effective method of solving exposure problems, that is, a combination of engineering controls, work practices, and administrative controls. This multifaceted approach to reducing levels is necessary to provide an effective, least-cost solution to the exposure problem. Because the industry estimates do not take this approach, they are probably overstated.

The study by Jacko and Overmyer similarly emphasized the multifaceted approach to lowering lead levels by utilizing housekeeping, work practices, proper layout of plant and equipment, and ventilation. Since it is important to reduce the amount of air exhausted, which is the most costly component of compliance, these other methods represent important ways of reducing costs for firms. In addition, the estimated costs of ventilation control per cfm typically include the costs of complying with EPA air pollution regulations. To the extent that this is the case, the costs attributable to OSHA should be systematically reduced (Ex. 475–3A(2)).

The Census of Manufacturers estimates that there are 489 brass, bronze, and copper foundries and 365 nonferrous foundries, not elsewhere classified (Ex. 476–26). However, according to the American Foundrymen's Society (AFS), there are 364 copper-base alloy foundries, 59 steel foundries, and 29 other nonferrous foundries in which exposure to lead may occur (Ex. 475–3A). The AFS also noted 246 gray iron foundries and 304 aluminum foundries in its estimate of the number of nonferrous foundries potentially using lead.

The two trade associations (CMF and AFS) concur that exposure to lead occurs in approximately 1,000 foundries (Ex. 475–3A and Ex. 475–33). The Census data identify 476 brass and bronze foundries but do not identify other foundries in which brass and bronze may be cast as secondary products or other alloys containing lead may be cast. Thus, OSHA accepts 1,000 firms as the best available estimate of the number of potentially affected firms.

Using this estimate of the number of affected foundries and the BBN cost estimate of $8,500 per foundry to reach 200 $\mu g/m^3$, OSHA estimates that at least $8,500,000 would be expended to achieve compliance with the 200 $\mu g/m^3$ standard. Assuming that the BBN estimates are understated by a factor of ten, that is, that there is a ten-fold difference between achieving 50 $\mu g/m^3$ and 200 $\mu g/m^3$, total cost in the foundry industry of achieving 50 $\mu g/m^3$ may reach $85,000,000. Butler's cost estimate of $107,000,000 to reach 50 $\mu g/m^3$ is based solely on controlling lead levels with ventilation (Ex. 479), which is likely to be more expensive than a multi-faceted approach. The best estimate of DBA for achieving the 100 $\mu g/m^3$ standard was $161,000,000. However, this figure was based on 1,620 foundries rather than 1,000 foundries producing bronze and brass castings. OSHA believes that the BBN data constitute the best available evidence, because they were collected more recently than the DBA data and because BBN visited a much larger sample of firms. Thus, OSHA concludes that the foundry industry may expend $85,000,000 to $107,000,000 complying with the lead regulation. On an annualized basis, these health-related expenditures range from $15.2 million to $19.2 million.

(i) *Industry Profile.* Exposure to lead in nonferrous foundries occurs primarily in the manufacture of brass and bronze castings (Ex. 478–1). According to the Department of Commerce, there are 476 companies operating 489 establishments in this industry, SIC 3362. About 10,200 production workers were employed in this industry in 1977 (Ex. 476–26). However other foundries may produce copper-base alloy castings as a secondary product, thereby increasing the number of workers potentially exposed to lead. For instance, the CMF estimates that there are about 1,000 foundries in the U.S. producing brass and bronze castings (Ex. 475–33), and the AFS estimates that 1,004 foundries in the U.S. produce nonferrous castings, including 364 which produce copper-base alloy castings as their primary product, and 246 gray iron, 2 malleable iron, 59 steel, 304 aluminum and 29 other nonferrous foundries with copper-base alloy casting as a secondary product. Total employment may be as high as 80,000 workers, according to the AFS (Ex. 475-3A). The value of shipments for the nonferrous foundries was $813.7 million in 1977; the value of shipments for the brass, bronze, and copper foundries was $553.3 million (Ex. 476-26).

Using employment as a measure of size, most of the foundries in SIC 3362 are small with 41 percent employing less than 10 employees, and forty-six percent of the establishments employing between 10 and 50 employees. Only three establishments employed between 250 to 499 employees, the largest firm size category. In other foundries producing bronze and brass castings, the number of employees per foundry is not known. However, since 10,200 workers are employed in the bronze and brass foundry industry, and since the AFS estimates that there are 80,000 workers in the nonferrous industry at issue (Ex. 475-3A), this leaves 69,800 workers in the remaining establishments.

The CMF and some of its members predicted severe financial hardship, plant closures, increased unemployment, and productivity losses of 10 percent to 20 percent after compliance with the lead standard (Ex. 475-33). The AFS addressed the issue of technological feasibility but did not submit data on the economic feasibility of compliance nor claim that this regulation would present a hardship for affected foundries (Ex. 475-3A).

One manufacturer of bronze bearings presented data in support of the feasibility of the lead standard. The Marion Bronze Company, with the assistance of Battelle Columbus Laboratories, developed a new method of casting bronze. The research and development effort was stimulated by the incentive to lower production costs associated with rising energy costs (Ex. 475-18). A grant was awarded by the Department of Energy to supplement the work prepared to date, which has been patented by the U.S. Patent Office. The funding is designated for the completion of the research necessary to market the new technology (Ex. 475-18B).

Because substantial cost reductions can be gained by manufacturers switching to the process, it is likely to be rapidly accepted. The National Bureau of Standards (NBS) regards the process as commercially feasible. The NBS indicated that reductions in costs are based on lower capital investments required to produce a wide range of bearing sizes, significant reductions in energy usage, and significant increases in productivity compared to current processes in use (Ex. 475-18C). In addition, the new continuous casting method is a cold process and does not require melting metal (Ex. 475-18). This new process which offers significant economic benefit to producers would also virtually eliminate lead exposures in the production of some bronze castings.

The conventional processes used in foundries involve pattern making (generally customer specific), mold making, metal pouring, and finishing. Foundries usually specialize in either job contract or volume business in producing standardized products. The demand for foundry products is determined by a highly diversified group of customers purchasing a wide selection of standard and specialty castings. The dominant factor in determining the price of final products is the price of brass and bronze ingots (Ex. 476-26).

There are less than 30 firms in the brass and bronze ingot manufacturing industry, which is separate from but essential to the foundry industry. Copper-based ingots of specific alloy compositions are produced and sold primarily to nonferrous foundries, which in turn melt the ingots and cast brass and bronze products. All but one of the ingot manufacturers are small, closely held corporations. Industry commented that the capital-intensive nature of the industry, the strong competitive pressures, and the demanding government regulations result in small profit margins for ingot producers relative to other manufacturers (Ex. 475-10). The industry also contends that lack of access to capital has forestalled modernization. The industry is composed of older facilities located in urban areas (Ex. 475-10).

The submission of the Joint Government Liaison Committee of the Assocation of Brass and Bronze Ingot Manufacturers and the Brass and Bronze Ingot Institute further describes the role of the industry as essential (Ex. 475-10). They describe no domestic competitors nor foreign penetration of the brass and bronze ingot market in supplying foundries with these alloys. Most foundries will not produce their own ingots because extensive and expensive laboratory facilities are required to produce alloys of specific compositions (Ex. 474-26). Thus, it appears that any compliance costs incurred in protecting workers in the ingot manufacturing industry could be passed on to nonferrous foundries. Furthermore, since the industry is described as consisting of small, highly competitive firms operating under similar conditions and producing a homogeneous product, compliance costs should not impose a disproportionate burden on any specific firm within the industry.

In the foundry industry, however, market conditions are somewhat different. Job shop foundries are supplying a service to customers who order specialty castings. Here, the quality of the castings produced appears to be an important method of product differentiation. Thus, the reputation of the foundry may be a critical factor under consideration by the buyer. Thus, small foundries with a reputation for high quality may retain their competitive advantages even in the face of rising costs. Castings that are mass produced, on the other hand, may meet much less stringent demands on quality (Ex. 476-26). Small firms in the market may be unable to compete with larger firms because of disproportionate cost increases.

Establishments in the industry are distributed throughout the nation with a large proportion of producers in the Middle Atlantic, East North Central, and New England census regions. For standardized products, competition is less regionalized than for job-contract work. Within given geographical markets, competition for specialty orders is fairly intense (Ex. 475-10).

While the foundry industry is vulnerable to business recessions, especially in construction and consumer durables, the industry's flexibility and diversity of product lines tend to buffer the severity of such impacts. As the economy recovers, the foundry industry should share in the growth. There may be a trend to shift from brass and bronze to ferrous castings; however, the magnitude and strength of this shift is not measurable owing to a lack of data.

The structure of the industry as a whole closely resembles a monopolistically competitive market. The low concentration ratios for 1972 from the Census of Manufacturers provide evidence of the competitive nature of the industry, although this measure probably overestimates the competitive nature of regional markets. Economic and technological barriers to entry appear to be very low on the basis of available evidence (Ex. 474-26), and the size distribution of firms does not indicate that there are significant economies of scale in production (Ex. 474-26). Thus, low unit production costs can be obtained at low levels of output.

About 25 percent of the foundries classified as brass and bronze foundries are unincorporated, single plant firms.

Since these companies produce at low volumes, they have not in the past benefited from bulk discount buying of raw materials. Therefore, when the price of brass ingots rose sharply in 1972 and 1974, many of these firms were unable to compete with larger producers (Ex. 474–26).

DBA indicated that costs of production rise as a result of compliance with the lead regulation, firms would initially pass on to consumers most of the increase. Moreover, in the long run, the prices would rise to fully pass on the costs of compliance, although there might be some increase in market concentration (Ex. 474–26).

Some of the present markets for brass and bronze castings may change to reflect increasingly elastic demand if plastic castings are accepted as suitable substitutes. Aluminum and ferrous castings may also compete successfully if the relative prices of bronze and brass castings rise.

One company commented that foreign competition was much stronger than in the past and was adversely affecting its ability to export castings (Ex. 475–33I). However, foreign producers do not appear to be competing with foundries in domestic markets. On the other hand, in an effort to escape regulatory requirements, and to lower costs of labor, some foundries may consider the option of moving abroad (Ex. 476–26). For instance, if some domestic foundries relocate to Mexico, the impact on the southwest regional market for brass and bronze castings might be disrupted (Ex. 476–26). The extent of this dislocation is not measurable with the available data.

(j) *Conclusion: Economic Feasibility*

The foundry industry has been given 5 years to comply with the standard. In light of this extended compliance period and the cost evidence, OSHA concludes that the economic impact of the lead standard will not prove disruptive to the domestic foundry industry. OSHA calculates that compliance costs will comprise between 1.4 percent and 3.4 percent of total shipments, valued between $553.3 million (brass and bronze foundries) and $813.7 million (nonferrous foundries) in 1977 (Ex. 476–20). Although marginal firms may exist the market or drop lead-related product lines from their operations, causing some increase in market concentration, entry barriers are low. Therefore, new firms may enter the market if others shut down. Thus, in the long run, increases in concentration may not occur.

30. Pipe Galvanizing

(a) *Uses*

Large quantities of steel wire, pipe, hot and cold rolled strip and sheet are coated with molten zinc in a process called galvanizing. Galvanized steel is used where corrosion resistance is required, for example, in the underbody of automobiles, for air conditioning ducts, culverts and storage tanks. Often the galvanized sheet is given a paint coating to make it fit more attractively in its surroundings. Some farm silos are made of continuously painted galvanized sheet. Curtain walls in building exteriors, interior partitions, and parts of kitchen cabinets or major appliances such as refrigerators may also be manufactured from painted galvanized sheet.

(b) *Process Description and Exposure Areas*

Metal to be galvanized may require annealing to remove the effects of cold working. For galvanizing wire a continuous annealing process consisting of a lead-bath is usually employed. A pan filled with molten lead is installed in front of the cleaning and galvanizing apparatus. The lead also serves to burn off the wire-drawing lubricant. Since the rate of cooling in continuous process annealing has little effect upon the physical properties of the wire, the wires are cooled in air, or, if the space is limited, low-carbon wires will be cooled by conducting them from the annealing furnace into a vat of water. Following annealing, the materials are cleaned of scale by being drawn through a bath of hot acid at predetermined concentrations and later through hot water. The cleaned wire must be dried before galvanizing. A flux is used to prevent any oxidation or rust from forming during the drying process. The dried wires are drawn at once into the molten zinc, or spelter. This molten metal is contained in a spelter pan, which is usually made of boiler plate and is supported by a brick setting of suitable construction for firing with the most satisfactory fuel available. Pans designed for galvanizing coarse sizes of wire may reach a length of 30 feet. The depth of the pan must be sufficient to prevent the wires from coming into contact with the dross which settles and collects upon the bottom. This dross which is an alloy of iron and zinc and solid at the temperature of molten spelter, forms a pastelike mixture that is very harmful to the coating. As molten zinc oxidizes rapidly, the pan is provided with some form of covering, which rests upon the molten spelter and protects it from the air, except at the ends where the wires enter and leave the bath. Here, the surface of the metal must be kept free from oxide by frequent skimming. The mixture of zinc and zinc oxide thus obtained is known as zinc skimmings.

The wire, just after it emerges from the zinc bath, is passed through either one of two devices known as wipes or headers.

Galvanizing of cold rolled sheets and strips is performed in a similar manner, however, annealing is performed in a box furnace which eliminates the need for the lead bath preceding the zinc-bath. Pipe and hot rolled steel do not require annealing so the lead bath is likewise not necessary.

Electrogalvanizing, as the name implies, is a process which applies a coating of zinc to steel by means of an electric current. Electrogalvanizing uses a long, shallow plating vat, usually from 100 to 200 feet long. This vat is filled with a solution such as zinc sulphate which must be continuously agitated to maintain a uniform density. From the vat the steel goes to a wiping unit and is then permitted to dry in air.

Lead exposure results from processes preceding the hot galvanizing, such as annealing, which is often done in a lead bath (Ex. 476–483). Lead is sometimes added to the zinc bath because a lead layer acts to hold down other impurities which may be present in the zinc bath (Ex. 22, p. 209).

(c) *Controls Currently Used*

Suggested control technology consists of two hoods, one over the dip tank and one to exhaust the blowbox (steam ejector for removing coating metal from the inside of the pipe) (Ex. 476–344).

(d) *Exposure Levels*

Specific exposure data was unavailable, although the consensus among those expressing an opinion was that lead exposure poses no problems in this industry (Ex. 22, p. 209). AISI furnished blood lead data to the record, but furnished no exposure data (Ex. 500).

(e) *Population Exposed*

No data was available.

(f) *Additional Controls*

AISI stated that engineering controls were infeasible and that fluidized bed systems (which cannot be used in all cases) have replaced the galvanizing process. (Ex. 500, p. 9). While this may be a reliable way to eliminate lead exposures, other traditional methods such as those recommended by Short appear suitable (Ex. 22, p. 209). The submission from industry (Ex. 476–343) also indicates that relatively standard control technologies are being used. The less costly housekeeping and worker rotation controls are also available to the industry.

(g) *Conclusion: Technological Feasibility*

The data which was available indicate the exposure to lead from galvanizing is low and poses very few compliance problems (Ex. 22, p. 209). Controls appear relatively simple and consist primarily of hooding. Additional preventive measures such as enhanced maintenance and housekeeping may also be used to insure that levels are kept below 50 $\mu g/m^3$. Compliance with the standard thus is feasible.

(h) *Economic Feasibility*

Data was not submitted by any industry source which indicated that there would be any costs of compliance associated with the use of traditional controls for complying with this standard. Exposure levels are low and the costs incurred, if any, will probably be for maintenance and housekeeping improvements, both of which require minimal expenditures. AISI did submit data in their post hearing comments which indicated that replacement of existing controls with a fluidized bath in galvanizing operations would be $650,000 (Ex. 500, p. 9). They further indicated delivery of the system would occur 1 year after the purchase order.

In view of the apparent low exposures in this industry and the relative simplicity of the controls required, compliance with the standard should not cause significant economic impact on this industry.

31. Plastics and Rubber Manufacture

(a) *Uses*

Polymerization processes result in many different kinds of bulk plastics and resins which are later molded to form plastic products or processed to form paints, solvents, varnishes, etc. Rubber has many uses, but is primarily used in the formation of tire and rubber hosing. Linoleum is no longer made in the United States (Ex. 476–286) and therefore its manufacture is not discussed.

(b) *Process Description and Exposure Areas*

The processes for the production of plastics and resins are numerous. Eighteen general processes are used to produce various plastics. Only the compounding of lead based ingredients poses an exposure problem in rubber and plastics manufacture (Ex. 22, p. 224).

Lead exposure may result from the compounding of a polymer. The term "compounding of a polymer" refers to those chemical and, especially, physical methods used to modify the polymer's properties in accordance with specific performance, appearance, or economic requirements. Most commonly, the compounding of a plastic involves the incorporation of certain additives, the compounding ingredients, into the polymer to produce a homogeneous dispersion or mixture. In this way, improvements may be made in processing characteristics (e.g., by the use of plasticizers), in resistance to degradation (e.g., by stabilizers), in strength (e.g., by modifiers or reinforcing fillers), in appearance (e.g., by antistatic agents), and in cost (e.g., by fillers or extenders). Curing agents are also important compounding ingredients, especially in the case of thermosetting resins and elastomers. The nature and proportions of the compounding ingredients; i.e., the formula or recipe to be used depends primarily on the nature of the polymer and its intended use (Ex. 476–286).

Important classes of compounding ingredients are: Antioxidants; antiozonants; antistatic agents; biocides; blowing agents; carbon; catalysts; curing agents; driers and metallic soaps; dyes; inorganic fibers; fillers; flame retardants; pigments; plasticizers; release agents; stabilizers; and ultraviolet radiation absorbers. (Id.)

Polymers are modified using a multitude of products, but most compounding methods generally consist of three steps. The premixing or preblending step involves breaking of agglomerates and gross dispersion of compounding ingredients. The compounding ingredients are heated and intensively mixed or blended in order to give the polymer particles a homogeneous dispersion on a molecular level. The last stage in compounding involves shaping the compounding material into a usable form (Id.).

General methods of compounding polymers may be divided into those of compounding thermoplastics and those for compounding thermosetting resins because the effect of heat differs greatly depending on whether the polymer is in the former or the latter group. The compounding of elastomers is a specialized technology. (Id.)

(i) *The Compounding of Thermoplastic Polymers* Premixing operations may be carried out in large batches with the aid of mixers and blenders. In mixing dry materials (e.g., in dry coloring), a less intensive type mixer, like ribbon blenders, conical mixers or sigma-blade blenders, may be used. If the material is dough or taffy-like, a more intensive mixer like the Muller-type mixer or vertical-action mixer will be required (as in the mixing of color concentrates with uncolored resin). The premixed materials are usually screened to eliminate remaining aggregates before the next operation. (Id.)

Fusion is accomplished by the external application of heat, shearing action, or both. A number of different types of equipment are available for this purpose. Extruders are widely used because they provide heating by shear and permit continous operation. The Banbury internal mixer is particularly useful for compounding plastics that are difficult to process and for compounding and reclaiming elastomers. It is usually employed in conjunction with a two-roll mill or an extruder (Id.).

The last stage in compounding a thermoplastic involves shaping of the compounded material into a usable form. For example, the Banbury mixer will produce thick, shapeless masses of several hundred pounds that must then be cut into small pieces. The compounded material is therefore placed on a two-roll mill and a sheetlike material is produced. The sheet can be reduced in size by cutting and further subdividing into granules or rounds (Id.).

The final product from an extruder can be obtained in tape, tube or strand form, or, after cooling, may be granulated. Pellets can be obtained directly by die-face cutting where the extruded polymer is cut underwater upon emerging from the extruder while still hot (Id.).

(II) *The Compounding of Thermosetting Resins.* Thermosetting resins are usually in the form of a syrup or of a finely divided powder prior to compounding. They are mixed with a variety of other solids, e.g., fillers like wood floor, asbestos, clay or mica. In addition to the usual compound ingredients, thermosetting resins are also compounded with suitable curing agents before they are fully set. Equipment used for compounding includes ball mills, sigma-blade blenders and vertical mixers. Ball milling is particularly useful for the production of powders with exact shades of color (Id.).

The sensitivity of resins to heatsetting requires that heating only be carried out at low temperatures and for short periods of time. Likewise, pH conditions must be carefully controlled. Fusion (fluxing) for brief periods can be performed on two-roll mills or a Banbury mixer. (Id.) The compounded material produced from the two-roll mills or Banbury mixer may then be reground into a powder or granulated after extrusion. (Id.).

(iii) *The Compounding of Elastomers.* High quality natural rubber is too hard and tough to process. Therefore, the first step in its use is a preliminary breakdown or mastication. This is accomplished by the shearing action of a two-roll rubber mill or an internal mixer such as a Gordon plasticator. This breakdown causes the rubber to become smoother, more plastic and more thermoplastic in subsequent steps. Most synthetic elastomers also require some breakdown of a similar type. The amount of breakdown required varies with the type and grade of elastomer. In most cases, the breakdown of synthetic elastomers differs from and is less extensive than that of natural rubber. All rubber compounds contain some added chemicals and most contain softeners and pigments. All of these materials must be thoroughly blended with the rubber to give an essentially homogeneous mixture.

When using an internal mixer of the Banbury type, the rubber is added first and then worked; the compounding ingredients are added later. Many elastomers, such as those for tire treads, are mixed in several steps.

The first step in the process is premixing. Mixing results in elevated temperatures as a result of the mechanized agitation. In many cases, especially when mixing is in a high-speed mixer, the temperature rise in the batch is quite rapid. To prevent scorching or premature vulcanization, part or all of the curing agents may be kept out of the batch until the final mix. The batch is dumped onto a sheeting mill as soon as it reaches a definite temperature instead of being mixed for a definite period of time. The batch comes out of the Banbury mixer in chunks of various sizes which are dropped onto a two-roll mill under the mixer. On this mill, the batch is further blended, sheeted and cooled. It is cut off the mill in sheets, cooled in water, dusted or dispersed with separators to prevent sticking and stored for further processing.

There are many ways to shape rubber products. One widely used method, for either an intermediate or end product, is extrusion through a tuber or extruder. Calendering, another method, produces a smooth, uniform sheet of unvulcanized rubber by pressing between rollers. Such sheets may be cured as sheeting, cut into threads, or plied with fabric. In a friction calender, the rubber stock is pressed and smeared into the interstices of woven fabric to make raincoats, boots, etc. Another method spreads or coats properly compounded latex or cements onto fabrics. The machines required for spreading and coating are simpler and cheaper than those used for calendering but the coated fabrics must be dried. When cords are used instead of fabrics, they are usually dipped into latex and then dried.

Lead is used at the beginning of the process, in the compounding of the rubber and plastic itself, and later in the fabrication of rubber and plastic goods (Ex. 489). Lead oxide is used to accelerate the rubber vulcanizing process (Ex. 489).

Lead is used in the compounding of chlorosulfonated and isoprene-isobutene rubbers and is the common heat and light stabilizer for vinyl plastics where they often do double duty as lubricants or colorants (Ex. 489).

Lead exposures occur as a result of handling, weighing, applying and using lead bearing anti-oxidants, colorants, color concentrates, plasticizens, fillers, stabilizers, inks, paints, and internal and external lubricants (Ex. 22, p. 224). The potential for lead exposure exists in the following circumstances: (1) Whenever dry lead-bearing powder components are introduced into the system and until they become combined with liquids or reacted constituents; (2) when heating or curing operations raise temperatures sufficiently to increase vapor release; (3) during grinding, buffing, and machine operations which create airborne dust; or (4) in spray operations for coloring, painting or other purposes which disperse lead-bearing particulates into the atmosphere (Id). Specifically, the operations which are major sources of toxic dust generation are raw material handling and storage, additive weighing and batch recipe make-up, entry of additives into mixing and blending operations until the additives are fused into resin, and all hoppers and material transfer systems.

(c) *Controls Currently Used*

Numerous control technologies are available and used by the industry to control lead exposures: Total enclosure of the system; control by computer vacuumized propolymerization; local exhaust and general ventilation; mechanical stepping switches to control operations; enclosed control rooms under positive pressure; air local entry systems in charging operations; batch mix tanks with a flexible hose exhaust permanently situated at the top inside of the point; blend tanks equipped with an exhaust hood for the manway; screw conveyors under negative pressure; and small mobile blowers (Ex. 476–286).

The following controls are in use in a congoleum industry's plant (Id.). In the pigment preparation area, one employee working in a chemical kitchen area makes up all the additive solutions for addition to solution tanks of the reactors and coagulation area. The kitchen area is well ventilated and good housekeeping is emphasized. Attempts are made to receive dry materials in flake or large particle form, rather than as a fine powder. Also, material container sizes are selected to correspond with the weight requirements of the various batches, thus minimizing the need for the operator to measure shortweights (removal of part of the contents in the bag to obtain the desired weight) of dry materials, which is usually a very dusty operation. The solution tanks are open to the room and are not provided with local exhaust (Id.).

Exposure of workers to solid catalysts during normal plant operations is eliminated by the Catalyst Vacuum Loader. The solid catalyst for the solid resin facilities is unloaded from drums into a charge system via a vacuum conveying system to eliminate contact with personnel and reduce dust. The sensors and control elements interface with a computer and are automatically controlled (Id.).

While dumping dry additives, bags are positioned directly in front of the charge booth. One at a time, they are placed over a grate, slit open, turned over and dumped into the mixer. Empty bags are purged of residual particulate matter by vigorous shaking directly in front of the exhaust slot. Depending on the contents, the bag is either dropped into a polythylene-lined container, or flattened and baled inside or outside the booth. Any spillage is swept into the booth (Id.).

Partial or short weight amounts of additives are handled specially; the bags are slit into two equal sections, one is dumped and the other is carried to the scale and weighed. If short weight operations are frequent then an exhausted scale facility is probably necessary. Major spills from leaky pallet loads are vacuumed up immediately (Id.).

Good housekeeping is also essential to proper control, as is evidenced by the low measured concentrations of airborne dust. In some plants (Ex. 489) every 2 weeks, the entire plant (including rafters) is thoroughly vacuumed. This means that settled dust will never accumulate sufficiently to become a significant secondary source of contamination.

(d) *Exposure Levels*

The Kentile Floor Co. (Ex. 476–271) is a manufacturer of vinyl coating and vinyl floor covering. Dust samples were collected in the compounding area where compounders load a compound, charging the hopper with dry chemicals. The chemicals are then transferred to the pre-mixer and finally to the Banbury mixer. Lead levels in the process area were nondetectable.

In the compounding department materials are transported by vacuum to compounders who weigh and mix pigments etc., and ultimately charge the Banbury mixer. Levels in the charging areas ranged from 43–70 μg/m³ (three samples were taken). The survey concluded that even though the two samples exceeded OSHA limits, this did not constitute a major area of exposure. The significantly higher lead concentrations measured on one filter would indicate that a re-evaluation of the compound-charging area is necessary to determine whether this sample's filters were inadvertently contaminated or whether employee work practices here are significantly different than those of other workers. In fact, the survey recommends that compounders be instructed to empty bags of chemicals more gently in order to prevent dust generation.

Representatives of Monsanto (Ex. 476–289) and Dow (Ex. 476–287) indicated that lead was not a problem in their operations.

Armstrong Cork (Ex. 476–297) also manufactures several types of floor tiles where lead is used in the pre-mix stages. Levels of exposure were approximately 0.01 μg/m³. In 1975 this plant was re-evaluated and lead levels were nondetectable. Ventilation controls had been implemented to control asbestos exposure; these also served to reduce lead levels.

Dover Molded Products (Ex. 476–280) is a job shop producing small plastic items by injection molding. Colorants are added to the plastics by mixing white plastic with a dry colorant in 55 gallon drums. Of 9 samples taken, lead levels were nondetectable except for one which measured 0.02 μg/m³. Even though lead levels were low, exposure to cadmium and chromates exceeded the PEL's. The survey recommended that colorants be substituted in these operations; discussions with company and supplier representatives indicate that it is technically and economically feasible to replace these colorants with nontoxic substitutes.

Lead exposure in the rubber industry occurs during vulcanization when lead oxide is added as an accelerator and during the manufacture of braided hose. The Rubber Manufacturers Association (Ex. 476–290) estimates that the amount of lead used in tire manufacture is relatively small and exposures are well controlled and pose no problem. Lead may also be used as a balance paint (a paint with a litharge to give it weight) which is painted on the side of a tire to give them balance. Monitored exposures were less than 6 μg/m³.

The manufacture of braided hose can also result in lead exposures when the hose is vulcanized by encasing it in molten lead, and heating the encased lead in an autoclave to yield a smooth surface (Ex. 476–290). The lead is then stripped off, melted and reused.

At the Gates Rubber Co. (Ex. 476–293) 20 environmental samples were taken. Exposures ranged from 10–190 μg/m³. The average of the samples was 87 μg/m³. The Gates Rubber Co. (Ex. 476–288) submitted data which indicate that all employees have 8-hour time-weighted averages below the PEL and that most are below the action level. The company does have problems with intermittent exposures in dross handling (these exceed 1,000 μg/m³) and maintenance, although the company is planning to install a new system for dross barrel handling which should reduce exposure.

B.F. Goodrich submitted sampling data from their braided rubber hose operation and found levels in 1971 with a median exposure of 34 μg/m³ and 1980 levels with a median exposure of 5 μg/m³. The lower exposure figures in 1980 may have resulted from an improved air filtering system which was installed primarily to comply with EPA lead regulations.

(e) *Additional Controls*

The control technology to comply with the PEL exists and in many cases has been installed by various plants. In some plants general ventilation may be inadequate to remove very small particulates and these systems may have to be upgraded. Also, some employers still use dry sweeping and compressed air blowing to remove dust; this must be replaced with vacuuming or wet sweeping. The transportation or storage of toxic materials in open containers (i.e., half bags, plastic cups) must also be replaced by contained methods.

Work practices are critical to successful dust control and many plants may have to use added efforts to change poor practices into good ones. Opening additive containers outside of the hoods provided for dust containment, sloppy handling of additive powders, poor opening procedures for bags, and generally improper use of local exhaust systems must be stopped and replaced with good work practices.

In plants with either nonexistent or poorly designed local ventilation systems, efforts must be made to insure that airflows are proper, exhaust slots are properly sized and placed, the appropriate duct transport velocities are achieved and hoods are of the proper depths. Ventilation systems should also be checked to ensure that they are not rendered useless by excessive cross drafts either from pedestal fans or open windows. Mixers, blenders, hoppers, feed chutes and conveyor belts should also be provided with local ventilation. Not enough emphasis can be placed on the importance of maintaining dust collecting systems.

Another control which may be required in some cases is the use of less dusty forms of the lead compounds. For example, Halstab offers lead stearate under the trade name, Hal-Lub-N, (described as light-tan flakes about 1 inch in diameter to keep down dusting in compounding operations) (Ex. 476–41). Kenrich Petrochemicals, Inc. offers litharge pre-dispersed in a rubber base under the trade name, Kenlastic. Litharge is also offered pre-dispersed in process oil in the form of a paste under the trade name, Kenmix. (Ex. 489). The use of pre-dispersions may offer other benefits. Kenrich points out that the use of pre-dispersions is standard practice for some applications where it is necessary to insure even mixing of high concentrations of litharge.

The use of a returnable container and sealed materials-handling systems to prevent escape of the product into plant atmospheres may also be necessary. Plastic bags which are soluble can be added unopened to the mixer, such as a product "Elastifilm," made by Goodyear (Ex. 489).

In some cases complete elimination of existing equipment may be necessary. Both ribbon blenders and Banbury's are internal mixers, and thus may be readily equipped with ventilation. The use of open two-roll mills for the initial mixing of rubber batches has largely been eliminated in the industry. It may not be feasible to install ventilation which would reduce airborne lead to acceptable levels on such equipment. The URW believes that the complete elimination of open mill mixing of hazardous materials for production batches is both feasible and necessary. (Ex. 476–291).

Once the rubber or plastic batch is compounded and mixed, exposure to lead from the batch itself is not usually a problem. Grinding or machining operations may generate rubber or plastic dust, but these operations are not unique to the rubber and plastics industry. Workers are also exposed to lead in the mixing and application of paint and ink, casting of lead tools and fittings, machining, of bushings, battery repair, soldering, etc. Again, these processes are not unique to the industry.

Metallic lead is used in the curing of rubber hose. While the process itself is not found in any other industry, the principles of control are the same as those for any process in which slab metallic lead is extruded, scrapped and melted to be reclaimed. Sampling data from URW Local Union No. 241 (Ex. 475–14) indicates that engineering control are feasible.

There has been widespread substitution of other materials for lead in the rubber industry. Further substitution of less toxic materials may be feasible in both rubber and plastics (Ex. 476–285) as well as in pigments for resilient flooring. Lead exposure in compounding can be controlled through the use of non-dusting forms of lead or through the use of engineering controls.

The URW (Id.) submitted exposure data for the Inland Division of GMC, using wipe samples for lead. Dust was settled on handrails and eye wash fountains, as a result of dry sweeping; some high dust levels were detected. This clearly demonstrates that the use of housekeeping will prevent secondary re-entry of dust into the workplace.

(f) *Conclusion: Technology Feasibility*

It appears that the technology exists in the compounding of plastics and rubber to achieve 50 $\mu g/m^3$. The exposure data which has been compiled indicates that levels are generally well below 50 $\mu g/m^3$ in some operations and exposures only intermittently exceed the PEL in others. The plastics industry is an extremely automated industry and controls used to increase productivity and product quality have also resulted in reductions in lead levels. Pre-measured colorants, stabilizers, etc., only insure that entire batches of plastics are not spoiled by sloppy, weighing. The URW submissions (Ex. 475–14) clearly demonstrate that compliance has been achieved in many operations by the use of controls such as automated and mechanized material handling and mixing operations, enclosed processes, and worker operating booths. The advent of pre-mixed and containerized additives has further eliminated the need for workers to handle toxic additives.

(g) *Costs of Compliance*

(i) *Plastics.* Of the four manufacturers of lead stabilizers, only American Cyanamid submitted data to OSHA. They indicated that a study performed for them by a consulting firm estimated a cost of $746,600 to install engineering controls to lower levels to 200 $\mu g/m^3$ and to modernize the plant. The company further indicated that the cost of implementing a 1979 settlement agreement between them and OSHA was estimated to be $75,000 for feasible engineering controls (Ex. 475–30). However, assuming that each of the four companies producing lead stabilizers will each need to spend $750,000, the total capital costs for this industry would be $3,000,000. American Cyanamid stated that levels would not be reduced below 200 $\mu g/m^3$ and contended that "space age" technology would be necessary to achieve a 50 $\mu g/m^3$ standard (Ex. 475–30). OCAW argued, however, that using design concepts based on existing technology, American Cyanamid has a good chance of meeting the current lead standard (Ex. 475–34).

No manufacturers of plastic products submitted any cost or other data to OSHA on the issue of feasibility. However, Monsanto Corporation indicated that it does not have any lead exposure problems (Ex. 476–289). Similarly, Dow Chemical, which infrequently uses lead in its plastics operations, does not have an exposure problem (Ex. 476–281). Congoleum Corporation, which produces resilient vinyl flooring, uses lead predominantly in a wet form, thereby virtually eliminating an exposure hazard (Ex. 476–286) Armstrong, which is also a producer of resilient vinyl flooring, has substituted other materials for lead in its pigment and stenciling operations (Ex. 476–285).

(ii) *Rubber.* In 1976, B. F. Goodrich contended that engineering controls would cost a total of $255,000 to control 600 exposures to lead (Ex. 474–3(133)). This is an average cost of $425 per exposure. No supporting data were provided to explain what controls the estimate reflects or how the estimate was calculated.

In connection with the October 1980 hearings, B. F. Goodrich provided data indicating that its lead encased hose plant is substantially in compliance with the lead standard, most likely as a result of installing an improved air filtering system to reduce emissions into the ambient air (Ex. 476–284). In a similar operation, Gates Rubber reported that while all employees were below the 50 $\mu g/m^3$ standard, brief high excursions occur in three operations. It was added that control of these operations by means of engineering controls would be prohibitively expensive, however, no cost estimate was offered (Ex. 476–288). OSHA assumes worker rotation will be used to achieve compliance, thus creating no significant costs.

No compliance costs were submitted for other users of lead compounds in the rubber industry. This is most likely because the potentially affected companies have already come into compliance by means of process changes or substitution. For example, B. F. Goodrich no longer uses lead as an accelerator in the manufacture of tires (Ex. 476–284), and in compounding, exposure can be controlled by substitution of less toxic substances or by use of nondusting forms of lead products which are supplied by a wide range of producers (Ex. 489). Significant commercial benefits in the form of increased product quality are also promoted as advantages of these control measures (Ex. 489).

(h) *Industry Profile*

(i) *Plastics.* From 1972 to 1977, total value of shipments in the plastic materials industry (SIC 2821) increased 141 percent to $10,818,000,000 and total value of shipments in the manufacture of miscellaneous plastic products (SIC 3079) rose 121 percent to $23,688,000,000. There were an estimated 397 establishments employing 36,700 production workers in SIC 2821, and 10,212 establishments employing 358,000 production workers in SIC 3079. New capital expenditures have grown from $654,000,000 to $1,154,200,000 in SIC 3079 and from $253,200,000 to $895,200,000 in SIC 2821 between 1972 and 1977. (Ex. 476–20). The plastics industry is expected to outperform the economy and grow at a rate of 4 percent to 5 percent in 1980 (Ex. 476–26).

However, only four companies—American Cyanamid, Associated Lead, Hammond Lead, and to a limited extent, Eagle-Picher—produce lead-based stabilizers (Ex. 475–30). These stabilizers are commonly used in the production of polyvinyl chloride (PVC) plastic insulation for application in commercial and residential electrical wiring. The final product contains 4 percent to 6 percent lead stabilizer which prevents degradation. There is no substitute available, that can impart the same heat stability and electrical properties (Ex. 475–30). Therefore, because no substitute products are available, any increases in costs due to the lead standard can be passed on to the consumers.

Approximately 21,000,000 pounds of lead stabilizers were produced in 1976 and the projected growth rate for the industry is 3 percent per year. The industry is characterized as mature with a flat sales growth curve. Over 100 downstream consumers of lead stabilizers produce finished products containing stabilizers. The wire and cable industry alone annually uses about $200 million of lead stabilized PVC for insulation (Ex. 475–30).

Lead compounds are also added to plastics as colorants. The market for colorants varies with cyclic changes in color preferences or tastes and is generally characterized by a steady mass market for a few simple "wide-tolerance" colors (Ex. 476–295). The incorporation of colorants should be done in a manner that speeds production, upgrades product quality, and reduces cost. Dry coloring, which is the most hazardous operation for workers, offers the marketing advantage of almost unlimited color range and flexibility in production color changes. However, it generates dust which may contaminate other products, does not disperse as completely as other forms of colorants, and involves careful weighing, timing of batch mixing, and drying of the resin (Ex. 476–295). Other methods of adding colorants, such as using wet or paste colorants or pelletized products, avoid these disadvantages while virtually eliminating the potential exposure of workers to lead. Thus, OSHA concludes that methods for complying are readily available and that these measures will probably yield commercial benefits for producers in addition to bringing them into compliance with the lead standard.

(ii) *Rubber.* There are an estimated 56 companies operating 63 establishments that employ 7,100 production workers in the manufacture of synthetic rubber (SIC 2822). In addition, there are 127 companies employing 88,300 production workers in 200 tire manufacturing plants (SIC 3011) and 102 companies employing 23,400 production workers in 146 establishments manufacturing rubber and plastic hose and belting (SIC 3041).

One-third of the establishments in SIC 2822 (synthetic rubber manufacture) employ fewer than ten employees per plant, nine employ more than 500 employees per plant and one firm employs between 1,000 and 2,500 employees. Data on the latter are withheld to avoid disclosing operations of the company, however, the ten largest companies by employment (or one-sixth of the firms) produce $1,355,100,000 out of a total value of shipments of $1,863,300,000 (or 72.7 percent) and invested $36,200,000 in new capital expenditures in 1977. Similarly, 65 of 200 establishments in SIC 3011 (tire manufacturing) employ fewer than 10 employees and 46 establishments employ more than 1,000 employees. One-quarter of all firms produced $7,500,700,000 in value of shipments out of a total of $8,971,000,000 (or 83.6 percent). The distribution of firms by employment in SIC 3041 is much more even, however, the top five firms produced $675,100,000 in value of shipments out of total industry shipments of $1,765,700,000 (or 38.2 percent). Thus, some degree of concentration is apparent in the three industries (Ex. 476–20).

Exposures above the standard (although not necessarily as TWA's) occur only in the production of lead-encased hose. There are only 12 to 15 domestic companies out of more than 100 involved in such operations (Ex. 476–290). No evidence of a suitable substitute for lead-encased hose was apparent. Therefore, OSHA concludes that the demand for this product is inelastic and that the increased cost of production as a result of potential compliance costs, if any, can be passed on to consumers.

(i) *Conclusion: Economic Feasibility.*—(i) *Plastics.* In their submission, American Cyanamid did not provide any financial or profit data for their firm's operations upon which OSHA could evaluate the economic feasibility of these costs (Ex. 475–30). OSHA estimates that if each of the four companies producing lead stabilizers will each need to spend $750,000, the total capital costs for this industry would be $3,000,000. This represents an annualized cost of about $540,000 or about 0.3 percent of the $200 million in annual sales of lead stabilized PVC for insulation alone. OSHA therefore concludes that the standard is clearly economically feasible for this industry.

No other manufacturers of products submitted data concerning the issue of economic feasibility. However, Monsanto Corporation, Dow Chemical, Congoleum Corporation, and Armstrong have no exposure problems or have already eliminated such problems. Moreover, the control of lead exposures, in particular in its use as a colorant through the use of wet or paste colorants and pelletized products, will probably yield commercial and financial benefits to producers which will offset, at least partially, the cost of complying with the lead standard. Since the total value of shipments in the plastic materials and miscellaneous plastic products industries is over $34 billion, OSHA has concluded that the minimal increases in costs that may be necessary to comply with the lead standard are clearly economically feasible.

(ii) *Rubber.* Exposures above the standard occur in only 12 to 15 domestic companies. If each of these companies needs to spend $255,000 to install engineering controls, as B.F. Goodrich estimated, this would total, at most, $3,825,000 in capital costs or about $687,000 in annualized costs. This amounts to $45,800 for each of the 12 to 15 companies involved. The total shipments for the manufacture of rubber and plastics hose and belting is $1,765,700,000. Dividing by the number of companies in this industry (102) yields an average of $17,310,000 in shipments. The annualized cost of $45,800 represents less than 0.3 percent of the average shipments for these companies. OSHA therefore concludes that the standard is economically feasible.

32. Plumbing

(a) *Uses*

Lead is utilized in about 15 percent of the plumbing business. Lead is still used in extra heavy pipes, some drain wash and vent systems, and in roof flashing to waterproof the area where a pipe penetrates the roof. It is also used in 4-inch pipes for closet benz and ¾-inch pipe for water surfaces. Previously, lead has been used as a noncorrosive lining for shower floors, but this use is being displaced by plastics, copper and coated steel. (Ex. 22, p. 284).

The most common use of lead is for lead and oakum (jute-like fiber) joints used to repair oil lead-oakum joints. The use of lead-oakum is a time-consuming and old-fashioned method of plumbing repair, and is most prevalent in the Eastern Seaboard area. The old lead-oakum joints are being replaced by metallic clamp joints with compression gaskets. The newer materials are often easier to work with and much lighter than lead and, therefore, more desirable. (Id). Lead is also used in the soldering of copper pipe joints.

(b) *Process Description and Exposure Areas*

When used in joints, lead is melted in a small pot and typically dipped out with a 24-inch ladle. The plumber's work areas are 18–25 inches from their noses. They wear gloves, but not respirators, and the lead is barely molten, with few fumes present (Ex. 22, p. 384).

(c) *Controls Currently Used*

Plumbers may work in well ventilated open areas or in confined areas. The controls most often used in confined areas would be local exhaust ventilation or dilution, although the data submitted showed no use of ventilation. (Ex. 22, p. 384).

(d) *Exposure Levels*

The American Society of Plumbing Engineers, the Plumbing, Heating and Casting Information Bureau, and the Plumbing Manufacturers Institute indicated that lead in plumbing is being phased out and they know of no exposure data. (Ex. 476–346, 349 and 350). The Plumbing and Mechanical Officials indicate that lead is still in the Codes of Chicago and New York (lead-oakum). (Ex. 476–353). The only exposure data available came from a report from the Heating and Plumbing Contractors of California which indicated that levels were well below the OSHA Standard, ranging from 4–10 $\mu g/m^3$. A NIOSH survey on the Denver Dry Good Company showed similar results with lead levels from 0.01—0.03 $\mu g/m^3$ (Ex. 476–351). This is a once-a-year operation with no ventilation. The levels are sufficiently low that they will rarely exceed the 30 $\mu g/m^3$ action level.

(e) *Additional Controls*

None are necessary, since compliance with the standard is already achieved.

(f) *Conclusion: Technological Feasibility*

Exposure data indicates that lead levels are below the 50 $\mu g/m^3$ standard and that this industry is in compliance with the lead standard. However, it should be noted that plumbing work which is part of construction operations is beyond the scope of the standard.

(g) *Economic Feasibility*

No cost of compliance and no economic impact are anticipated, because levels are below the 50 $\mu g/m^3$ level.

33. Pottery and Ceramics

(a) *Uses*

Pottery and ceramics manufacture includes production of ordinary building bricks and tile, sewer pipe and electrical conduit, drain tile, refractory bricks of all kinds, electrical and chemical porcelain and stoneware, whiteware such as dinnerware, china, floor and wall tile, porcelain enamels and abrasives. (Ex. 476–359).

(b) *Process Description and Exposure Areas*

The process begins with the proper amounts of clays being weighed and blended to form a slip. The slip flows to filter presses where it is pressed into cakes (aging may be done). The slip is then converted through more mixing into a casting slip or sent for jiggering or jolling. (Ex. 476–5 G).

Casting of the slip is usually done in plaster of paris molds. Castings are dried in hot air dryers prior to firing. Glaze coastings may also be applied to dry ware prior to firing.

In jiggering or jolling the clay is fed from the storage bins to a pug mill and mixed with water to form a mud. The mud is then forced by augers through a die to form a wad. The wad is fed to the jigger which consists of a rotating unit carrying a mold which will form one face and a tool which will form the other. The ware is then dried, and glazed (if necessary) prior to firing.

Exposure to lead results from the use of frits applied as a glaze (Ex. 22, p. 211; Ex. 476–357, 373). These are nonsoluble lead silicates, lead borates or bi-silicates. (Ex. 22, p. 211). Some companies also make the raw material which comprise the glazing compounds (Ex. 476–369). A discussion of the control problems in the manufacture of glazing materials is discussed in pigment manufacture. Fine china manufacturers may also use white lead (Ex. 476–363).

The preparation of frits for glazing requires that lead-based materials be mixed with other materials and ground in a ball mill. (Ex. 476–373, 363). Water is usually added (Ex. 22, p. 211, Ex. 476–373) and the glaze applied to the piece by spraying or dipping, (Exs. 22, p. 211; 476–371); 476–372; 476–373), either manually or by machine. The piece is then placed on a "setter" which is introduced into a kiln for firing (Ex. 22, p. 211).

The other processes and job titles in which lead exposures occur include the manufacture of the glaze (the slip house leader, journeyman, forklift operator); the application of the glaze to the ware (the dipper, duster, glaze cleaner, glaze sprayer, inspector, spray machine loader, unloader, operator, setter-carrier, reclaim operator, and service operator); and, the handling and firing of the glazed piece (kiln placer, setter, reworker and kiln utility). Other exposed employees include the production supervisors and technicians. (Ex. 476–373).

(c) *Controls Currently Used*

The materials handling controls used to handle glazes or glazing compound components are the same as those used by many other industrial segments. Materials may be mechanically dumped or pneumatically conveyed. Materials may be stored in bins and gravity fed or containers may be dumped in ventilated areas. Premeasured, containerized glaze components may be added to the mixers in disposable containers to reduce the potential for dust exposure. System enclosure and local exhaust ventilation at point of emission are controls which have been used successfully. Also, mixing the glazing compounds with water at the ball mill reduces the dust exposure but does not eliminate the potential for lead exposure since the mist formed may contain lead.

The glaze is usually applied to the ware either by spraying or dipping the ware. Spraying or dipping may be done manually but spray booths and mechanized dips are usually used. Local exhaust ventilation is used in both manual and mechanized operations to reduce exposure levels. Spray booths may be automated with workers controlling operations from outside the booth or may require the worker to hand spray the ware from within.

Glazes which are applied as powders to heated surfaces require extensive automation and ventilation controls to achieve exposure limits of 50 $\mu g/m^3$ (Ex. 476–369).

Once the ware has been glazed, it must be dried. Drying is done either by allowing the ware to sit in well-ventilated areas, or gas-fired or infrared dryers may be used. Local exhaust ventilation is usually employed to capture emissions from the drying ware.

(d) *Exposure Levels*

Data submitted by Employers Insurance of Wausau indicated that lead levels in the tile and ceramics industry ranged from 10–140 $\mu g/m^3$. The highest measured levels, 140 $\mu g/m^3$, were found in the batch making process. Workers in glaze making areas were exposed to levels of 210 $\mu g/m^3$ and the machine operator had an exposure of 130 $\mu g/m^3$. Weighing and mixing workers were exposed to levels of 70 $\mu g/m^3$ with hand dipping glaze workers being exposed to 60 $\mu g/m^3$ of lead. A description of the engineering controls used, if any, was not provided, also it is not clear whether these were time-weighted averages, area exposures, or peak exposures.

Exposure data collected at the Allan-Bradley Co. indicated that lead levels in their mixing and pressing departments were 0.4–0.3 $\mu g/m^3$ (Ex. 476–367). This company employed 374 persons; 246 production workers of whom 36 were monitored for lead exposure.

A survey done by NIOSH on the Lance Corporation found lead levels ranging between 10–70 $\mu g/m^3$ in the dipping operation. (Ex. 476–370). Data was not available for mixing operations. Lead levels resulting from the firing of glazed ware were nondetectable in the kiln area.

During an OSHA inspection, levels of 19–31 $\mu g/m^3$ were reported for a company using a Binks spray booth in the glaze application department (Ex. 476–377).

Other companies submitted data indicating percentages of employees above or below 50 $\mu g/m^3$, however, the exact levels above 50 $\mu g/m^3$ were not provided. For example, Piezoelectric (Ex. 475–40) which mixes and applies glazes containing litharge and red lead estimates that 80 percent of their employees are exposed to 50 μg/m³ or less and that 20 percent are exposed in excess of 50 μg/m³. The company also indicated that exposure above 50 μg/m³ occurred from "time to time" and did not indicate that levels were generally above 50 μg/m³.

Lenox China estimated that out of 130 lead exposed workers, 50 percent are exposed to less than 50 μg/m³. The other 50 percent are estimated to be exposed in excess of 50 μg/m³ (Ex. 476–373).

(e) *Population Exposed*

Short estimates that the total population of potentially exposed employees in this industry ranges from 1,000 to 10,000 people. (Ex. 22, p. 211). Data presented from companies indicate that levels are closer to 1,000. (Ex. 475–25; 475–29; 476–371; 476–372; 476–373). This lower figure is consistent with the statement from the Fine Earthenware Food Utensils and Vitrcore China Food Utensils who have estimated that potentially exposed employees range from 1.5 percent to 8 percent of production workers in these industries (Ex. 22).

(f) *Additional Controls*

Some companies appear to be in compliance, some are nearly in compliance and some will be required to make changes in current controls to achieve compliance with the 50 μg/m³ standard. The controls are available and many companies have used engineering controls to effectively reduce lead exposure levels. Others may have to apply these successfully used controls to achieve compliance with the 50 μg/m³ standard. For example, problems in batch processing areas have been solved by installing new conveying systems including tanks, pneumatic conveying systems and local exhaust ventilation at emission sources (Ex. 476–369).

Some companies that manufacture the raw chemical ingredients used to prepare the glazes have installed reclamation systems in which the plant is blown down every two weeks and materials are collected and remelted to be used again in the process. These reclamation systems may also be effectively used by companies mixing and applying the glazes (Ex. 476–356).

In one plant, through various control strategies, several areas are kept below 50 μg/m³. These areas were not identified but the controls which had been installed included total enclosure of certain equipment, installation of wet scrubbers with special ductwork, employee rotation and upgrading the housekeeping (Ex. 476–373).

In areas of exposure above 50 μg/m³ the employer stated that additional scrubbers and dust collection systems can be installed, with increases in the air velocity of existing systems (Ex. 476–373).

Billings testified that exposure to lead in the spraying operation could be reduced by dipping the ware rather than spraying. However, Merwin of the USPA said that dipping is much slower and that generally, spraying is done automatically in an enclosed booth (Ex. 476–363; 476–366), although some companies must dip odd shaped ware. Airless spraying may also be used to reduce lead exposures. Although, as Mr. Merwin testified, to his knowledge there is no airless spraying done in this country. Currently, however, there is a company in the United States (U.S.P.A.) selling airless units (Ex. 476–363).

If methods such as dipping or airless spraying cannot be done, more effective spray booths such as the Binks spray booth may be used. This booth is 37 inches in height, 42 inches in width, and 46 inches in depth. It spins the ware and has a deflection screen. Face velocities ranged from 200 to 350 fpm and behind the booth there is an exhaust chamber which collects the excess glaze. This booth is very efficient and does keep levels below 50 μg/m³ (Ex. 476–377).

Where employers are reluctant to replace existing spray booths with more efficient models, upgrading of existing ventilation controls may be necessary.

In finishing operations requiring buffing and grinding of ware, local exhaust ventilation may need upgrading. For example, in a NIOSH survey of one finishing operation, ventilation hoods had face velocities of 0–10 fpm for soldering, 200–600 fpm for the buffing, 0–960 fpm for polishing operations, 50–200 fpm for spray booths, and 60–150 fpm for the toolroom. NIOSH recommended upgrade and repair of existing systems and noted that maintenance appeared to be lacking in most cases (Ex. 476–370).

In may cases, effective maintenance, improved housekeeping, and worker rotation may be necessary to achieve compliance with the 50 μg/m³ lead standard.

Lenox indicated that they have been unable to reduce air levels to 50 μg/m³ through engineering controls. At present they have plans to add controls in the glaze department including modifying the hand dip dryer and installing down draft tables, purchasing a high lift truck for overhead cleaning, purchasing a high efficiency vacuum and filter system, installing a scrubber, installing a spindle wash system, modifying spray booths and tunnels, modifying dust collectors, installing infrared dryer systems, applying sealant to the floors and walls and purchasing a truck and board cleaner. Lenox is also installing a dust collection system at the ball mill loading area in the slip department and at the die making area in the mall department. These controls will be completed in 1981. Work practices currently being implemented include both daily clean up in the glaze department and quarterly cleaning (which includes all elevated equipment, piping, electrical conduits, light fixtures). This employer is continuing to share information with other manufacturers to improve work practices and expects the improvements will take another 2 to 5 years to complete. Thus they summarize their submittal by recommending a 5-year implementation schedule (Ex. 475–25).

(g) *Conclusion: Technological Feasibility*

As previously stated, some companies and some processes are in compliance with the 50 μg/m³ standard. Others like Lenox will be required to make improvements to existing controls to achieve 50 μg/m³. The company anticipates that these controls will achieve the PEL but notes that they are not certain that this will be the case. The company also stated that 5 years will be necessary to implement all controls—work practices and engineering (Ex. 475–25).

OSHA finds several puzzling problems with these industry compliance assessments. First, as Dr. Billings testified, careful planning and design of ventilation equipment require that companies plan controls with the premise that a margin of error is designed into the equipment. More precisely, if you are to comply with the 50 μg/m³ PEL, controls should be designed to achieve a level equal to 10 percent of the desired PEL (5 μg/m³) or at least some margin of error should be used (Tr. 106). Also, since OSHA was not furnished with a description of specific controls for this particular company, it is difficult to determine if the need for extensive use of ventilation equipment is a result of the inadequacy of existing controls or the complete lack of any controls. Also, the Agency wonders if some of these controls, especially those having to do with scrubbers and capture equipment, require extensive upgrade as a result of the high levels of silica found in the plant and only secondarily to reduce lead levels. As a result of these questions, the Agency is unable to determine with any certainty the extent to which these controls will actually be necessary to achieve compliance with the lead standard and the extent to which other airborne contaminants will also be reduced. Also, the Agency is unable to determine, what, if any, controls were existing before this extensive remake was begun.

The company also indicated that 2–5 years would be necessary to implement work practices and 5 years would be necessary to implement engineering controls. Clearly, however, it does not take two years to train employees in the proper handling of toxic materials and to maintain surfaces free from dust accumulations. The most effective work practice programs have been developed by employers simply observing employee work habits. Not every employee has to be followed through his daily routine; excessively high blood lead levels often signal the employer that employee practices may be the source of the problem (See Cable Coating discussion). Regarding the issue of whether a 5-year implementation period is necessary to achieve compliance with 50 $\mu g/m^3$, it appears that this company may need this amount of time. The time indicated by this company only considers the implementation of engineering controls to achieve compliance. OSHA, however, has given all industries the option of using a variety of control strategies as opposed to specifying only the use of engineering controls. By employing this strategy, OSHA is allowing employers the maximum amount of flexibility in complying with the standard and in fashioning solutions consistent with their particular workplace situations. Therefore, OSHA finds that compliance with a 50 $\mu g/m^3$ PEL is feasible within one year for the pottery industry.

While some employers may experience difficulty achieving compliance in some operations, it is not because the technology does not exist. Also, this industry appears to rely too heavily upon engineering controls to achieve compliance and has ignored the less costly approaches of work practices, housekeeping and worker rotation.

(h) *Cost of Compliance*

Several producers in different SIC's within the pottery industry have provided cost data to OSHA for this standard. In SIC 3261, Vitreous Plumbing Fixtures, Koehler estimates that it has already spent $2.5 million to eliminate its exposure problems. Controls included an entire new structure, tanks, pneumatic conveying system, and ventilation (Ex. 476–369). The specific controls are not described in detail, nor was a derivation of the cost estimate provided. However, the costs attributable to the lead standard are properly represented by the difference between the costs for a new plant and equipment including control equipment, and the costs that the firm would have undertaken in the absence of the standard. In this case, Koehler may have changed systems primarily for commercial reasons, such as to increase productivity or capacity, rather than as a response to a regulatory action. Koehler indicated that the changes made were beneficial to production but did not indicate why this was true (Ex. 476–369).

In SIC 3262, Vitreous China Food Utensils, two producers provided cost data to OSHA. Lenox has already invested in some control technology. By 1981, Lenox will have spent $230,000 on engineering controls and $200,000 on work practices (Ex. 475–25). Lenox also indicates that it is converting to "low solubility fritted glazes", and requests that a 5-year implementation period be adopted for the schedule of compliance in pottery manufacture (Id.).

On behalf of the producers of products in SIC 3263, Fine Earthenware Food Utensils, the American Ceramic Tableware Council submitted comments indicating that the standard will require extensive and costly engineering controls and new work practices (Ex. 475–29). Neither the specific controls required nor the actual cost estimates were provided. However, the submission states that the Department of Commerce, which is currently devising strategies to increase the competitiveness of domestic earthenware producers, may recommend expenditures for new, technologically superior plant and equipment (Ex. 475–29). Expenditures of this kind, incorporating modern control technology, would be preferable to more costly and often less efficient retrofit technology. Such outlays may provide long-run savings with respect to production compliance costs by removing workers from exposure sources. A quantification of these savings, however, must be postponed until data on compliance costs become available.

Finally in SIC 3264, Porcelain Electrical Supplies, Vernitron Corporation submitted cost information for its Piezoelectric Division. Vernitron indicates that numerous engineering and work practice controls have already been implemented and asserted that the cost of achieving compliance with the 50 $\mu g/m^3$ standard, would be between $300,000 and $500,000 (Ex. 475–40).

DBA submitted the only industry-wide estimates of the costs of compliance in the pottery industry. They considered both the installation of local exhaust ventilation at stations where workers may mix and spray frit and the additional costs for maintenance and housekeeping. DBA's estimates of the total capital costs ranged from $1,000,000 to $10,400,000 and annual costs from $770,000 to $7,700,000 on the basis of a population at risk of 1,000 to 10,000 exposed workers. Their estimates of annualized capital costs ranged between $177,000 and $1,869,000. OSHA believes that these estimates are reasonable and thus the industry's total annual costs are not expected to exceed $9,569,000 and may be as low as $947,000.

(i) *Industry Profile.* There are 54 companies operating 70 establishments in SIC 3261, Vitreous Plumbing Fixtures. The firms employ 7,800 production workers whose average hourly wages were $6.23 in 1977. The four largest companies, measured by number of employees, produce about 25 percent of the total value of shipments, while the top 30 firms produce $390,900,000 out of $411,400,000 (or 95 percent) of shipments (Ex. 476–20).

Both Koehler and Eljer Plumbingware said that lead is no longer used in coating sanitary pottery, but potential exposures to lead may occur through application of glazes on product lines (such as sinks and bathtubs) in which porcelain enamels are sprayed onto cast iron base metals (Exs. 476–356, 369). While stainless steel sinks and plastic bathtubs and other plumbingware products made from relatively inexpensive materials have captured an increasingly large share of the market, Koehler, Eljer, American Standard, and a few other firms still make cast iron products (Ex. 476–350). Since these firms appear to be substantially in compliance and have not submitted contrary evidence to OSHA, compliance costs, if any, are assumed to be minimal and will not result in significant economic impact. If some consumers maintain preferences for the cast iron base plumbing fixtures, then the relatively inelastic demand for this "specialty product" would allow producers to pass on the costs of compliance with the standard to the customers.

Porcelain enamel is also applied to many durable goods, such as stoves, refrigerators, washers, and dryers (Ex. 476–360). There are no substitutes for porcelain enamels in these uses. However, the lead colorant is a very small proportion of the final price of the product. Thus, costs of compliance are not expected to significantly increase the price of major appliances, and this minimal cost would likely be passed on to consumers.

Since 1963, the number of firms in SIC 3262, Vitreous China Food Utensils, has risen slightly from 26 to 27, with a maximum of 35 firms in the market in 1967. Employment has been relatively steady with about 6,000 production workers in the industry in 1977. Capital expenditures have risen steadily from $700,000 in 1963 to $5,400,000 in 1977. Average wages have increased from $2.22 per hour in 1963 to $4.82 per hour in 1977. Three establishments employ more than 50 percent of the production workers and produce over 50 percent of the total value of shipments in the industry, which were $170,700,000 in 1977 (Ex. 476–20).

There are only three producers in the American fine china industry today. These companies are Lenox, Gorham Division of Textron, and Pickard (Ex. 476–362). Manufacturers of fine china are the only users of white lead in the pottery industry (Ex. 476–363). Lenox alleges that competitive pressure from foreign producers has caused eight domestic firms to close down (Ex. 475–25). It contends that foreign imports now dominate 75 percent of the fine china market (Id.).

In SIC 3263, Fine Earthenware Food Utensils, the number of establishments has been relatively constant over the years (20 firms in 1963; 22 firms in 1977). However, the number of production workers has fallen from 6,600 in 1963 to 3,500 in 1977. Capital expenditures have increased from $800,000 in 1963 to $1,700,000 in 1977, while average hourly wages have risen in that period from $2.14 to $4.23. Four establishments produce $52,400,000 (or 64 percent) of the total value of shipments of $81,300,000 and employ 2,000 of 3,500 workers (Ex. 476–20).

The American Ceramic Tableware Council has submitted comments (Ex. 475–29) on behalf of several of the producers of earthenware (Anchor Hocking, Hall China, Homer Laughlin, Pfaltzgraff, Royal China, Sabin, and Scio Pottery), who use lead in their glazes (Ex. 476–362). Lenox also produces dinnerware in this market (Ex. 475–25). However, there are many small firms with limited access to capital and who use labor intensive processes in the industry (Ex. 475–27).

SIC 3269, Pottery Products, Not Elsewhere Classified, consists of 727 establishments employing 9,200 production workers. The industry has grown since 1967 when 434 establishments employed 6,700 production workers. Average hourly wages in the industry have risen from $2.05 in 1967 to $3.88 in 1977. More than half of the establishments are small (four employees or less) and 677 (or 93 percent) out of the 727 establishments employ fewer than 50 employees. Most of these small plants are centered in and around Ohio (Ex. 475–29). The top four companies, measured by number of employees, employ at most 500 workers each and produce $41,700,000 (or 18 percent) of a total value of shipments of $229,900,000 (Ex. 476–20).

Lenox and the American Ceramic Council report that the domestic earthenware industry is struggling to maintain a 20 percent share of the domestic market in the face of severe foreign competition (Ex. 475–25 and Ex. 475–29). The industry submissions cite 75 percent and 80 percent penetration of the market by foreign producers, chiefly from Japan. However, the Department of Commerce shows imports of china dropping by 7 percent and earthenware imports by 9 percent in 1979. Total market share in 1979 by foreign producers is estimated at 44 percent and 59 percent for china and earthenware, respectively (Ex. 476–26).

Industry cites lower labor costs (Ex. 475–25), more relaxed regulatory constraints (Ex. 475–29), and unfavorable tariffs (Ex. 475–25) as major reasons for domestic competitive disadvantages. The claims are made, for instance, that British regulations classify low solubility fritted glazes as nontoxic, and that wage differentials between the United States and Japan create a situation in which the Japanese worker is paid 55 percent of the average American worker's wages for comparable work (Ex. 475–25). However, it is not clear that the wage comparison reflects real wages. Furthermore, the conclusion assumes that the Japanese and other foreign producers are not enjoying cost advantages based on a more advanced technology. Finally, since the Japanese pursue stringent environmental regulations, they probably have no competitive advantage in this respect.

Lenox China, which is a wholly-owned subsidiary of Lenox, Inc., and which was the only company responding individually, did not submit financial data to OSHA on the grounds that the information is confidential (Ex. 475–25). However, OSHA is not convinced that Lenox will be forced to absorb compliance costs. Luxury items, such as fine china, are often purchased on the basis of brand reputation. Thus, increases in price may not significantly affect demand.

There are 77 companies operating 86 establishments in SIC 3264, Porcelain Electrical Supplies. The industry employs 9,100 workers whose average hourly wages were $5.55 in 1977. The six largest firms, measured by employment, produced $172,700,000 (or 47 percent) of a total value of shipments of $367,500,000 and invested $11,600,000 (or 56 percent) of the industry total of $20,900,000 in new capital expenditures (Ex. 476–20).

Vernitron Corporation, which manufactures piezoelectric ceramic parts, is aware of eleven other plants distributed nationwide that compete with it in the electrical porcelain market. Total sales in this market are estimated at $20 million with no one company holding a dominant position (Ex. 475–40). The company comments that imports are increasing steadily although it has not provided documentation or estimates of the market share controlled by imports. This company shows a negative rate of return on equity from 1975 through 1977 (an average of minus 11 percent) and a 1979 profit of 10 percent. In view of its poor performance, the company may close its facility rather than invest in additional control measures (Ex. 475–40). However, no other companies in the industry came forward with similar data. Thus, OSHA has no reason to conclude that Vernitron's financial situation is typical of the industry.

(j) *Conclusion: Economic Feasibility*

The five markets within the pottery industry that are potentially affected by the lead standard produced shipments valued at $1,260,800,000 in 1977 (Ex. 476–20). OSHA estimates, based on the calculations of DBA, that compliance costs in these industries may be as low as $947,000 annually, but are not expected to exceed $9,569,000 annually. Hence, the costs of compliance range between 0.075 and 0.76 percent of total value of shipments.

The minmial size of the estimated costs compared to shipments leads OSHA to conclude that compliance with the lead standard will not cause economic disruption in the pottery industry. The industry appears to be under increasing pressure from foreign imports, a trend that is not likely to end in the near future. This pressure may reduce future profits for American firms, but the small, additional profit reduction that these firms may incur as a result of the lead standard should not severely affect the profitability of most firms in this industry. Although it is possible that some small firms may have some difficulty competing, OSHA does not expect, and the evidence does not show, that the viability of the industry as a whole will be threatened by compliance with this standard. OSHA therefore concludes that the standard is economically feasible for the industry. Moreover, this OSHA action may stimulate modernization in this industry, which should result in both increased protection for workers from lead exposures and an improved competitive position vis-a-vis foreign producers.

35. Shipbuilding

(a) *Uses*

The shipbuilding industry includes repair as well as construction of ships. The sizes of the shipyards and the types of vessels being repaired or built vary widely. Also, shipbuilding may involve many construction activities found in other industries. Some shipyards have their own foundries, furniture shops, restaurants, alloying departments, blacksmith shops, carpenter shops, machine shops, etc. However, the major activities of the shipbuilding industry are: (1) The building of steel frames and hulls, and (2) the outfitting of the ship with its propulsion and support equipment (Ex. 26). Both activities are very closely related and are often present in the same shipyard. This industry also includes the conversion or alteration of ships.

Although the number of establishments included in SIC code 3731 exceeds 450, the actual number of private American shipyards totals approximately 138. Ten additional shipyards are operated by the U.S. Navy. It is estimated that only three shipyards are capable of constructing nuclear powered vessels.

(b) *Process Description and Exposure Areas*

(i) *Construction.* A ship's hull is almost invariably made of sheel sheet plate of varying thickness that is often coated with a primer paint to reduce corrosion and make the work cleaner. The steel plate is treated initially by automatic shotblasting machines that shotblast both sides of the plate at once. (Small components (e.g., castings) may be shotblasted manually.) The plate is then painted, mostly by automatic spraying in booths by multi-head spray-guns. Hand-spraying and brush painting must be repeated to prevent corrosion because subsequent burning and welding removes paint. Final painting of the hull is done by airless spray painting.

The steel plate is then ready to be cut and bent to shape. It is cut by oxyacetylene, oxypropane or oxybutane flame. Larger or duplicate pieces are cut on automatic machines. Cutting by hand-burner is done mainly during hull erection since surplus material must be removed and small holes made for access or fittings. Some cutting is done by guillotine. Small parts may be formed using a punch press.

The shaping of steel pieces is accomplished by hot or cold processes which bend, roll or press. The shaped pieces of steel plate are then welded together to form units and subassemblies, a technique which has largely superseded drilling and hot riveting.

The majority of welding is performed manually, using consumable stick electric-arc electrodes, although increasing use is being made of automatic and semi-automatic electric-arc processes. These are often CO_2-shielded, and may use flux-cored or plain wire continuous electrodes. Gas welding is often used for pipe assembly.

Subassemblies are usually prepared in fabrication sheds and virtually all work is done under cover. The trend toward subassembly manufacturing techniques reportedly will continue in many shipyards. The number of launching berths has been reduced to increase the ground area available for prefabrication sheds. Thereafter, these large pieces, which will form the hull when fitted together, are moved by crane to the slipway or dock where the hull is being erected, usually in the open. They are welded together mainly by portable automatic welding machines.

Where high-quality welding is required, weld metal may be cut back to remove flaws either with compressed air chisels or by electric-arc air-gouging, where the melted weld metal is blown away with a high-pressure air jet. Further welding fills the groove and completes the joint. At this point, X-ray or ultrasonic equipment may be used for quality control. Finally, the weld bead may be trimmed flat by mechanical chisel or grinder (Ex. 476–385, p. 1303).

In recent years, more and more stainless steels have been used in shipbuilding, particularly in ships designed for nuclear propulsion or in cryogenic liquid container ships. Additionally, lead has become a prevalent material in nuclear powered vessels and submarines. A certain amount of the superstructure may be formed from aluminum alloys using argon-arc welding.

Once the hull of the ship has been erected it is launched from the slip or dock and floated to a fitting-out berth. In the fitting-out berth, pipes are fitted and insulated, electrical wiring and controls are installed, living accommodations are constructed, the super-structure is completed, and the deck equipment and rigging are installed. Fitting-out involves the skills of numerous workers such as engineers, plumbers, electricians, insulators, carpenters, joiners, boiler makers, technicians, etc.

The last step in shipbuilding is the trial of the newly completed ship at sea. The ship undergoes various tests to determine whether or not mechanical or physical defects exist. Rectification of faults may involve the removal of components, stripping of insulation, welding and the cleaning of oil tanks and lines prior to repair.

(ii) *Repair.* Major shipyards usually combine repair, overhaul, and conversion with shipbuilding capabilities. It is difficult to distinguish among these types of activities in shipbuilding yards and ship repair yards, since many engage in both types of work. However, the four activities commonly performed in ship repair yards include: unscheduled or emergency repair and casualty work, scheduled maintenance and inspection of ships, major overhauls and conversions and non-ship industrial work.

Planned maintenance or preventive maintenance is atypical. Ships generally come to be repaired due to a breakdown in machinery or equipment which cannot be repaired on board, when the ship's hull must be cleaned and painted to achieve greater fuel efficiency or when repairs are necessitated by casualties. Over the years, planned maintenance, especially that requiring drydocking, has been scheduled to coincide with required inspection activities and with the periodic application of antifouling coatings.

Conversion of ships to increase their size, change their purpose, etc., is also an activity of the repair yard. Conversion activity presently includes jamborizing—placing a new midship section between the bow and stern to allow more cargo to be carried. Other conversions involve a change in propulsion systems to a type that burns less fuel, or even a complete change of the commodity carrying characteristics of a ship. Both conversion and major overhaul work typically involve lengthy repair activities. A complex overhaul of a naval ship may take a year or more. In these major overhauls, virtually every part of the ship is removed, inspected, repaired and/or replaced.

(iii) *Operations in Construction and Repair Which May Result in Lead Exposure.* Shipyard operations in which lead exposures may arise include welding, sandblasting, painting and other lead working activities, such as tinning, torch bonding, lead caulking, casting hull shielding panels, grinding of leaded surfaces, sawing and packing lead ballast, burning on leaded or tinned structures, burning on lead-contaminated steel, carbon-arc gouging of canning plates overlaying lead, steel gritblasting on or near leaded structures, mineral gritblasting of steel prior to point application, and sorting scrap lead for salvage. A discussion of these operations is presented below.

(*a*) *Abrasive Blasting.* Gritblasting with open gun-type blast systems is widely employed in ship reworking and rapaid to remove paint from lead-painted surfaces. Gritblasting is necessary to remove old, deteriorating paint and to create small indentations or etchings on the ship's surface to facilitate the bonding of new paint.

(*b*) *Lead Bonding/Tinning.* The first step in a lead bonding operation is "tinning" prior to the installation of a lead panel. Tinning is the operation by which a thin coat of lead-tin alloy is applied to a clean and heated steel surface. The surface is heated by an oxygen-hydrogen torch to provide a thin lead film on the steel. Tinning is essential because, without the application of such an alloy, the metallurgical bond between steel and lead would be inadequate to assure the structural integrity of a lead panel under shock.

This process requires a team, with one or two operators using oxygen-hydrogen torches in the joint while another operator ladles lead into the joint. The ladle operator transports molten lead from a small portable lead pot to the joint or seam that is being bonded.

Manual torch bonding is used in lieu of manual ladling for local repairs. In such situations, accessibility to the joint is reported to be limited in the majority of cases. Manual torch bonding is the process of depositing lead into a joint by melting prefabricated lead bars with an oxygen-hydrogen torch. The purpose is to effect fusion of the lead to the base metal. In both construction and repair, this process occurs chiefly on the hull.

Manual ladle bonding is the process of depositing molten lead in the joint or seam between steel and lead panels from a hand ladle. The bonders use oxygen-hydrogen torches to fuse the molten lead to the lead base metal and to bond the lead to tinned steel surfaces. When it is applied, the molten lead must be between 700°F and 850°F.

Although the temperature of the molten lead is such that its vapor pressure is insignificant, the ladle operator is exposed to light lead suboxide dust from drossing both the portable pot and the joint that is being bonded. The Shipbuilders Council (SBC) maintains that in bonding operations, although the portable pot may be ventilated, the ventilation serves no useful purpose once the lid of the portable pot is opened. To fill the ladle, the ladle operator must expose the molten lead. SBC noted that the use of excessive ventilation on the portable lead pot would cool the lead surface and cause excessive dross to form, requiring the operator to dross more frequently, thus, exposing the operator to greater amounts of lead dust then would otherwise be the case.

(*c*) *Welding/Burning.* Although welding is not a work function performed with lead, welding on lead structures can cause lead exposures. Exposure may occur when a welder strikes an arc in close proximity to lead-contaminated surfaces. The heat generated is sufficient to vaporize the lead, which then becomes airborne. Exposures to lead can occur also during burning on leaded or tinned structures. This may occur when a burner cuts off a strip of steel contaminated with lead splatter or tinning paste for fitting up to a hull. Exposure to lead occurs when the heat of the burning torch is applied to the steel and causes lead, lead dust or tinning to fume off and become airborne. The Shipbuilders Council believes that, when this occurs, the operation has created high-velocity airborne particles that are not readily captured by local exhaust ventilation because space constraints and configurations often prohibit the use, or eliminate the effectiveness, of units capable of capturing such emissions.

(*d*) *Milling, Chipping, and Grinding.* The fabrication and subsequent fit-up of lead panels involve milling, chipping, grinding and planing. Exposures during these operations result from mechanical working of the lead surface. Grinding on leaded structures can also generate airborne concentrations of lead. The grinder is responsible for cleaning and flushing off welds and for removal of any defects which inspection may identify. Airborne lead results from grinding on structures contaminated with lead tinning and in areas adjacent to lead shielding.

(*e*) *Foundry Operations.* The melting, pouring, and casting of lead is done to form lead hulls and reactor shielding.

(*f*) *Caulking.* Lead caulking is another operation occasionally performed on nuclear ships. This is a procedure in which lead wool rope is installed in a joint or seam and compressed to a solid mass using a flat-ended tool driven by a pneumatic hammer. Bonders may be exposed to airborne lead when the lead oxides on the surface of the lead wool become airborne as a result of repeated mechanical compression.

(c) *Current Controls*

(i) *Abrasive Blasting.* Gritblasting of lead paint generates respirable airborne lead particles. The Council indicates that blast operators are currently equipped with air-fed respirators and protective clothing. Further, whenever possible, work areas are restricted and blasting is performed during the least busy shifts.

In one category of work involving lead exposure, mineral gritblasting on unleaded surfaces, the SBC suggested the possibility of substituting steel grit for lead containing mineral grit. Mineral gritblasting removes rust, hull scale and paint and provides an anchor pattern suitable for the application of new paint. Steel grit provides a comparable anchor pattern.

Gritblasting, whether mineral or steel grit is used, creates a high volume of abrasive that rebounds at very high velocity. The SBC maintains that even if steel grit were substituted for mineral grit, the operator of the blasting mechanism would still have to wear personal protective equipment, such as full-face airline respirators, coveralls, etc. Thus, the SBC argued that substitution would not afford the worker any additional protection and would be highly costly, since the current market price of mineral grit is approximately $40 per ton, while the current market price of steel grit is approximately $378 per ton. It takes 2.5 times the weight of steel grit to achieve the same coverage achieved by mineral grit.

(ii) *Tinning/Bonding Operations.* Local exhaust ventilation hoods are necessary at tinning operations because the bonding must be performed at the job site. This is true whether the tinning is performed onboard the ship or off. When work is performed off hull, it is performed on sections of bulkheads of varying configurations. Thus, the angles at which lead bonders must approach their work vary. Even though shipyards have developed portable hoods designed to suit a variety of structural configurations, the SBC indicates that the system still requires continual placement and replacement of the hoods by employees. The Council argues that since the torches used in this process produce combustion products with an initial velocity of over 20,000 feet/minute, creating high turbulence, the capture velocity of local exhaust ventilation will be exceeded, thus, portable ventilation systems would be unable, in this instance, to achieve the 50 $\mu g/m^3$ PEL.

The SBC indicates that while most of the applications of manual torch bonding can be serviced with local exhaust ventilation, manual torch bonding is often performed in confined spaces, in which local exhaust ventilation is ineffective, or in spaces that are too constricted to allow access by portable ventilation equipment. As described by the SBC, the breathing zone of the operator, who is often sitting or kneeling, can be within six to ten inches of the heated surface being worked. In such circumstances, the Council notes that local exhaust ventilation may be above the worker's head and, therefore, ineffectual in protecting the worker from fumes. In such cases, respirators are usually used.

(iii) *Lead Welding/Burning.* For burning operations, oxygen-acetylene torches are used to cut through coated metal. The flame velocity blows molten metal and fume on both sides of the surface. The SBC maintains that there is no hood that can provide adequate protection from the exposures this process creates. In other lead burning operations, portable exhaust ventilation is most often used.

The SBC believes that the only known means of reducing a welder's exposure to lead by engineering controls is through the use of local exhaust ventilation, but that this approach is not possible when operations are performed in areas in which accessibility is limited. In these instances, respirators are used.

(iv) *Milling, Chipping, and Grinding.* The SBC maintains that reducing exposure to lead by use of local exhaust ventilation is of questionable value in this process because grinding on lead-contaminated steel surfaces generates high velocity particulates that can not be readily captured by local exhaust ventilation. The SBC also states that configurations exist which would often prohibit access of the large-diameter local exhaust ventilation ductwork that is necessary for the capture of high velocity particulates. Therefore, OSHA assumes that ventilation is rarely employed.

(v) *Foundries.* The SBC reports that approximately two percent of lead workers in the shipbuilding industry perform foundry work. Lead hull and reactor shielding are made by pouring molten lead from a lead furnace into adjustable molds. The operation is performed under a canopy hood that, the SBC believes, significantly reduces employee exposures. Employee exposures also result from drossing the lead furnace, preheating molds, preheating the chute, tinning and drossing molds. Even with what is described as state-of-the-art ventilation, however, SBC reports that some exposures above the 50 $\mu g/m^3$ PEL continue to occur. This is especially true when specific applications require the operator to move under the hood and his breathing zone is placed between the source of emission and the point of exhaust.

The SBC states that local exhaust ventilation has been found to be effective in reducing exposures below the 50 $\mu g/m^3$ PEL in some open spaces, but that caulking must often be performed in enclosed spaces that preclude the use of local ventilation and result in exposures exceeding 50 $\mu g/m^3$.

(d) *Exposure Levels*

(i) *Abrasive Blasting/Painting.* The SBC maintains that exposure levels in excess of 50 $\mu g/m^3$ and, sometimes, in excess of 100 $\mu g/m^3$ (on an 8-hour time-weighted average), are encountered by employees in the areas where blasting of lead paint takes place. (Specifically, levels were indicated as being between 62 and 3,984 $\mu g/m^3$.)

Sandblasting is used to remove all coating materials, including those containing lead, before painting the hull of a vessel. DBA estimated that the exposure levels of sandblasters exceed the PEL (Ex. 26, p. 5–117). Painters, in contrast, are assumed to fall into the low energy category. When painting is not done in a ventilated spray booth, however, most painters now wear respirators (Ex. 26, p. 5–117). Lead-based paint is being replaced and some shipyards no longer use lead-based paint (Ex. 22, p. 321).

(ii) *Bonding/Tinning.* According to the SBC, ship construction and repair yards experience mean air-lead levels in tinning of 100 $\mu g/m^3$ to 150 $\mu g/m^3$ TWA, with excursions in excess of 150 $\mu g/m^3$ caused by the oblique angle at which the flame impinges on a flat surface.

Exposure data presented by SBC indicated that lead levels in tinning operations conducted in open areas were 120 to 1949 $\mu g/m^3$ (uses 4" to 8" ducting) and 41 to 374 $\mu g/m^3$ (uses 8" ducting). In enclosed areas, levels were 38 to 160 $\mu g/m^3$ (4") and 29 to 436 $\mu g/m^3$ (8"). These levels represent area samples rather than eight-hour TWA's. Since the fpm's per ducting were not provided, OSHA does not know what the effectiveness of the system was. Manual ladle and manual torch bonding exposures were 55–2254, 47–2072, 7–332, 11–1702, 8–526, 18–410 $\mu g/m^3$. There are obvious problems with these data, because no information was provided concerning the number of workers, the nature of the samples taken, etc.

(iii) *Welding/Burning.* Exposure during welding can originate in the base metal being welded, the coatings used on the electrodes, and the coatings on the base metal. The studies reviewed by DBA indicate that welders may be exposed to concentrations of lead well in excess of 100 $\mu g/m^3$. One 1968 study, however, reported mean lead concentrations of 40 $\mu g/m^3$ in shipyard welding. DBA estimates that the exposures of 81 percent of welders would fall above 100 $\mu g/m^3$. Especially high exposures result from work in confined spaces and on galvanized metals coated with zinc silicates (Ex. 26, pp. 5–113, 5–114). The SBC reported levels of 0 to 1,599 $\mu g/m^3$ (Ex. 505).

Lead burning occurs only in the construction of nuclear ships, when lead is welded to the hull in order to shield the ship's reactor. DBA estimated that 40 percent of these workers have exposures above 100 $\mu g/m^3$ (Ex. 26, p. 5–111). The SBC reported levels of 45 to 540 $\mu g/m^3$ in carbon arc gouging and levels of 5 to 410 $\mu g/m^3$ in burning.

(iv) *Grinding/Finishing.* Measurements for grinding, without ventilation, indicated levels of 6 to 1651 $\mu g/m^3$. Saving lead ballast found levels of 55 to 365 $\mu g/m^3$. Passing and packing of ballast, measured without ventilation, indicated levels of 0 to 558 $\mu g/m^3$.

(v) *Foundry Operations.* Measurements taken during the casting of hull shielding panels indicated levels of 16 to 224 $\mu g/m^3$. Quality control inspections found levels of 6 to 367 $\mu g/m^3$. Measurements of scrap lead sorting indicated levels of 5 to 140 $\mu g/m^3$.

(vi) *Lead Caulking.* Caulking operator's levels were reported to be 0 to 161 $\mu g/m^3$.

(e) *Population Exposed*

The number of workers exposed to lead during burning is estimated to be 1,374; during sandblasting, 264; during welding, 16,120 and during painting, 4,495. However, employees often work at a variety of assignments, and thus their work may expose them to lead only 1 or 2 days per week (Ex. 26, pp. 5–110 and 5–111).

(f) *Additional Controls*

The engineering and work practice controls applicable to the operations of welding, burning, brazing, abrasive blasting, painting and tinning have been effectively used by other industries to obtain compliance with the 50 $\mu g/m^3$ lead standard. The need for upgrading of ventilation systems, improved housekeeping and the rotation of workers varies according to the industry and its state-of-the-art with respect to the use of these controls.

Substituting less hazardous materials, equipment or processes may be the least expensive, as well as the most positive, method of controlling occupational hazards resulting from spray painting. In order to minimize the hazards in spray finishing, coating materials should be formulated with relatively safe ingredients, and with minimum amounts of solvents.

In many instances, organic pigments can be used in place of the lead pigments currently used in industrial finishes. However, the organic pigments are less durable, have reduced corrosion resistance, and have a tendency to fade. Therefore, they are not always adequate substitutes.

Shipbuilding is not a process that uses a production line or work stations to which engineering controls can be attached. As ship construction proceeds, the work environment changes. In such operations, compliance calls for local exhaust ventilation, using portable, flexible equipment and absolute filters. Large shipyards have installed such controls. Some confined spaces, however, may not have room for portable ventilation ducts (Ex. 26 p. 5–119).

Complying with the standard may be more difficult for some small companies, especially during work on hulls painted with lead-based paints. If the proper welding practice of removing an area 3" wider than the weld is strictly followed, however, exposure above the PEL is less likely to occur (Ex. 26, p. 5–119). Also, replacement of lead-based paint by non-lead-based substitutes will reduce exposures in welding and repairing (Ex. 22, p. 323). Otherwise, operations involving exposures to lead-based paint (blasting, welding, burning, painting, chipping and needle gun) were described by the SBC as not lending themselves to engineering controls.

For ship exteriors, the SBC argues that because of the large cloud of respirable lead particles generated by abrasive blasting, there is no ventilation-extraction system that can be employed to reduce respirable lead particles to a concentration below the PEL, and further, since employees engaged in blasting of ship exteriors must constantly shift positions, any type of engineering control would have to be portable, capable of ventilating large air volumes and capable of reaching inaccesible areas, including the underside of the hull.

The SBC believes that no feasible alternatives to gritblasting are available. It stated that while needle gun vibrators are sometimes used to remove paint from small or highly inaccessible ship surface areas, this mechanism is too slow for general blasting of a ship's hull or interior. (Ship repair yards are required to blast ship hulls within a short period of time since prompt repainting is necessary to avoid rusting of exposed surfaces.)

The SBC argued that, for several reasons, self-contained robot-like abrasive blasters would not be feasible for general blasting of ship hulls. First, a hydraulic crane is required to maneuver the robot blaster around the ship and, according to the SBC, many small ship yards do not have, and could not afford, such cranes. Further, SBC maintains that robotblasters are incapable of effectively removing paint from curved surfaces, such as the undersides of hulls; that robot blasting is slower than hand blasting and would unduly delay the completion of repair jobs; and that robot blasters would only limit exposure of the worker who otherwise would do the blasting function, but would not limit exposure of other workers in the area in which the blasting is being conducted.

For blasting ship interiors, SBC states that the only potential engineering controls for lead exposure are portable ventilation systems (with flexible ductwork and filters). However, the SBC characterizes these systems as extremely cumbersome, requiring substantial time and labor (by multiple trades) to disconnect, rewire, transmit and rearrange, and in any case, inadequate to reduce exposure levels below 50 $\mu g/m^3$ in confined spaces.

Gritblasting generates lead particulate matter that collects on platforms used by workers blasting the hull, under the hull, in the bay of the dry dock and on the floor of ship interiors. Several personnel are required to collect and dispose of this material through vacuuming and shoveling. The SBC maintains that this cleanup process agitates the lead particulate residue, resulting in exposures in excess of those permitted under the standard, and that engineering controls are as infeasible for this operation as for the initial blasting operation itself.

In ship repairing, welders and burners may be required to work near lead-painted surfaces and on surfaces from which lead-based paint has been removed. Burners and welders may work in a variety of situations, including enclosed or confined spaces, and they also may operate in close proximity to other types of workers, such as machinists, pipe fitters and shipfitters. The SBC states that airborne lead concentrations greatly in excess of the PEL occur in such operations and that engineering control of lead exposures in welding is infeasible because of the numerous spaces in which portable ventilation cannot be placed or is ineffective. On the exterior of ships, the problem, as described by SBC, is that portable ventilation is suitable on elevations accessible only through use of stage work or hydraulic lifts and there is no place, in these cases, to hang portable equipment. In ships interiors, SBC indicates that numerous welding operations occur in spaces so confined that they are not accessible to ventilation equipment or so shaped that ventilation cannot be placed in positions that will effectively protect the worker.

As noted earlier, it is often necessary to remove lead paint from small or inaccessible areas of a ship's surface to prepare for welding, burning or similar repair functions. Chipping or needle-gunning operations are performed. The SBC states that airborne lead concentrations, substantially in excess of the PEL, occur during those operations, and that because chipping and needle-gunning are almost always conducted in confined areas of the ship interior and difficult to reach exterior surfaces, engineering controls are infeasible.

For the actual painting operation, SBC reports that, due to the excess amounts of paint projected into the air by spray painting, local exhaust and/or general mechanical ventilation are, in themselves, inadequate to reduce lead exposure levels below the PEL.

In addition to the engineering problems encountered by shipyards due to lead-based paints, shipyards that do construction, conversion, overhaul or repair of nuclear vessels for the United States Navy are confronted with additional circumstances in which, according to SBC, control of airborne lead to the PEL is infeasible.

The use of lead in nuclear ship construction and repair is required by the United States Navy for the purpose of shielding the reactor compartment and for ballast. As perceived by the SBC, the essential problem with the use of engineering controls in nuclear shipbuilding stems from the fact that a majority of the lead worker population is engaged in work that must be done on location, involving mobile operations in a variety of structural configurations.

The installation of lead panels is the largest source of exposure to lead in nuclear shipbuilding. Lead panels must be bonded to steel structural components. Because lead and steel resist the bond, very close work is required. Lead bonders and quality control inspectors can be expected to have daily exposures to lead during nuclear ship construction.

For welding operations the Council maintains that, even in areas where ventilation is adequate for most purposes, welders will come upon unexpected situations resulting in high lead exposures due to the fact that shipbuilding and ship repair are not standardized operations. As an example, the SBC reports that a welder may be welding on canning plates above exposed lead or tinning and the exposure to lead will be determined by the amount of exposed tinning paste on the surface of the steel, which will vary with the thickness of the lead panel, the location of the canning plate and the technique of the person who applied the tinning paste.

Welders may also be exposed to lead concentrations in the process of carbon-arc gouging of canning plates which cover lead. Carbon-arc gouging is the process by which defective welds are removed and steel structures are cut. In carbon-arc gouging, an arc is formed between the carbon rod and a grounded steel structure. The metal surface becomes molten and is removed from the gouge path by the controlled release of compressed air. Exposure to lead occurs due to gouging on steel plates that cover lead bins or during operations that are performed on lead contaminated surfaces. The SBC reports that both repair and construction yards have had limited success in using local exhaust ventilation since the lead exposure of any worker engaged in carbon-arc gouging is dependent upon that individual's work practices. High air-lead levels are said to occur when the arc burns completely through the steel and impinges upon the lead surface beneath. When this occurs, the SBC reports air-lead levels of up to approximately 540 $\mu g/m^3$ TWA, because of the high velocity at which molten metal is ejected. Thus, according to the Council, control of lead exposure depends upon the welder's care in adjusting the arc height so that the steel is not penetrated.

The SBC reports that Navy specifications require lead ballast installation on Naval ships. (1,000,000 pounds of ballast are installed per vessel.) Carpenters may be exposed to lead oxides in sawing lead ballast, as well as in passing, packing and in overhaul work requiring the removal of ballast. Ballast is sawed in shops. Sixty-pound planks, or "pigs," are sawed into shapes for fitting into the hull as specified by design drawings. Lead oxide abrades off the surface of the pig during handling, and lead dust is generated by the sawing. The SBC indicates that this is one of the few shipyard operations that resembles stationary factory work. Thus, SBC believes that fixed ventilation systems may, in fact, control these exposures to below the 50 $\mu g/m^3$ PEL.

The SBC does not believe, however, that this is true with respect to passing and packing lead ballast. Lead packers, who are commonly the same carpenters responsible for sawing lead pigs, are responsible for installing the lead in ballast bins. The pigs are hammered, cut and shimmed to fit. Airborne lead may be generated when lead oxide is dislodged from the surface of the lead while it is being handled and during hammering. SBC argues that lead passing is a mobile activity and lead packing takes place in confined quarters and, therefore, local exhaust systems are infeasible.

A lead boot is required by Navy specifications to be installed inside the primary shield tank in the installation of nuclear instrumentation. The lead boot is designed to protect measurement instruments placed in the radioactive area. Since the precision of this instrumentation must be maintained, the lead boot must be bored to close tolerances. Work on a lead boot occurs during the construction of each ship, and boring of the boot takes about six weeks out of the multi-year schedule for construction of a ship. Thus, machinists having responsibility for boring the boot will go for long periods with only background exposures to lead, even in the busiest nuclear yards.

The lead boot is machined with a boring bar that simulates the proper configuration required in the boot. The outside machinist who performs this operation is exposed to airborne dust. SBC believes that heavy dust vacuums can collect most of the lead chips that are generated in this operation but that, even though control of exposure is dependent upon the housekeeping procedures, employee exposure to levels below 50 $\mu g/m^3$ can generally be achieved.

The SBC reports that approximately two percent of lead exposed shipyard workers do foundry work. Lead hull and reactor shielding are made by pouring molten lead from a lead furance into present adjustable molds. The operation is performed under a canopy hood that the SBC believes significantly reduces employee exposures. Employee exposure results from drossing the lead furnace, preheating molds, preheating the chute, tinning and drossing molds. Even with state-of-the-art ventilation, however, the SBC reports that some exposures above the 50 $\mu g/m^3$ PEL continue to occur where specific applications require the operator to move under the hood and place his breathing zone between the source of emission and the point of exhaust. OSHA regards these foundry operations, however, as essentially the same as all foundary operations, and will treat them accordingly.

The SBC indicates that control to the PEL has been achieved in the pouring of molten lead into missile tube ballast cans since the pouring of the missile tube resembles a fixed factory operation that is stationary and can be exhausted by one hood.

SBC believes that no engineering controls exist that can keep lead exposures to the worker consistently under even 100 $\mu g/m^3$ in tinning operations. The bonding torch must be maintained at a temperature of 4,820° F in order to create a heated structure adequate to take the bond. The alternative to such torches, oxygen-acetylene torches, cannot be used because they create carbon deposits in the structural bond unacceptable for nuclear shielding. The SBC attributes this to the nature of the work which generates large volumes of lead fumes that are difficult to capture because the high heat generated by the oxygen-hydrogen flame virtually boils off the lead.

(g) *Conclusion: Technological Feasibility*

The Court of Appeals, in finding that OSHA had not demonstrated the feasibility of the 50 $\mu g/m^3$ PEL for this industry, concluded that the original record supported the conclusion that attaining exposure levels of 100 $\mu g/m^3$ is generally feasible (Slip opinion, pp. 212–213). The first hearing record indicated that attaining exposures of 100 $\mu g/m^3$ is generally feasible in the shipbuilding industry. The SBC, as well as General Dynamics and Ingall Shipbuilding, a division of Litton Industries, described the proposed standard as "technologically possible" (Ex. 230, p. 2; Ex. 28(30), p. 3; Ex. 3(58), p. 2). Whether further reductions to 50 $\mu g/m^3$ can be achieved requires an analysis of methods of controlling each particular operation generally and under the conditions peculiar to shipyards. OSHA believes that its analysis of technological feasibility in the general sections on welding, burning, brazing, spray painting, foundries, abrasive blasting, etc. are applicable as a general matter to these operations when performed in a shipyard. In each of these, OSHA has found the 50 $\mu g/m^3$ PEL feasible in one year.

However, in shipyards, these operations may be performed under conditons where controls, otherwise effective, might not be adequate. Where this is the case, engineering controls and work practices must be used to reduce exposure to the extent feasible and must be supplemented with respirators. No data have been presented to assess the extent of respirator usage required, but it may be prevalent in most operations. Clearly, in abrasive blasting operations respirators are already required by existing regulations when certain abrasives are being used. Spray painters are also required by the Longshoremen and Harborworkers Act to wear respirators (Ex. 505, p. 3). And as the Shipbuilders Council stated, "respirators for this reason would be worn regardless of the lead standard."

Although, the Shipbuilders Council discussed extensively the problems associated with using engineering controls and work practices in the shipbuilding and repair industry, they did not consider the alternative approach to compliance of worker rotation. Worker rotation, in some instances, could be used by the industry to replace the current, extensive reliance on respirators.

It should be noted that no industry-wide implementation schedule has been provided for shipbuilding. For example, shipyard foundry operations are controlled by the general section discussing foundries; lead burning by the lead burning section; and spray painting by the spray painting discussion.

(h) *Costs of Compliance*

DBA estimated that the average costs of compliance with the lead standard would be approximately $5.69 per worker in capital expenditures and $1000 per worker in annual operating expenditures (Ex. 474–26). These costs were derived by estimating the numbers of workers and levels of exposure of these workers, and by developing a compliance scenario for all feasible engineering controls and work practices. DBA estimated that a total of 22,253 workers in shipyards are potentially exposed to lead in welding, burning, painting, sandblasting, and lead worker (in nuclear shipbuilding yards) occupations. Thus, the total compliance cost to this industry would be about $127,000 in capital expenditures and $22,253,000 in annual operating costs.

On the basis of estimated exposure levels, DBA prepared compliance cost estimates for monitoring, personal protective equipment and clothing, housekeeping, engineering controls, maintenance, work practices, medical surveillance, training, and recordkeeping. The capital costs of compliance per worker for workers exposed in excess of 100 $\mu g/m^3$ was $90; for workers exposed between 50 $\mu g/m^3$ and 100 $\mu g/m^3$ the cost was $16.33; and for workers exposed to less than 50 $\mu g/m^3$ the cost was $.50 (Ex. 474–26). The annual operating expenditures per worker were estimated to be $2000, $1358 and $883 for workers above 100 $\mu g/m^3$, between 50 $\mu g/m^3$ and 100 $\mu g/m^3$, and under 50 $\mu g/m^3$, respectively (Ex. 474–26).

The SBC did not offer counterestimates to the DBA figures. The SBC did charge that DBA had neglected to count the costs of "reduced worker efficiency, disruption of repair operations, production upsets, and work schedule delays" that the engineering and work practice controls might cause (Ex. 475–26). However, to the contrary, the DBA estimates did incorporate the additional costs of lost production associated with housekeeping, maintaining and setting up portable engineering controls, time lost for medical exams and training, and time lost for hygiene practices. Furthermore, DBA did calculate the cost of hiring the additional labor required to prevent production delays and losses (Ex. 474–26). These costs have been included in the estimates of the total costs per worker provided above.

Therefore, OSHA believes that the DBA estimates constitute the best available evidence on costs of compliance. Neither the SBC nor any other participants in the rulemaking effectively refuted them or supplied other estimates of the actual costs in this industry.

(i) *Industry Profile*

There are approximately 537 establishments in the shipbuilding and repairing industry (SIC 3731) employing 175,365 workers. Of the 208 firms operating these establishments, about 80 are shipbuilding firms and about 128 are ship repairing firms (Ex. 475–26(b)). Only 3 shipyards are equipped to build nuclear-powered ships (Ex. 474–26). Classified by employment size, 19 percent of all establishments employ 4 or fewer workers. The distribution of establishments with 5 to 9, 10 to 19, 20 to 49, 50 to 99, and 100 to 249 employees ranges from 11 percent to 16 percent for each size category. Only 4 percent of the establishments employ 1000 or more employees (Ex. 476–25). Within the industry, a greater proportion of small establishments are in ship repairing than shipbuilding (Ex. 475–26(c)).

The industry appears to be characterized by a high degree of concentration. There are 9 conglomerate-owned, 16 independent, and 100 general yards. But a few large firms control most of the major shipyards. Tenneco owns Newport News Shipbuilding and Drydock, Congoleum owns Bath Iron Works, Sun Oil owns Sun Shipbuilding, Fruehauf owns Maryland Shipbuilding and Drydóck, and Bethlehem Steel owns the Bethlehem Shipyard. Todd Shipyards is the major independent yard. Two of these large shipyards control 13 repair yards that provide 60 percent of all repairs, Assuming each yard has a fairly equal market share, this evens out to approximately 5 percent per yard. Forty three yards control 75 percent of all private repairs (Ex. 475–26(b)). Due to the highly competitive nature of ship repairing among the yards, this distribution is expected to be maintained (Ex. 475–26(c)).

Ship repairing is more profitable than shipbuilding (Ex. 475–26(c)). Approximately 75 percent of the revenue from ship repairing is generated by the federal government (Ex. 475–26(b)). The total number of repairs done in domestic shipyards is a function of world trade (the major determinant), the age of the fleet, and the rate of technological change. Proximity to ship traffic is a basic element in establishing a successful repair yard. Consequently, U.S. yards are located predominantly on the west, east and Gulf coasts and on the Great Lakes (Ex. 475–26(c)).

There are several criteria that customers consider in addition to placement of repair yards along shipping routes. Four major factors are cost of the repair, the yard's reputation for quality, turnaround time, knowledge of the ship, and other special skills.

The U.S. has a reputation for quick turnaround with fewer days both in a drydock and in completing the repair. Thus, while the U.S. is not as price competitive as foreign shipyards, the service offered is characterized by more rapid turnaround time (Ex. 475–26(c)). The U.S. is, however, becoming more price competitive with foreign shipyards. In the face of worldwide overcapacity, the gap in foreign versus domestic drydock charges is narrowing and labor costs, which are critical in an industry as labor-intensive as shipbuilding and repairing, are becoming less of a cost disadvantage to U.S. yards as wages rise abroad. Fluctuations in exchange rates have also been advantageous to the U.S. shipyards in terms of major competitive foreign countries, especially West Germany, the Netherlands, and Japan. Thus, whereas costs in West Germany in 1976 were 98 percent of the lowest U.S. cost, they were 117 percent of the lowest U.S. cost in 1978. In Japan in 1976, average repair costs were 20 percent less than in the U.S.; by contrast, in 1978, Japanese costs were only 4 percent less than U.S. costs (Ex. 475–26(c)).

The ship repairing industry faces a stable future and will prosper well into the 1980s as a result of several factors. First, more stringent environmental safety requirements for tankers in U.S. coastal waters will generate an increased market for inspections, minor repair, and retrofit overhauls of ships. Second, there are perceived needs for modifying, especially "jumboizing" existing vessels to meet shipping demands more quickly and less expensively than by constructing new ships. Third, U.S. repair services are becoming more competitive in the world market. U.S. ship repair yards already have a reputation for superior work and high productivity and are continuing to improve efficiency by investing in more modern equipment. Fourth, shipyards are diversifying into non-ship-related industrial work that utilizes shipwork skills, such as sheet metal working, welding, and blasting. Fifth, repair and overhaul of Naval vessels is expected to increase. Sixth, increased shipping activity with the expansion of world trade and transportation of Alaskan oil will generate a need for more ship repairs (Ex. 475–26(b)). The anticipated increase in world trade is especially important since the demand for ship repairs is a derived demand, that is, it cycles with the demand for both domestic and international trade (Ex. 475–26(c)).

Revenue in repair yards is expected to grow at an annual rate of nine percent for the next decade. Funding for Naval repairs, which occur almost exclusively in Naval shipyards, is expected to increase by about 6.2 percent per year. Commercial ship repair is forecast to grow at 5.5 percent annually. The largest increase of 14.3 percent per year is expected in foreign repairs. Overall, revenue for commercial repairs are projected to stabilize at a 6.5 percent rate of return per repair over the next decade (Ex. 475–26(c)).

The market outlook for shipbuilding is not as stable as the ship repairing forcast. While most shipbuilders have integrated ship repairing operations into their facilities, new construction orders and employment in shipyards will probably decline in the immediate future, reflecting the worldwide slump in shipping (Ex. 475–26(a)). However, during 1978 and the first and second quarters of 1979, an unexpectedly large number of new orders brightened the outlook for the shipbuilding industry (Ex. 476–26). Total orders in 1979 were the largest since 1973, with contracts reflecting a healthy demand for deep-draft commercial vessels (Ex. 475–26(b)). A prime source of commercial ship orders for U.S. yards stems from the severe shortage of dry bulk charter vessels. The American-flag fleet includes only 19 bulk ships, and 13 of its ships are over 30 years old. The demand for product tankers has also shown a revival that should continue through the 1980s (Ex. 476–26). Furthermore, Naval expenditures authorized by Congress for new ships are expected to continue at least at the same level (Ex. 475–26(b)), thus bolstering the demand in the shipbuilding industry.

The shipbuilding and repairing industry considers shipbuilding less profitable than repairing. Ship repairs command excellent prices because the work is typically urgent and repair yards can usually control overhead more successfully than construction yards (Ex. 476–26). However, to ease the financial situation for shipbuilders, federal construction differential subsidies are granted for ships built, owned, operated, and manned by Americans. The amount of the subsidy is calculated on the basis of the construction cost difference between U.S. and foreign shipyards (Ex. 475–26(b)).

In the long-run, that is, beyond 1985, the market for shipbuilding looks very good. The future boom in fishing, resulting from the implementation of the 200 mile limit, will require larger and more efficient vessels. Also, the prospects for mining undersea mineral nodules may contribute to a rising demand for new ships (Ex. 475–26(b)). Since the industry is cyclical and dependent on worldwide conditions in many markets, recovery can be expected as water-borne trade expands again (Ex. 476–26).

In addition to the anticipated upturn in the shipbuilding industry, there appear to be long-run trends away from the use of lead in ships. The shipbuilding industry is currently in the process of adopting substitutes for lead-based paints in ships. Existing ships that still contain lead painted surfaces will continue to be a source of potential exposure during ship repairs. However, ultimately, this source of exposure will be eliminated. Some technological improvements that increase the mechanization and automation of shipbuilding and repairing processes may also lead to reduced exposures where lead use is retained. In addition, underwater painting and underwater welding processes are being developed (Ex. 475–26(a)).

There does not appear to be a perfect substitute for lead in nuclear shielding of reactors. One possible substitute is a cement shield. However, cement shields require much more space than lead shields (Ex. 475–26(a)). Only three yards have a current capability to build nuclear ships. For these yards, it is expected that the cost of controlling lead exposure would be such a small percentage of the total cost of building a ship that the percentage increase in price of the ship would be negligible. Furthermore, the production of nuclear ships is exclusively funded by the military, and military demand for nuclear ships is relatively insensitive, even to large increases in price. Any increased costs of production would be passed on ultimately to the taxpayers by the few yards involved in nuclear shipbuilding.

(j) *Conclusion: Economic Feasibility*

OSHA concludes that the economic impact of the lead standard on the market for ship repairing and shipbuilding will not be disruptive to the industry. Since the estimated total annualized costs amount to only about 0.68 percent of the value of the industry's sales (Ex. 476–20), ship repair yards will be able to pass costs on to customers because the commercial and military demand for repairs is relatively inelastic. Small independent yards may have more limited access to capital than yards that are owned by large parent corporations. However, competitive advantages of location and individual reputation for quality work will help to offset potentially adverse impacts on small versus large owners of ship repair yards.

Similarly, the shipbuilding industry will be able to pass costs of compliance on to commercial and military customers. The cost of controlling lead exposures represents a very small percentage of the cost of building a ship. Thus, any price increases are expected to be negligible. Furthermore, the future profitability of the industry will rise as the demand for new ships increases in the 1980s. Concurrent substitution away from lead use in most new ships will significantly reduce compliance costs, and consequently the economic impact of the lead standard.

36. Solder Manufacture

(a) *Uses.* Solder is sold in the form of ingots, rods, bars, anodes, solid wire, cored wire, foil, sheet and paste (Ex. 22, p. 294). In addition to its many other uses, solder is essential for the manufacture of electronic devices. No substitutes for solder are known (Ex. 65B, p. 40–42).

(b) *Process Description and Exposure Areas*

Refined lead is used to make lead-tin and other solders. The ratio of lead to tin, bismuth, antimony and other metals varies depending upon the type of solder desired. In the making of solder, metals are melted down at low temperature and blended in established ratios. Handling of lead is minimal, but employees do handle raw lead ingots before they are melted (Ex. 488).

Material handling includes manual material transfer or transfer by forklift. The material may be in the form of pigs, skidded materials, semi-finished products or final products exposed and/or in packages. Material handling often includes weighing, breaking up of ingots into smaller parts for accurate alloy charges, loading the solder pot with metal, transferring semi-finished or finished items from one operation to another, etc. (Ex. 488).

Alloying includes the melting of charges, mixing of molten metal, removing samples for analysis and the removal of dross from the charge.

The allowing of solder is usually performed by melting the elements at 100°F. above their melting point and stirring them to achieve homogeneity. Depending upon the composition of the solder, the temperature and the partial vapor pressure of lead, one can calculate the evolution of lead in air. In general, metallic lead fumes are unlikely to occur when the temperatures are kept below 1,000°F., as in the case with solder manufacture where the temperature is kept low to prevent excessive dross formation that reduces the yield of the charge (Ex. 488). Lead fumes are normally expected at temperatures between 1,500° and 2,700°F. (Ex. 488). ⅛ Thus, the exposure in this area is not from metallic lead fumes, but rather from the reaction of products with air (mostly lead oxide) which is called dross. This constitutes the greater potential for airborne lead since dross is a dry, powdery substance (unless special additives are used).

Finished solder is cast into blocks, ingots, rods or bars, sheets and foil, and extruded into solder wire and sheets (Ex. 22, p. 294).

Casting involves such operations as dross removal, pouring, topping of slugs and removal from the molds. Extrusion may be done directly from the melt in a continuous form or with the use of precast billets. Basically, this requires hydraulic pressing through dies to achieve final shapes. The extrusion often includes such operations as cutting, loading and unloading the presses, and transfer of the extruded material to the next operation (Ex. 488).

Hook attachment to anodes may be stainless steel or tinned copper alloys. (Tinning is often performed as an auxiliary operation to anode manufacturing. It involves the fluxing and dipping in molten alloy of the hooks in question.) The hooks are either attached mechanically (using a drill and tap operation) or by lead burning, which is a form of soldering (Id.).

Wire drawing is performed by running materials through lubricated reducing dies and includes threading the wire into the dies, reattaching the wire when it breaks, cleaning the dies, maintaining the solution, and a feed and unload operation. The lubricant (also called a drawing solution) contains fine particles of solder which may cling to the wire as it leaves at high speeds. These particles may then become airborne during spooling and handling (Id.).

Spooling of solder wire is often done manually, although semi-automatic and fully automatic equipment exists. This includes such operations as manual spooling, cutting and weighing, and reconnecting brakes.

Rolling and cladding are processes whereby solder is metallurgically or mechanically bonded to other metals, such as copper. This includes such operations as cleaning (dangerous only if it involves mechanical abrasion), feeding, measuring, and transfer of the finished product.

Stamping and wire forming (to make preforms) include such operations as setting up the dies and equipment, the physical operation of the equipment (lubrication used to prevent equipment damage eliminates particles from being generated into the air), and collecting, measuring, and cleaning the end product.

Powder blowing is an operation which, by its nature, creates airborne lead contamination. Although powder is often blown into a special environment of liquids rather than air, it requires special control. Powder blowing of molten solder is acknowledged to be the most hazardous operation, resulting in the greatest potential for lead exposure in solder manufacturing. Powder is normally blown from a molten reservoir by feeding a steady stream of liquid solder through an air nozzle. By the time the metallic droplets solidify, they settle into the bottom of the equipment where they are sized.

Powder classification or sizing is the operation where powders are separated into various sizes (referred to as mesh sizes). This is achieved either through gravity by horizontal air blowing or mechanically by a series of different sieves. Here again, there is danger of airborne lead and adequate controls are required.

Powder blending requires that powders be mixed with the fluxes to create the end product, which is either a paste or a cream.

Packaging and shipping is an operation which includes the handling, weighing, inspecting, and packaging of all final products. The exposure depends on the form of the product being handled (i.e., whether it is in powder or compressed forms).

Housekeeping includes the cleanup of all floors and surfaces to remove particulate matter containing lead. Wet sweeping and vacuum cleaning are two mechanized methods possible.

The potential for lead exposure exists for almost all operations, but the greatest potential is experienced in alloying, casting, powder blowing, housekeeping, and machine operations such as cutting and drilling.

(c) *Controls Currently Used*

Materials handling presently is done manually or with a forklift. Alloying operations have tight enclosures which use air exhausts. Casting operations use ventilation. Powder blowing operations are performed in tight enclosures with negative pressure. Ventilation is used in machine operations. (Ex. 488)

(d) *Exposure Levels*

Originally, in the Short Report, most industry sources indicated that lead levels were probably low and that problems in meeting the standard were not anticipated (Ex. 22, p. 394). OSHA inspections at two solder plants reported levels above 200 $\mu g/m^3$ in spooling operations, furnace areas, and kettle areas (Ex. 65B, p. 42). One company reported that even with excellent ventilation, lead levels in the casting area reached 200 $\mu g/m^3$. (Ex. 22, p. 294.) Levels of 220 $\mu g/m^3$ to 300 $\mu g/m^3$ were reported in the spooling and wire drawing operations (Id.). Results of OSHA inspection # CN-2 found lead levels of 140 $\mu g/m^3$, on an 8 hour TWA. The only control at this facility was ventilation consisting of two 42" ceiling fans located above the melting pot and one 30" wall fan (Ex. 476-16). In more recent exposure estimates, one large company reported that most of its direct labor force is exposed below 30 $\mu g/m^3$. In addition, in the older, smaller to medium sized plants, 20-25 percent of all employees (or 124-155 workers) are exposed above 50 $\mu g/m^3$ while in the large plants 8-12 percent (or 100-125 workers) are exposed above 50 $\mu g/m^3$ (Ex. 488)

(e) *Population Exposed*

The data presented by Howard Manko, an OSHA expert witness, indicate that approximately 250 workers in the entire industry may be exposed in excess of 50 $\mu g/m^3$. (Ex. 488)

(f) *Additional Controls*

Data indicating additional controls needed to comply with the 50 $\mu g/m^3$ standard were not submitted by the industry. Therefore a comparison of solder manufacture to comparable processes and a discussion of the applicable controls are provided in this section.

Materials handling may be done mechanically by conveyor system or pneumatically, depending upon the size of the materials being moved. Materials to be cut to smaller size or broken into pieces should be processed under exhaust hoods or should be broken and cut using automated mechanical devices. This whole area of exposure could be eliminated by buying scrap from collectors and processors already reduced to size. Weighing can be done in automated hooded weighing areas. (Ex. 270, 48, 488)

Additional ventilation may be necessary in some areas for compliance with the PEL. In a few areas that are difficult to ventilate, such as spooling, other protective measures may also be necessary. Slowing the spool rate is one possible method for controlling lead levels in the spool and wire drawing area, although this method would decrease the production rate. (Ex. 488)

Alloying operations can use exhaust ventilation in the melting areas and mixing areas. Dross can be mechanically conveyed to discharge areas with hooding of the conveyance ducts being provided. Casting areas can have local exhaust ventilation over casts. All machine operations can be successfully exhaust ventilated at the source of exposure and cutting fluids can be used to suppress dusts.

Spooling operations can be done automatically to avoid worker contact. Powder blowing may be done in fully enclosed systems of negative pressure with workers in clear air pulpits to minimize exposure. Powder classing and signing should be done mechanically with the entire sieving area ventilated and local exhaust ventilation being supplied to each sieve. Powder blending can be done mechanically and wet. Handling and shipping operations can also be mechanized, depending upon the substance being handled. (Id.)

Housekeeping should be emphasized with frequent wet sweeping or vacuuming. Floors and wall surfaces should be finished to eliminate cracks, crevices or porousness, which will tend to hold dusts. (Ex. 488)

In areas of high pressure, worker rotation should be utilized. Also, emphasis should be placed on the importance of proper work practices. Workers should be instructed to avoid stirring up dusts by improper dumping of materials, etc.

Mr. Manko suggested that manufacturers could also reclaim lead for reprocessing, which would greatly reduce the airborne contaminants and be cost effective by recycling wastes.

(g) *Conclusion: Technological Feasibility*

Most employers protect employees from lead exposure by ventilation. Hoods, exhaust fans, vents, air ducts, and baghouses are usually used. (Ex. 22, p. 294.)

Conclusions offered on the feasibility of achieving compliance with the 50 $\mu g/m^3$ PEL are based exclusively on the use of engineering controls. The consequence of work practices and effective housekeeping for complying with a 50 $\mu g/m^3$ standard was not considered. Solder manufacturing is an extremely dusty operation and re-entry of lead into the air from moving equipment could be effectively eliminated if proper housekeeping was practiced. In addition, rather than putting respirators on workers in high exposure areas, workers could be rotated, thereby minimizing their exposure.

Considering the available controls discussed here, the significant contribution which housekeeping can make in reducing levels, and the fact that at least one company has stated that most of its direct labor force is exposed to levels below 30 $\mu g/m^3$, compliance for the industry as a whole appears feasible. OSHA concludes that compliance with the standard as a whole is feasible for the industry within one year.

(h) *Cost of Compliance*

The total cost of compliance for the solder industry would include the capital expenditures and the operating costs that would be incurred to reduce lead levels. One industry source reported capital expenditures for EPA and OSHA improvements of $325,000 for two plants over a five year period (Ex. 488). This would suggest annual capital expenditures for the entire industry of $4.1 million. Annualized capital costs, therefore, are estimated to be $740,000. The corresponding operating costs for these two plants, as provided by this source, were $95,000 a year. Extrapolating from this cost figure to the entire industry yields an estimate of $5.9 million a year. Thus, total annual costs are estimated to be $6.6 million. However, four qualifications must be attached to these extrapolated figures. First, the costs provided by the industry source include costs for both EPA and OSHA improvements. Hence, using these estimates to evaluate the costs associated with the OSHA lead standard only is inaccurate. Second, the industry representative did not indicate whether these expenditures were necessary to achieve compliance with other OSHA standards. If these expenditures do include compliance costs for all OSHA standards then again these figures would be grossly inflated measures of costs of compliance with the lead standard. Third, these two plants need not be representative of the industry; in this case these figures would not be an appropriate basis from which to extrapolate to the entire industry. Fourth, these expenditures may have yielded other benefits to the employer in addition to those attributed to the EPA and OSHA requirements. These jointly produced benefits would then offset some of the costs of compliance with the OSHA standard.

(i) *Industry Profile*

Solder manufacturers are classified in either SIC 3356, in which the product is made from virgin metal, or SIC 3341, in which it is produced from secondary metal. Between 1975 and 1979, total value of shipments of solder averaged $306.5 million per year. The end uses of solder are divided among building and construction (9,777 metric tons or 18 percent), metal cans and shipping containers (14,485 metric tons or 26 percent), electronic components and accessories (10,344 metric tons or 19 percent), other electrical machinery and equipment (2,711 metric tons or 5 percent) and motor vehicles and equipment (16,961 metric tons or 31.3 percent).

In all uses, with the possible exception of other electrical machinery and equipment, declines in the use of solder are expected. Competition with light-weight plastics in the container industry has stalled the anticipated growth of the solder market. Newly designed automobiles, which will be smaller and lighter in weight, may reduce use of solder in this application.

Furthermore, substitutes for solder in the automotive industry have been developed. DuPont first invented and began licensing the technology for adhesives known as toughened acrylics five years ago. This glue, which is capable of eating through oil and grease, eliminates the need for arduous surface cleaning of parts to be joined and is superior to solder in resisting environmental degradation caused by heat and moisture. The Japanese auto industry already makes considerable use of adhesive chemistry to lighten the weight of cars (Ex. 476–26). Increasing miniaturization in the electronics industry will cause some contraction in demand for solder. Finally, declines in usage in construction are expected.

Production of solder from 1975 to 1979 closely tracked the general business cycle in the U.S. In 1976, the economy was in the initial stage of a recovery from the 1974–1975 recession. The demand for automobiles, machinery, and equipment was reviving. In addition, the building and construction industry was responding to a strengthened demand during this period. The production of solder paralleled this expansion. Output of solder increased from 73,987 short tons in 1975 to 105,504 short tons in 1978. Between 1977 and 1978, solder production expanded by approximately 27 percent. This rapid growth could be attributed to the upturn of the economy and perhaps to lags in the demand for durable goods during an expansion. The production surge could also be a consequence of the substantial increase in the average price of imports of solder. By the end of 1977, average solder prices for foreign producers had increased by $0.56 per pound; by contrast, average production costs for U.S. producers increased by only $0.07 per pound. One possible implication that could be drawn from these figures is that a change in relative prices between U.S. and foreign producers caused some shift in demand in favor of the U.S. industry.

The percent of lead in solder during 1975–1979 actually fell from 77.5 percent to 76.3 percent. The change in the percent of lead in solder was even more dramatic between 1977 and 1978. In 1977, the percent of lead in solder was 77.1 percent and, in 1978, it was 71.4 percent. Much of the increase in solder production appears to have been concentrated in non-lead solder.

The solder manufacturing industry can be characterized as a mature industry that has undergone few technological changes in the past 30 years. An estimated 20 percent of production equipment is less than 15 years old, while at least 60 percent of production equipment exceeds 30 years in age. Very few modern installations exist in the domestic market. This characteristic of the industry contributes significantly to the rising average cost of production.

There are an estimated 125 plants that are domestically producing solder. Twenty-seven firms, operating 30 plants and having total assets in excess of $1 million each, control 80 percent of the known solder production. Twelve companies, operating 13 plants and having total assets of at least $1 million each, and the remaining firms with fewer than $500,000 each, produce the remaining 20 percent of the solder. These smaller companies, whose raw material is predominantly scrap, generally market a limited product line of lower quality solder.

The small shops are dispersed across the U.S. This localization of operations results in some cost advantage to these producers. This advantage stems from both the proximity to scrap suppliers and the high costs of transporting solder. The latter is an especially important component of price, since solder is a heavy product.

Most of the large producers are located on the east coast. The maturity of the industry may inhibit these large producers from relocating to new areas. Hence, the small producers will probably continue to enjoy a substantial cost advantage over their larger competitors.

The cost of compliance with the standard may represent a higher proportion of total production cost for small producers than for large producers. However, in light of the immobility of large producers and the location advantages of many of the smaller plants, the competitive advantage of the small producers is not expected to be severely curtailed. This conclusion is supported by the fact that evidence of an increase in concentration in the industry, or a decline in the comparative advantage of small producers relative to large producers, has not been provided in the record.

However, foreign producers, who currently enjoy lower labor costs, may continue to increase their penetration of the domestic market, irrespective of an OSHA standard. In fact, some domestic firms have already begun some overseas operations in response to these cost advantages. Major foreign competitors are the United Kingdom and Canada, which account for 90 percent of the volume of imported solder. Other competitors include Spain, Denmark and Mexico. These latter countries present an attractive climate for business expansion and may prove to be dominant in the supply of solder for use in the electronics industry. In addition to this potential change in market concentration, foreign competition in higher grade solders, containing 37 percent to 40 percent lead, may increase since such operations typically have higher profit margins.

(j) *Conclusion: Economic Feasibility*

Annual compliance costs are not expected to exceed $6.6 million. (Shipments totalled $306.5 million averaged between 1974 and 1979.) Thus, OSHA estimates that annual compliance costs in the solder manufacturing industry will not exceed 2 percent of the total value of shipments produced in the industry.

Furthermore, the standard will not adversely affect the comparative advantage currently enjoyed by the smaller producers of solder. Hence, an increase in concentration in the industry is not expected. Foreign competitors may be encouraged to further infiltrate the domestic market. However, rising costs of energy and, consequently, of transportation will be constraining factors on foreign sales in the U.S. Evidence of this import constraint is provided by the rapid rise in the average price of imported solder between 1976 and 1977.

37. Soldering

(a) *Uses.* The application of solder, a lead-tin alloy, can be done mechanically or by hand. Operations performed by hand are usually "bench type" operations where employees are stationed individually and use soldering irons to melt solder to form a connection. Exposure occurs at the point of melting the solder (Ex. 79). Soldering in radiator shops seems to create lead exposure problems. During the repair of radiators, they are disassembled using oxygen acetylene torches. After the radiators are cleaned, they are reassembled using soldering wire. Lead fumes become airborne during the soldering and workers are also exposed to lead by handling the soldering wire and the lead contaminated radiators.

(b) *Controls Currently Used*

Local exhaust ventilation has been used to capture fumes in some cases but most stations have no ventilation. Each employee must clean his station and remove lead dross each day. Wetting down of dross is not done.

Soldering of small components or parts does not appear to cause a problem. Ventilation controls at most radiator repair shops were either non-existent or very poor. Ventilation at the Empire Radiator Company consisted of one large exhaust fan in the upper wall which moved air across the work areas at 50 linear feet per minute (Ex. 476–399). At George's Radiator Shop ventilation consisted of three roof-mounted exhaust fans with make-up air added by leaving doors open (Ex. 476–406).

(c) *Exposure Levels*

Numerous health hazard surveys have been done on hand soldering operations.

At the Monoghan Co. (Ex. 476–401), sampling was done at the hand soldering stations in the electronic assembly areas. Exposure levels were approximately 0.009 $\mu g/m^3$ of lead.

Western Electric did a study of its soldering operations and found that breathing zone samples indicated that exposures were less than 3 $\mu g/m^3$ of lead, typical of hand soldering operations. The average number of work years for employees of these operations was 16, and blood lead levels, when compared to those of a group of non-solder exposed office workers were also low. The author concluded that soldering does not present a health hazard associated with soldering does not exist (Ex. 3 (9)).

Similar surveys were done on the Hospital Medical Corporation (Ex. 476–400) and the Westinghouse Electric Corp. (Ex. 476–404). Most lead levels were non-detectable, except for one sample of 18 $\mu g/m^3$.

In some processes, automatic soldering irons may be used. Exposure levels were below the 30 $\mu g/m^3$ limit in this operation also (Ex. 476–405).

A survey at the Rock Mountain Radiator Shop found lead levels as low as 0.4 $\mu g/m^3$ and as high as 210 $\mu g/m^3$ for radiator mechanics (Ex. 476–402). At Empire Radiation Co. lead levels averaged 60 $\mu g/m^3$ (Ex. 476–399). At George's Radiator similar levels of lead were found for the repairmen. Levels ranged from 20 to 100 $\mu g/m^3$. Most levels were above 50 $\mu g/m^3$ (Ex. 476–406). Aero Radiator's levels were in excess of 50 $\mu g/m^3$ (Ex. 476–395).

(d) *Additional Controls*

NIOSH made recommendations to several companies to add local exhaust ventilation and increase general ventilation at soldering areas. Recommended controls include movable local exhaust ventilation installed at each repairman's station to capture lead fumes and acid mists. Companies were also advised to improve housekeeping. This would aid in removing dust from old solder areas, thereby reducing the amount of lead introduced as a secondary source of emission. Wet mopping and the use of water sprays to suppress lead dusts were also recommended.

(e) *Conclusion: Technological Feasibility*

Soldering operations, except for soldering of radiators, are in compliance with the 50 $\mu g/m^3$ standard. The control technology consists of simple exhaust ventilation and housekeeping. In radiator soldering, the data indicate that compliance with the 50 $\mu g/m^3$ standard has not been achieved. Soldering in these operations is done with virtually no use of ventilation equipment, even though portable units are readily available and inexpensive. Housekeeping also is virtually nonexistent in these small firms. NIOSH has recommended that implementation of ventilation, housekeeping also is virtually nonexistent in these small firms. NIOSH has recommended that implementation of ventilation, housekeeping, equipment, and wet suppression will enable radiator soldering operations to achieve compliance with a 50 $\mu g/m^3$ PEL.

(e) *Economic Feasibility*

The cost of compliance will be negligible and may consist of costs for portable ventilation systems; however, the less costly alternatives of housekeeping and worker rotation may suffice to reduce levels to the 50 $\mu g/m^3$ PEL in radiator soldering. The economic impact of the lead regulation on this industry is assumed to be negligible.

38. Spray Painting

(a) *Uses*

Spray painting is performed in two general situations: (1) Manufacturing processes where products are conveyed to a station and spray painted, and then conveyed forward for further processing, or (2) construction or repair painting requiring that the paint application workers and systems move to the location needing the coating (Ex. 228). Painting is usually done by spraying because of the excellent finish that can be obtained and the speed at which the coating materials can be applied (Ex. 476–412, p. 14).

(b) *Process Description and Exposure Areas*

There are four basic work environments in which employees may be exposed to lead. Manual spray booths require that the operator remain outside the enclosure and use various types of pressurized guns to apply the paint. Automatic spray painting booths require that the pressurized spray gun be automatically operated. Manual spray painting rooms are usually much larger than booths and may be either totally enclosed or open on one side. The objects to be painted are usually large and must be positioned in manual spray rooms, or automatically conveyed in. Open spraying consists of those paint applications undertaken outside locally ventilated spray booths or rooms. (Id.)

In any of these methods, the spray may be generated by compressed air, by hydraulic pressure, or by electrostatic forces (Id.). Compressed air spraying is the most widely used because of its versatility, low cost, and because it creates a high quality finish. In this method, compressed air provides the energy to atomize the finish. The atomization is produced by an air nozzle. Two types of nozzles are used: external mix and internal mix nozzles. In the external mix nozzle, the coating and the compressed air exit from separate orifices and are mixed outside the nozzle. The air jet atomizes and shapes the spray fan. Internal mix nozzles combine the compressed air and finishing materials in a chamber inside the nozzle. The atomized mixture is shaped by the geometry of the chamber opening. (Id.)

Airless spray equipment atomizes paint by forcing it through a very small orifice at a very high pressure. The airless spray gun simply consists of a device to hold the orifice and a value for shutting off the flow. The size and shape of the nozzle determine the volume of material sprayed and the geometry of the spray pattern. The hydraulic pressure necessary for atomization is provided by a high pressure pump that is operated by compressed air or an electric motor. (Id.)

In electrostatic spraying, an electrical charge is applied to the atomized coating particles, either by the creation of an ionized zone within the spray cone area, or by imparting a charge to the fluid stream prior to its release from the spray gun head. The charged, atomized paint particles are attracted to the conductive object being finished by the electrostatic field between the paint and the object. Atomization can be achieved by the use of air-atomizing or airless-type equipment, or solely by the use of electrostatic means. In this last method, the coating material is introduced into the center of a rapidly spinning disk or bell, which is highly charged. As the coating reaches the edge of the disk or bell, the repulsive forces of the like charges cause the coating to atomize. (Id.)

(c) *Controls Currently Used*

The use of airless atomization, heated paint, and electrostatic attraction in place of conventional, compressed air spray equipment can significantly reduce the amount of stray mist or fog produced. Compressed air spraying atomizes liquid paint by directing a high velocity air jet at the paint stream as it exits from a nozzle. The flow of air conveys the finely atomized droplets to the object being painted. This stream of air is deflected when it strikes the object. Paint particles of sufficient mass are not deflected and deposit themselves on the object. Additional paint mist is lost when the spray pattern does not completely contact the object. Total paint losses of 50 percent are not uncommon. (Id.)

On the other hand, in airless spraying, the paint is atomized by forcing it through a small orifice under very high pressure. This method produces less fog than compressed air spraying because not as many fine droplets are produced, and thus the "bounce-back" phenomenon is largely reduced because the paint droplets are conveyed to the object being painted by their own momentum rather than by a stream of air. Other advantages of airless or high pressure spraying include higher capacity, compatibility with high-solids coating, more adequate coverage of awkward shapes, and negligible stray mist. Some disadvantages include relatively high cost, limited pattern and flow adjustment, and difficulties in overlapping. (Id.)

In electrostatic spraying, the paint can be atomized with compressed air, by hydraulic pressure as in airless spraying, or solely by electrostatic forces. The chief advantage of electrostatic spraying is the improved working environment and the paint economy that is achieved. Electrostatic systems usually permit use of substantially less exhaust and make-up air than conventional compressed air spraying for the same painted surface area. This technique also provides significant wrap around, coats sharp edges, and can be highly automated. However, null points in the electrostatic field (caused by recesses or object interiors) may not be coated. (Id)

Isolation can be achieved by the use of a physical barrier, or by the separation of the worker from the hazard by time or space.

Automation of the paint application process is another means of isolating the worker from the hazard. There are two fundamentally different methods of automating spray finishing operations. The first method involves mounting the spray guns in fixed positions or on a reciprocating assembly. The product items are painted as they pass by the assembly on a conveyor. The parts may be rotated as they are painted. This type of automation is designed and built for the requirements of a limited product line, where the size and shape of the objects finished are easily definable. Manual paint sprayers are often required for touch-up. The second method of automation involves the use of programmed robots. These machines can accommodate production runs of various sizes and shapes. Since they can duplicate virtually all of the movements of a manual spray painter, the use of robots allows for the removal of workers from potentially hazardous areas or unhealthful working conditions. (Id.)

Ventilation systems can be either local or general in nature. A general ventilation system supplies and exhausts large volumes of air in an attempt to dilute air contaminants. General ventilation can successfully control the buildup of explosive vapors in enclosed spaces. (Id.)

The practice of placing a fan in a manhole, doorway, or window is not satisfactory to reduce paint mist because the air is circulated only at the opening; the fan does not move or dilute the air in other portions of the enclosed area. Munger recommends that clean air be drawn into the enclosed space from an opening at the top by exhausting air from the lowest portion. (Id.)

Reichenbach describes a similar procedure for ventilating the spray painting of ship holds and tanks and other confined spaces and recommends that painters in enclosed areas should wear supplied-air respirators. The fan capacity required for dilution ventilation can be calculated from the lower explosive limits for the solvents employed and the paint application rate, using the formulas in *Industrial Ventilation: A Manual of Recommended Practice.* (Id.)

Excessive quantities of air need to be handled to protect the breathing zone of a spray finisher solely by the use of general ventilation. Hence, indoor spray finishing operations are usually controlled by ventilated spray booths. They function by directing relatively uncontaminated air past the worker towards the process, and into a collection point or exhaust hood. The source of the uncontaminated air may be a tempered fresh air supply or simply general workroom air. (Id.)

For practical purposes, spray booths can be classified into two basic designs based on the direction of air flow. Booths with a horizontal air flow are termed "sidedraft booths." These booths take advantage of the momentum of the spray mist and can successfully be used when painting small- to medium-sized articles. With larger articles, it may not be possible to maintain adequate air flow on all sides of the object being painted, and rotating the workpiece may not be practical. In these situations, a downdraft spray booth permits greater protection, while allowing more freedom of movement for the painter. Both sidedraft and downdraft booths will vary in size, in the degree of enclosure, in the method of air makeup, in air velocity, and in overspray control. (Id.)

Spray booths range in size from small bench-type models that are designed for spraying small objects to huge chambers that are capable of holding a large airplane. The basic consideration in determining the size of a spray paint booth is the size of the object being painted; adequate space around the top and sides of the object are needed to permit the painter easy access to these areas. The booth should be deep enough to allow the operator to work inside. If the object is transported by a conveyor, the booth must be sufficiently long to permit coating within the time the object remains inside the confines of the booth at the maximum line speed. (Id.)

Both sidedraft and downdraft booths are available in open or enclosed versions. Overspray is easier to control in a closed booth; random room air currents may upset the flow pattern designed for an open booth. In addition, an open booth is more costly to operate than an enclosed booth, because a larger volume of air is necessary in order to achieve a given air velocity at the operator's location. (Id.)

The air exhausted from the spray booth must be replaced in order to achieve optimum plant environmental control. Whether this air is supplied directly to the spray booth or to the general workroom is largely a function of how dusty the plant air is. Spray booths may be equipped with filter doors or fresh air inlet plenums to prevent plant dust from settling on freshly painted surfaces. Air should enter the booth at low velocity (200 fpm or less), and in the same direction as it is being exhausted to avoid unnecessary turbulence. Fresh air inlet plenums should be equipped with baffles or other positive means of air distribution. (Id.)

The air cleaning section of the spray booth not only removes paint mist from the exhaust air, but acts as a means of air distribution within the booth. An arrangement of metal baffles is the simplest form of air cleaner. Specific design criteria for baffle-type booths are listed in *Industrial Ventilation: A Manual of Recommended Practice.* The baffle-type booth provides a constant flow of air. Mist removal and clean-up difficulties limit its use to low production applications. Dry filter booths combine low cost with high efficiency paint mist removal, but have the disadvantage of a variable air flow. The air flow is at a maximum when the filters are clean, but continuously decreases to a point where the filters require replacement. Like baffle-type booths, the dry filter booth is best suited for low production operations. Water wash booths incorporate various combinations of water curtains and sprays to scrub the paint mist from the exhaust air. They have the advantage of constant air flow, inherent fire protection, and high mist removal efficiency, but at a greater cost than dry-type booths. Maintenance is necessary to retain the high rate of mist removal. Cost of maintenance may equal or exceed that of the dry-type booths. (Id.)

Inadequate training and supervision in the techniques of spray finishing can result in a poor work environment as well as a faulty finish and a waste of paint. Because spray booths function by directing clean air past the worker towards the process, the operator must not position himself between the object being painted and the point of exhaust. (Id.)

When four sides of an object are sprayed in a sidedraft booth, all four sides can be painted without the operator being covered with his own overspray by incorporating a turnable. The painter's breathing zone can be removed from the area of active mist generation if an extension or pole gun is used. Airless spray equipment is useful for such cases because of its inherent low mist generation and its superior coverage of deep recesses. In a tall object in a downdraft booth, stepladders, platforms, or manlifts can be employed to avoid exposure to the spray backwash. (Id.)

(d) *Specific Applications*

(i) *Automotive Manufacture.* Autombile manufacturers utilize a booth which is designed with downdraft supplied at 1600–2000 cfm per linear foot of booth. An equal exhaust volume is provided. The supply air provided overhead is tempered, filtered and directed downward over the product, which moves through the booth at a rate of approximately 70 jobs per hour and is exhausted through a grating in the floor and scrubbed in the back section of the booth. Velocities of approximately 200–300 feet per minute exist on the skin of the product being painted. This type of ventilation system represents the current "state of the art" technology. Individual plants may have slight variations in the design; however, the basic control system has remained essentially the same in motor vehicle assembly plants over the past 30–40 years. (Ex. 476–411). Air-supplied respirators are also used.

(ii) *Automotive Refinishing.* The automobile refinishing industry is considered separately from the automobile producing industry because of the nature of the refinishing production process. Many of these shops can be characterized as small, poorly ventilated, and having few or no controls. Only modern, larger automobile paint shops use auto refinishing booths.

The surface that is to be painted is normally cleaned, sealed, and sanded before paint application. These operations are usually performed by hand. Coatings are normally applied by hand-held air atomizing equipment. The coating material is generally cured by air drying.

Alkyd enamels are used for total body repainting because, unlike the case with lacquer finishes, no hand rubbing is needed to gain a high gloss surface film. The rapid cure of lacquer finishes permits blending of spot repairs into undamaged areas, which makes this type of finish more popular in body repair shops. The air drying alkyds are more typically applied in spray booths because of their suceptibility to contamination by airborne dust. (Ex. 476–412)

(iii) *Wood Furniture.* Before coating, the wood surface is prepared and pretreated in several steps, such as sealing, glazing, sanding, and polishing. These techniques are used for both natural wood and unfinished exterior or interior grades of plywood. Some materials may require solvent wiping and sanding. Coating materials are generally applied in several layers, which require intervening steps like sanding, rubbing, daubing, and polishing. These procedures are performed by hand and, therefore, the workers are exposed not only to the liquid coating material itself, but to the wood dust that may also contain the coating material. Coating materials are predominately applied by hand. Sometimes electrostatic spray techniques are used; they require the use of a conductive primer (applied by dipping), or controlled moisture content. (Id.)

(iv) *Metal Furniture.* The metal surface to be coated is cleaned and pretreated. Most plants use automated three-stage or five-stage pretreatment processes, incorporating hot water rinses, phosphoric acid baths, and chromic acid rinses. (Id.)

Alkyd baking enamels are most used. Various acrylics (both thermosetting and emulsion), high-solid polyesters, and powders are also used in lesser quantities. Electrostatic spray guns are used in both automatic and hand-held operations. Both liquid paint and powder coating lines are highly automated, but hand-held conventional and airless spray guns are still used in reinforcement operations. It is common for defective coating to be manually reworked. (Id.)

(v) *Major Appliances.* Before coating, the metal surfaces are prepared in order to remove rust, oil and other unwanted material. Treatment generally involves eight automated stage, consisting of alkali cleaning, double water rinsing, and a zinc-phosphate bath, followed by water, chromic acid, and deionized water rinsing.

Primers are generally applied by electrocoating in a water bath that contains 8 to 10 percent paint material. As alternatives to this method, dip and flow coating techniques can be utilized. Some primers are still applied by manual or automatic spraying. (Id.)

Top coating is usually accomplished by electrostatic spraying. Both automatic and hand-held electrostatic guns are used. The automatic equipment is typically an electrostatic bell or disk. Manual spray equipment is used primarily for reinforcement on less accessible surfaces and touch-up operations. (Id.)

(vi) *Transportation (Non-automotive).* Because of the size and shapes of these products, both primers and topcoats are generally applied by hand spray equipment. Railroad cars are painted primarily for protection against corrosion; aesthetic considerations are secondary. Application techniques (primarily airless) are therefore geared to providing a high film build in a minimum amount of time. Truck finishes are also applied by hand-held spray guns and cured by baking or air drying. Alkyd-type finishes predominate in this industry. (Id.)

In the aircraft industry two component epoxy and urethanes predominate because of their ability to produce a baked quality finish without baking. Airless spray equipment is generally not accepted because of aesthetics. (Id.)

(vii) *Machinery and Equipment.* Coating application is generally by airless or electrostatic-airless spray technology; however, dipping and flow coating are also used. Despite some automation, most top coating is done by hand-spray equipment. As a curing method, air-dry and force-dry techniques are used. (Id.)

(viii) *Spray Painting in Other Industries.* Spray painting is done in many other industries, primarily those in which repair and refurbishing are performed. The shipbuilding industry is discussed under that industry category. Wherever spray painting is done the controls and method of application discussed in the general section apply. (Id.)

(e) *Exposure Levels*

(i) *General Methods For Determining Exposure Resulting From Paints.* Paint mist refers to the nonvolatile component of the coating aerosol. Its concentration in the breathing zone of spray painters can be determined gravimetrically as an index of overspray control. NIOSH reports concentrations for continuous painting operations as 8-hour time-weighted averages; results from intermittent painting operations are reported for the duration of the specific painting operations. (Id.)

The level of airborne paint mist is a more reliable indicator of the degree of control in manual spray finishing than the concentration of solvent vapors. Solvent concentrations were well below the recommended maximum even when paint mist levels exceeded the maximum concentration permitted for nuisance dusts. In no case was the reverse true. If the paint composition is known, the concentration of paint mist can also be used as a guide in estimating the potential exposure to specific nonvolatile paint components. For example, if the concentration of paint mist is 5 $\mu g/m^3$, and lead represents 1 percent by weight of the paint solids, then the airborne concentration of lead could be estimated at 50 $\mu g/m^3$. (Id.)

Continuous operations include both manual and automatic application processes where the painter remains in one location as the workpiece passes by on a conveyor. The concentration of total paint mist for the majority of continuous spray finishing operations did not exceed 5 $\mu g/m^3$, provided that spray booth ventilation rates met minimum OSHA requirements (specified in 29 CFR 1910.94) and good spray painting practices were observed. The continuous painting operations that exceeded this concentration involved either the spraying of internal cavities (case study 6) or faulty ventilation and work practices (case study 3). With the corrections suggested in these case studies, paint mist levels could be controlled to below 5 $\mu g/m^3$, and would achieve compliance with the lead standard (Id.).

Intermittent operations are non-conveyorized processes where a relatively large workpiece is positioned in a booth; after finishing operations are completed by a mobile painter, the workpiece is removed and replaced by the next unit. The concentrations of paint mist reported for intermittent painting operations range from 2.0 to 43.3 $\mu g/m^3$. Differences were due to the relative success in maintaining proper air flow orientation as the painter changes position and the degree of sophistication of the paint application equipment. The paint mist concentration for the majority of these operations could be controlled to below 10 $\mu g/m^3$ if ventilation and/or application techniques were improved. An exception would be the finishing of relatively enclosed spaces, such as vehicle interiors. (Id.)

Specific data have been compiled which indicate the levels of lead which may be in some paint mists. The amount of lead, by weight, in the dried film of paints using these pigments may reach 15 percent. In no case where the lead content approached this figure was the 50 $\mu g/m^3$ limit for lead met. Operations using alkyd resin enamels employing lead only as soaps for paint drying did not exceed the 50 $\mu g/m^3$ standard when minimum ventilation requirements were met. (Id.)

Based on the maximum paint mist concentration of 5 $\mu g/m^3$ found in well-controlled finishing operations, up to 1 percent lead could be tolerated in the dried film and the OSHA standard for airborne lead would still be met. This is not a practical concentration for the pigments typically used. However, where a variety of colors are painted, the "average" paint for the workshift may be well below this figure and the subsequent average exposure for the shift may be below 50 $\mu g/m^3$. (Id.)

The lead pigments provide durability to paint finishes and thus find greatest use on transportation and heavy equipment. Of the operations in these categories, the heavy equipment finishing operation comes closest to meeting the 50 $\mu g/m^3$ standard, with an 8-hour time-weighted average concentration of about 100 $\mu g/m^3$ during painting of equipment exteriors. (Id.)

(ii) *Specific Exposure Data.* Some data specific to lead exposures have been compiled as a result of OSHA compliance activities. Case No. PIT-3 involves spray painting in the automobile industry (Ex. 476-16). Automobiles are moved by conveyor system, electrically charged with the opposite charge of the paints being used, and then sprayed on the cars as they leave the booth. Exposures were 32.8 $\mu g/m^3$. The company indicated that in its previous sampling, levels were generally around 30 $\mu g/m^3$. All workers are exposed below 50 $\mu g/m^3$ of lead, although the company requires that MSA comfort II respirators are worn. OSHA Case No. TD-5 involved spray painting of plastic parts for automobiles. Levels measured were 157 $\mu g/m^3$, 293 $\mu g/m^3$ and 132 $\mu g/m^3$ before the company upgraded the spray paint facility. After upgrading, the levels ranged from 0 to .087 $\mu g/m^3$. Respirators also were being used. Most of the upgrading consisted of increasing the ventilation, improving or replacing filters, installation of new fans, and performing needed maintenance. Two spray booths were replaced by ones which utilize a water-wash entrapment technique to collect contaminants.

OSHA case number WB-2 involves painting of large industrial mufflers. Painting was done in an enormous spray booth. Levels of exposure were measured at 14 $\mu g/m^3$ and 24 $\mu g/m^3$. Compliance was achieved solely through the use of exhaust ventilation of the booth. However, although the company was in compliance, company policy requires that respirators be worn at all times. The company also stated that its implementation of this ventilation system in the spray booth resulted in an improved spray finish on its products.

(f) *Additional Controls*

Spray booths that meet OSHA design requirements are capable of controlling total paint mist and organic solvent vapors to within recommended maximums. Spray booths are partially effective in the control of toxic metals and other dangerous materials, insofar as they contain the hazard within the booth.

Several factors not addressed by the OSHA standard have a significant bearing on the effectiveness of a booth in protecting the health of the painter.

The distribution of air within the spray booth is at least as significant as the average air velocity. Supply and exhaust air chambers are often built without regard to accepted criteria for plenum design (Ex. 476-412). Particular problems occur where fresh air is supplied at a velocity that is too great, introduced in a direction other than the direction of exhaust, or introduced between the painter and the point of exhaust.

In order for protection to be maintained, the spray painter must not position himself between the object being painted and the point of exhaust. Where all sides of an object require painting, the operator can maintain proper position if the object is rotated, or if a downdraft booth is employed. (Ex. 476-12)

The air velocities recommended in the standard are useful guides in determining air volume requirements, but may be either too restrictive or inadequate, depending on the toxicity of the paint material, and the method and rate of paint application. Higher air flow rates should be considered for highly toxic materials in order to minimize exposure, although even at these higher rates control may not be complete.

In spray booths equipped with dry filters, airflow must be monitored because it decreases with the build-up of overspray on the filters. Manometers are frequently used to monitor the pressure loss across the filter media. Filters are changed when resistance reaches a predetermined level. Too often these manometers are broken, low on fluid, mounted where they cannot be seen, or no change point has been determined. A more positive means to ensure that the filters are changed is the use of a pressure switch and interlock that prohibits activation of the spray gun when the filter is fully loaded.

The working environment of the spray finisher can be improved by the use of paint application methods that minimize the energy expended in the atomization process. Electrostatic discs and bells atomize paint primarily by electrostatic forces and produce very little stray paint mist. An electrostatic bell system was evaluated in case study 6 (Id.). With minimal air movement in the automated spray room (for the purpose of diluting the evaporating solvents), the mean concentration of paint mist was only 0.1 $\mu g/m^3$.

When either air-atomized or airless electrostatic methods are used with heated paint, they can produce low levels of overspray, even when relatively large and complex shapes are painted. Paint mist concentrations of 2.0 $\mu g/m^3$ were measured when these methods were used to finish the exteriors of heavy equipment. Airless techniques appear to be particularly useful in painting recesses or internal cavities. Not only do they provide a cleaner work environment, but they apply paint faster and cover inside corners better. In a similar operation using conventional spray guns, paint mist concentrations were over 10 times as high. This higher level of paint mist was found despite the fact that the total number of units requiring internal painting was significantly less.

There is some reluctance to use high technology application equipment, especially where appearance is a critical factor. This is due either to the greater versatility of conventional air-atomized spray equipment or to some inherent cost limitations with the more sophisticated techniques. However, in many operations, ventilation is impractical, and efficient application techniques are the only logical choice.

Respiratory protection may be required in those spray finishing operations that employ significant quantities of highly toxic materials, such as lead, chromium, or reactive compounds (isocyanates and epoxy curing agents). It is also necessary for protection against paint mist and organic solvents in painting enclosed spaces and other areas where ventilation is compromised. The lead standard contains respirator selection guidelines.

(g) *Conclusion: Technological Feasibility*

OSHA has determined that substitution of non-lead based paints is one feasible alternative for the industry. Lead and other toxic metal pigments should be eliminated where possible.

Spray booths can be used which maximize the enclosure of the painting operation. The choice of a downdraft or sidedraft booth depends largely on the configuration of the object that is to be painted. Air flow must be in a direction which will carry contaminated air away from the breathing zone of the painter. If necessary, work platforms, product rotators, or other means must be provided in order that the proper orientation of air flow can be maintained.

Application equipment is available which minimizes the energy expended in the atomization process, thus reducing the amount of stray mist that is generated. The recommendations of the paint formulator concerning the method of application and the atomization parameters should be strictly followed.

Several commenters discussed the problems associated with applying lead paint to surfaces. Billings noted problems encountered with "bounce back" and suggested that application be automated or be done by brush or roller in these instances where possible. However, it appears that in some cases, depending on the number of spray painters, the size of the object, and numerous other environmental factors, the PEL in spray painting can be achieved through the use of currently acceptable control technologies and without reliance on a respirator, as OSHA's compliance activities demonstrate (Ex. 476-16). Even in industries such as the automobile industry which were previously felt to be at the state-of-the-art, new techniques are being used which are achieving compliance with 50 $\mu g/m^3$. In most of these situations, even when compliance is being achieved, employers are requiring workers to wear respirators as an added safety measure, but not air-supplied respirators. Certain operations, such as painting deep recesses or confined spaces cannot be effectively controlled by ventilation. Airless application methods can be used for these operations. However, OSHA recognizes that in some of these cases, due to the conditions of application, engineering controls alone will not be adequate to achieve the PEL and respirators may be necessary in addition to currently available controls. However, the industry generally appears to have the control technology necessary to achieve compliance with 50 $\mu g/m^3$. In addition, employers may rotate workers, thereby reducing levels to an even lower extent.

39. Steel Manufacture

(a) *Primary Steel Production*

(i) *Process Description and Exposure Areas.* The basic oxygen steelmaking process uses as its principal raw material molten pig iron from a blast furnace. The other source of metal is scrap. Scrap is processed similar to the methods used in scrap processing and collection; hydraulic scrap cutters may be used. Only the processing of lead scrap poses a problem. Lime, rather than limestone, is the fluxing agent. As the name implies, heat is provided by the use of oxygen.

The basic oxygen furnace (BOF) is a steel shell lined with refractory materials which is supported on horizontal trunnions so that it can be tilted. Usually these furnaces are installed in pairs so that while one is making steel the other can be filled with raw materials.

The first step for making a heat of steel in a BOF is to tilt the furnace and charge it by larry car with steel scrap. Immediately following the scrap charge, an overhead crane presents a ladle of molten iron from a blast furnace or from a holding device called a mixer.

As soon as the furnace is charged, and set uprighted the oxygen lance is lowered and the oxygen is turned on. In a very short time the heat increases and lime, fluorspar (and sometimes scale) are added via a retractable chute to the metallic charge. From that point on, the blowing procedure is uninterrupted. Oxygen combines with carbon and other unwanted elements eliminating those impurities from the molten charge and converting it to steel. The lime and fluorspar help to carry off the impurities as a flowing layer of slag on top of the metal which is now entirely molten.

When the batch of steel is complete, the oxygen is shut off, the clamps on the lance are released, and the lance is retracted through the hood. The furnace is then tilted in the direction opposite to that in which it is charged, and molten steel flows through a tap hole that is located near the top of the furnace. A ladle receives the molten steel. The slag, which floats on top of the steel, stays above the taphole by the progressive tilt of the furnace.

Electric arc furnaces are used for producing alloy, stainless, tool and other specialty steels. More recently operators have also learned to make larger heats of carbon steels in these furnaces. Therefore, the electric steel making process is becoming a high-tonnage producer.

Electric arc furnaces are shallow steel cylinders lined with refractory brick. They are charged in one operation from buckets or other containers brought in by overhead cranes. The roof of an electric furnace is pierced so that three carbon or graphite electrodes can be lowered into the furnace. These electrodes provide the current arcs from one electrode to the metallic charge and then from the charge to the next electrode, causing intense heat.

In each process the end product is molten steel in a ladle. In this form the steel is useless. It must be solidified into forms that are suitable for further shaping by the steel industry's rolling mills and other finishing facilities. Molten steel direct from furnaces is rarely cast into finished products.

The traditional method of handling raw steel from a furnace it to "teem" it from the ladle into ingot molds of various sizes and shapes. Alloys are added to the ladle of steel often by chutes extended from above the teeming floor. However, injection may be by gun.

The ladle into which the molten steel from the furnace has been tapped is usually mounted on a railcar which is moved to a position where an overhead crane can lift it. The overhead crane lifts the ladle of molten steel to a position where it can be poured into ingot molds, (or into a strand or continuous casting machine) for solidification.

The size and shape of an ingot is determined by the size of the roughing mill designed to handle it. Roughing mills produce semifinished forms of steel such as blooms, which are roughly square in cross section; slabs, which are rectangular in cross section; and billets which are smaller than blooms in cross section and usually much longer.

A more modern technique than the traditional ingot procedure is the use of a strand casting machine to receive molten steel and produce such semifinished solid products as slabs or billets. In so doing, they bypass ingot teeming, stripping, soaking and rolling.

There are several kinds of strand casting machines, but the principles of their operation are similar. Molten steel from a furnace is carried in a ladle to the top of the strand caster. A stopper in the bottom of the furnace ladle is lifted so that molten metal drops into the tundish (which provides an even pool of molten metal to be fed into the casting machine), which also acts as a reservoir allowing an empty ladle to be removed and a full ladle to be positioned and to start pouring without interrupting the flow of metal to the casting machine. In some strand casters the descending column of steel is cut to desired lengths while still in a vertical position. This is done by traveling cutting torches.

Molten metal is often received from conventional steelmaking furnaces and refined to remove impurities quickly before the steel solidifies. Among the vessels and other facilities used in this operation are those for vacuum stream degassing, vacuum/ladle degassing, argon-oxygen decarburization and vacuum/oxygen decarburization. Electron beam processing generally begins with carefully selected and prepared cold raw materials. However, there is nothing to prevent the electron beam facilities from being charged with molten steel from a primary smelter. These remelting processes are used mostly in the production of sophisticated alloys and specialty steels.

Sources of lead exposure in steel making include leaded heats (i.e., additions of lead either to the blast furnace as an additive to the molten iron or to the ingot molds at the time that the steel from the furnace is poured into the molds). Lead is usually added to ingot molds as lead shot in order to provide the finished steel with useful properties for machining operations (477–5G). More specifically lead exposures occur at the pouring stand of the "Pit" section where leaded steel is produced. (476–442). From the BOF, a steel ladle is transported via a crane to a stand where ingot molds are present. During each "teeming" (adding molten steel to ingots molds) 50 pounds of lead shot are added to each ingot when it is one-third to two-thirds full. Lead is added to the steel stream with a "lead" gun comprised of a rubber hose and long steel pipe with a nozzle. Workers must operate the guns, throw toppings on each ingot to keep the molds from losing their heat, and must take a steel sample.

(ii) *Controls Currently Used.* Materials handling is often done mechanically or pneumatically. Scrap is processed by using hydraulic cutters to reduce its size prior to charging furnaces (Ex. 500, p. 5). Local exhaust ventilation of furnace areas, ladles carrying molten melts, and casting areas is also used.

Companies may (Ex. 476) use a pneumatically operated "lead gun" to inject lead shot into the molten metal stream from the teeming ladle. A traveling ventilation system is attached to the teeming ladle. A hood serves the ingot mold being filled, and is connected to a 20-foot flexible duct which exhausts through a plenum to a baghouse. The traveling exhaust system is disconnected and reconnected during teeming so that it can be moved along with the teeming ladle. The duct (which ventilates the exhaust hood) is moved manually at its point of connection into the plenum.

At the molding operations, the ventilation consists of built-in local exhaust systems. Adjacent to each ingot mold there are lateral exhaust hoods. Hoods are opened in a sequence to reduce total ventilation air quantity. Lead captured is conveyed to fabric filters, shaken into polyethylene lined bags.

An OSHA inspection identified as case #PIT–2 reported that 3–4 hours per day, while the molten steel is being poured (Ex. 476–460), once or twice per shift. Also, this company invented a sliding ventilation system with telescoping duct work. The system was also connected to a baghouse which emptied the contaminant collected into a drum for disposal. The system is used exclusively for leaded steel pours. In this particular operation the crane operator was not in an enclosed cab and his exposures were in excess of 200 $\mu g/m^3$; the company is installing a positive pressure, filtered air cab on the crane to achieve compliance with 50 $\mu g/m^3$. This company also rotated workers' shifts (i.e. one crew works one month with lead and spends two months removed from lead).

(iii) *Exposure Levels.* Exposure data collected at teeming operations indicate that at the CFI Steel (Ex. 476–457) plant lead breathing zone samples ranged from 1 $\mu g/m^3$–79 $\mu g/m^3$ with 22 percent of the samples exceeding the 50 $\mu g/m^3$ standard. Other comparable data has been recorded which ranges from 10 $\mu g/m^3$–190 $\mu g/m^3$ with the mean value near 50 $\mu g/m^3$ (Ex. 476–456).

Data collected during teeming indicates that levels range from 20 $\mu g/m^3$ to 2600 $\mu g/m^3$ with the majority of data exceeding 200 $\mu g/m^3$ (Id.). OSHA inspection number PIT–2 found levels at one teeming operation of 200 $\mu g/m^3$ for the ladle preparer, 60 $\mu g/m^3$ and 70 $\mu g/m^3$ for helpers, 40 and 50 $\mu g/m^3$ for pitmen, 60 $\mu g/m^3$ for pourer's and 30 $\mu g/m^3$ for the pourer's helper and 230 $\mu g/m^3$ for the craneman (Ex. 476–460). Controls which were in place were designed to achieve compliance with a 200 $\mu g/m^3$ standard.

(iv) *Additional Controls.* The controls exist to achieve compliance in steel manufacture, more specifically in alloying, but some employers may need to upgrade existing equipment. In fact, OSHA's recommendation in case #PIT–2 was that compliance in this operation with 50 $\mu g/m^3$ could be achieved by widening the flanges on the hood of the telescoping duct work and increasing the total ventilation system air volume flow rate.

Materials handling operations should include more local exhausting of emissions sources. Recommended controls also consist of improving the ventilation at the teeming operations. The local exhaust hoods used are only as wide as the molds. Flanges and side baffles should be used to increase the capture area. Crane operators can be placed inside enclosed cabs.

Good employee work practices can help minimize exposure. High lead concentrations are a result of workers heaving toppings into the molds instead of gently pushing to avoid splattering (Ex. 476–455). NIOSH HHE–CFI). Workers can be taught to position themselves in pouring operations, etc. in such a fashion as to minimize their lead exposure. In addition, employers may find it necessary to rotate workers on a more frequent basis than monthly to comply with 50 $\mu g/m^3$ standard.

(v) *Conclusion: Technological Feasibility.* The steel industry is presently undergoing a modernization program. To be consistent with the modernization program, OSHA recognizes the need to have control of lead exposures accomplished in conjunction with these modernization efforts. The extended compliance period of three years is consistent with these efforts and is provided despite the fact that existing controls can technologically control lead. Rather, OSHA believes lead control should not occur in a vacuum when a more cost-effective, long-term solution to a host of environmental problems can be accomplished within the framework of modernization. OSHA has concluded that compliance deadlines for the lead standard should parallel the timetable established for modernization by the Steel Tripartite Advisory Committee. The Committee envisions that modernization will be completed in 3 years; then, if retooling is not completed another two years will be provided. Accordingly, OSHA has provided a 3 year compliance deadline and may reconsider extending that period based on existing conditions at that time (Slip opinion, p. 162).

OSHA has also set an interim level of one year in which to achieve compliance with the 100 $\mu g/m^3$ level. This action is taken to assure that employers who do not plan to remodel their teeming facilities do not allow lead levels to remain unnecessarily high. Those employers who do plan to modernize their teeming facilities will be eligible to bypass the interim level. 29 CFR 1910.1025(e)(4). In the interim, these employers should maintain the effectiveness of existing systems, provide enhanced housekeeping, and rotate workers to maintain lead levels as close to the 50 $\mu g/m^3$ standard as possible.

(b) *Secondary Steel Manufacture*

(i) *Process Description and Exposure Area.* Scrap steel is received and cut using acetylene cutting to reduce the size of the scrap so that it will be suitable to feed into the furnace. Exposure to lead may occur where the scrap contains lead.

Electric induction furnaces are primarily used to remelt scrap. As the steel scrap melts, a pool of liquid metal is formed on the furnace bottom, but when the entire bath is molten, the stirring action of the inducing current moves all of the liquid steel with no dead spots.

There is little need for a slag during induction melting since the surface of the liquid metal exposed to air is small in relation to its volume.

After melting is complete, the operator makes necessary additions of alloys or deoxidizers to bring the steel to a specified chemical composition. When the analysis and temperature of a heat are completed the furnace is tilted and the molten metal runs out over the lip into a ladle or directly into a mold.

(ii) *Controls Currently Used.* Materials handling is done mechanically or pneumatically, with scrap either being processed on the site or purchased ready to use. Scrap processing in the steel industry is comparable to general scrap processing and requires sorting, chopping, and burning (cutting). Local exhaust ventilation at the ladles, molds, and other sources of emissions is also used. Generally, the ventilation controls are similar to those found in the primary steel processes.

(iii) *Exposure Levels.* Exposure data submitted by USWA (Ex. 483) indicates that lead levels in scrap processing are low. Out of 13 samples taken none were above 36 $\mu g/m^3$ and most were between 7–15 $\mu g/m^3$

(iv) *Population Exposed.* The number of workers exposed in secondary steel operations is unknown. However, since the data indicate that lead levels in scrap processing may be low, OSHA estimates that only a small percentage of workers are exposed in excess of 50 $\mu g/m^3$

(v) *Additional Controls.* None are required. Maintenance of existing controls and housekeeping should keep lead levels below 50 $\mu g/m^3$.

(vi) *Conclusion: Technological Feasibility.* In secondary steel manufacture it appears that 50 $\mu g/m^3$ can be met and in some operations is currently being met with existing technology. In those instances where levels are in excess of the PEL, upgraded ventilation systems coupled with worker rotation can be used to achieve compliance with 50 $\mu g/m^3$. In addition, improved housekeeping and maintenance of existing controls will permit compliance with 50 $\mu g/m^3$ in one year even in the more difficult situations.

(c) *Forming Steel Products*

(i) *Process Description and Exposure Area.*—(*a*) *Processes.* Forging may be defined as using compressive force in such a manner that the lines of metal-flow in a product put the greatest strength where it is needed. There are two major types of hot forgings—open-die and closed-die. In open-die forgings, large presses are used which squeeze the steel between two flat surfaces. Closed-die forging uses matching tool steel dies into which the shape of the desired finished product has been "carved." The steel is placed between the two dies which are hammered together. The hot metal inside the closed dies flows to fill both halves upon impact from a steam hammer. Forging presses may be driven hydraulically, although some exert pressure through mechanical devices.

Other operations which fall under the general category of forging include extrusion, upsetting and roll forging. All of these knead the original steel into a denser structure and bring it so close to its original finished shape that it requires minimal cutting with machine tools. Thus, very little metal is lost as scrap.

Steel may be rolled hot or cold. The cold rolling process hardens sheet steel so that it must be heated in an annealing furnace to make it more formable. The batch (or box) annealing furnace requires that coils of cold rolled sheets be stacked on a special base with huge covers that are cylindrical. Then a huge box-like annealing furnace is lowered over the covered stacks of cold reduced sheets and the temperature is increased to a specific level for the desired end product. The length of time that the sheets are heated at a given temperature, and the length of time allowed for them to cool is of extreme importance in meeting customer specifications. The heating and recooling of the cold, reduced sheets may take 5 or 6 days.

Alternatively, continuous annealing facilities may be used, depending upon the end product desired. Continuous annealing lines are imposing structures often longer than a city block and several stories high. The coils of cold rolled sheet are uncoiled and led up and down through towers in the annealer, and subjected to heat. The steel is "softened" in preparation for further processing.

If the desired end product is cold rolled sheet and the product will not be coated, the annealed cold rolled sheet will often be sent to a temper mill. The temper mill provides flatness and surface quality for many end products such as sheets for automoble bodies, or home appearance.

It is not at all uncommon to prepare steel slabs scheduled for rolling into high quality sheet and then strip these sheets by grinding or burning off surface imperfections on them with torches in a process called scarfing.

A Sendzimir mill rolls extremely thin-gage steel sheets. Most tin plate is produced by the electrolytic method.

There are three continuous tin plating processes in general use in the United States today; halogen, alkaline and acid. All three start with a product called black plate which is actually a form of cold rolled sheet that has been annealed, usually in a continuous annealing line.

Other products formed from steel are hot rolled or cold drawn bars, structural steel shapes, steel plates, clad plates, pipes, tubing, and wire. A discussion of pipe galvanizers and wire patenting is provided in separate sections.

Lead exposure only results when the steel being worked contains lead.

(ii) *Controls Currently Used.*

The initial operation in the forming of steel is the heating of metal ingots in soaking pits. These pits are charged and emptied by overhead cranes and are heated by gas. Potential contaminants from this operation include carbon monoxide from incomplete combustion of the gas, and dust from the slag that falls from the ingots and is removed from the bottom of the pits in the cinder tunnel. The soaking pitmen and bottom-makers are the most likely employees to be exposed to toxic dust when they clean and repair the pits. The crane operators who work above the soaking pits are in air conditioned crane cabs, so their exposure is expected to be low.

The hot ingots are moved by crane from the soaking pits to a transfer table which moves them to the rolling or roughing mill. The transfer table is operated from an air conditioned enclosure or "pulpit" and employees are exposed to very little dust or other contaminants. (Ex. 476–453).

The roughing mill is operated from an air conditioned pulpit and the ingot is passed back and forth between the rollers until it has been reduced to a billet or slab of desired dimensions. It is then sent to a scarfing operation, also controlled from an air conditioned pulpit, where the outer coating of impurities is removed with a combination of high pressure water and flame. The ends of the bloom, billet, or slab are then sheared off and the semi-finished shape is removed from the area. This shearing step is also controlled from an air conditioned enclosure.

While the first few passes of the ingot through the rollers creates some metal fumes and dust particles, these are generally of a large diameter and nonrespirable and the major source of toxic contamination is the scarfing. During a NIOSH investigation, a dense smoke was observed rising from the scarfer, especially during the scarfing of ingots identified as being from high sulfur heats. There is one overhead crane operator who works in this area in an open cab and his exposures can be quite high except that he does not spend his full work shift in the crane. There are also workers on the floor in the vicinity of the rolling mill and these employees are potentially exposed to many contaminants.

Other employees routinely stationed in this department are the scarfer repairmen who spend much of their time in a workroom partitioned off from the general mill area. They are exposed to the fumes and dust from the mill and also to metal dust created in grinding and cleaning operations they perform in their workroom.

(iii) *Exposure Levels.* Exposure levels averaged 10–20 $\mu g/m^3$ of lead except for one sample from a mill laborer which was 190 $\mu g/m^3$ (Ex. 476–452). Two years later lead levels were 17 $\mu g/m^3$ (Ex. 476–453). One sample in the study was as high as 35.4 $\mu g/m^3$. (Id.)

Exposure data collected at scarfing operations shows a great deal of variation; sometimes these jobs are below 50, sometimes they are not (CFI).

Lead exposure reductions in flame scarfing operations have been accomplished by staggering the workers. Conditioning may be done by grinding. In fact CFI suggests that flame scarfing is being replaced by grinding machines due in part to the fact that the cost of gas used in scarfing is prohibitive in certain locations. (Ex. 476, CFI)

(iv) *Additional Controls.* The controls needed for compliance when forming steel products consists of the use of existing technologies such as ventilation, isolation and enclosure. AISI (Ex. 500, p. 6) estimates that some companies which have not used these controls may have to isolate processes and install crane pulpits, although, AISI states that even with these engineering and administrative controls levels would not consistently be below 50 $\mu g/m^3$. AISI also maintains that ventilation of mill stands is not possible, because ventilation above the stands would be destroyed by cobbles (twisting masses of steel). Down draft ventilation in these instances could be used, although with some effort and keen awareness of engineering design, a local exhaust system for this operation could be devised. Grinding operations can be controlled by the use of local exhaust ventilation although AISI maintains that the use of air-supplied respirators is necessary to comply with 50 $\mu g/m^3$. Scarfing operations could be substituted with grinding, thereby reducing levels. However, while this may be an alternative, more traditional methods have been used in other burning operations to achieve compliance with 50 $\mu g/m^3$ (See Lead Burning section).

(v) *Conclusion: Technological Feasibility.* Although AISI maintains that it is not feasible to use existing technologies to achieve compliance with 50 $\mu g/m^3$ in steel product formation, the data suggests that compliance is achievable and existing technology need only be applied to the industry. Unlike the primary production of steel, this portion of the industry is not modernizing due to financial constraints. Easily installed, available technology can reduce lead to the PEL. Therefore, compliance with the standard is required within a one-year period. The exposure data indicates that some mills are complying. Scarfing operations (Ex. 476–455) in some cases are merely being controlled by staggering workers and the alternative of grinding is being reduced in some instances by the high costs of fuel needed to operate scarfing torches. Firms not in compliance in this industry need only try, and through the use of control strategies consisting of engineering controls, work practices, and worker rotation the 50 $\mu g/m^3$ standard can be met.

(d) *Steel Fabrication*

Sheets of steel are cut using an oxygen-acetylene cutting torch, then welded together to produce a finished product.

Lead exposure could result if the sheets being cut are lead steel. The NIOSH HHE (Ex. 476–456) done on the Grand Junction Steel Co. indicates that lead levels were nondetectable, however, excesses of iron oxide, etc., were found. Recommended controls include the use of local exhaust ventilation and/or electrostatic precipitators to minimize welding fumes. The same controls would reduce lead exposures if lead were present.

(e) *Economic Feasibility*

(i) *Cost of Compliance.* There are several potential sources of lead exposure in the steel industry. These include the production of leaded steel and terne metal (a lead-tin alloy), and the processes of annealing, patenting, grinding and scarfing steel products (USWA, Ex. 477-5).

The American Iron and Steel Institute states that compliance with the lead standard is "prohibitively costly" and estimates costs in the range of $500,000 to $1,000,000 per teeming facility for upgraded evacuation systems, and $3,500,000 per teeming facility when no evacuation systems are currently in place (Ex. 475-39(A)). No engineering or financial details were provided with these estimates. Similarly, an unsupported estimate of $5,800,000 for a completely redesigned hood in a teeming operation was provided by AISI (Ex. 500). With respect to operations in rolling mills, AISI received estimates from one member company of $10,000 for isolation controls, $20,000 for two crane pulpits, and $200,000 for four crane cabs to control exposures in soaking pits. Ventilation of mill stands was estimated to be "so expensive that it is not economically feasible." Downdraft ventilation, which was the only type of ventilation deemed effective, would necessitate reconstruction of complete facilities (Ex. 475-500).

Estimates for substitution of two salt baths, which have been substituted for lead baths in wire patenting processes, were $85,000 to $115,000 where existing controls were in place. Replacement of existing controls with a fluidized bed system was estimated to cost $750,000. The Stelmor process, which reduces but does not eliminate the need for patenting operations in the production of wire or rod (Ex. 475-500), requires capital investment of about $100,000,000 for new plant construction (Ex. 476-482). However, about 25 steel works in the steel industry have already switched to the Stelmor process (Ex. 474-22), and some steel plants have substituted salt baths for lead baths in annealing and patenting operations (Ex. 476-486). Bethlehem Steel has instituted a process change in wire patenting operations that enables it to achieve compliance, but neither the details or the process nor the costs were specified (Ex. 476-481). According to the International Wire Association, the use of lead in wire patenting is being phased out by replacement with other processes (Ex. 476-484).

Cost data for the substitution of grinding for scarfing operations, which reduces exposure to lead (Ex. 475-500), were estimated at $1,530,000 with a 2-year period required for design, building, and installation (Ex. 476-425). AISI stated an additional cost of $2,750,000 for a baghouse (Ex. 500) to prevent release of pollutants into the ambient air, however, this cost is not attributable to OSHA. Furthermore, there may be cost incentives spurring the move from scarfing to grinding in certain locations where the price of special gases needed for scarfing is rising. This increase in price limits the attractiveness of scarfing when compared with grinding (Ex. 476-425).

AISI did not describe the baseline of current controls in the industry nor did it attempt to show examples of current attempts at compliance in the industry. Both Copperweld and Jones and Laughlin stated that OSHA requirements were "burdensome," but they also indicated that process controls, such as stationary and traveling local exhaust ventilation systems, were in place and effective in reducing air lead levels (Ex. 476-449 and Ex. 476-431). In addition, AISI did not consider the effectiveness of housekeeping and work practices, which are relatively inexpensive methods of control, in estimating costs of compliance. Thus, OSHA believes that their costs are biased upward for each plant and, if extrapolated, would substantially overstate costs for the industry as a whole.

OSHA estimates, based on the data of DBA (Ex. 474-65B), capital costs for the wire patenting firms would range between $1.25 million and $2.5 million. In addition, firms may also need to spend $3 to $5 million in annual operating costs. For long terne metal producers the annualized capital costs are estimated to range between $63,000 and $125,000. Estimated annual operating costs range between $157,000 and $265,000 for these producers.

(ii) *Industry Profile.* Within the steel industry there are an estimated 58 companies in SIC 33122 producing steel ingot and semifinished shapes, 85 companies in SIC 33124 producing hot rolled bars, bar shapes, and plate, and 24 companies in SIC 33125 producing steel wire as part of steel mill operations. Alloy steels, including leaded steels, valued at $1,067,343,000 comprised about 25 percent of total steel ingot shipments valued at $4,028,900,000 in 1977. Steel wire, some of which is produced by lead patenting or annealing), manufactured in steel mills was valued at $606,300,000 in 1977. The quantity and value of long ternes (SIC 3312317) and short ternes (SIC 3312329) were not disaggregated from other tin mill products in the published data (Ex. 476-438), but represents a relatively small portion of steel mill production (Ex. 476-475). All processes that potentially involve exposure to lead in steel production are included in the industrial classifications above.

Several of the major steel producers, including Bethlehem Steel, U.S. Steel, Inland Steel, Copperweld, Republic Steel, and Jones and Laughlin, produce leaded steel alloys (Ex. 476-434, Ex. 476-431, Ex. 476-449). In addition, some specialty steel producers may also add lead to steel ingots for end use in free machining castings (Ex. 474-22, p. 263).

Very few companies produce terne metal products (Ex. 476-475). Long ternes (sheet steel that has been coated with a tin-lead alloy) can be produced in continuous and single-sheet coating processes. The latter is less efficient than the continuous process which eliminates some intermittent operations associated with sheet pots and produces a higher quality product since the coating is more uniform. All long terne production processes at U.S. Steel facilities are continuous, but other companies may still use single-sheet coating, which has the advantage of being more adaptable to small, varied orders, especially with respect to the size of sheets needed. Gasoline tanks for tractors, trucks, and automobiles are the major end use of long ternes (Ex. 476-475). Terne plate, occasionally known as short terne, is produced in very small quantities today. It is no longer used at all for roofing material, firedoor plates, or other former uses (476-475).

An estimated 100 plants produce wire by using lead patenting operations (Ex. 474-22). Not all patented wire is produced by steel companies, however, and those steel companies that do produce wire usually have separate facilities or distinct plants for this purpose. At least two of these producers have used substitution or other controls to comply with the lead standard. CF&I has switched to a sodium bath (Ex. 476-435), and Bethlehem Steel has controlled lead exposures by improving local exhaust ventilation and adding a surface active agent to the molten lead (Ex. 476-454).

Another producer, who produces lead patented wire only when orders are received from customers, considers the operation "marginal." Exposures, which occur intermittently, are not controlled by any ventilation at all. However, housekeeping, including vaccuming of dust created in scale from the dragout operation, is performed (Ex. 476–431).

For this analysis, OSHA recognizes that data specific to the producers of leaded products within the steel industry would be preferable to data for the steel industry in general. However, neither the published data nor the submission of AISI are disaggreated in this manner. Therefore, the following discussion of economic conditions in the steel industry is assumed to be applicable to those firms within the steel industry that are affected by the lead standard.

The steel industry has been characterized as a laggard industry that has failed to keep up with changes in technology. The industry faces strong foreign competition and recent reduced demand for steel stemming from the decline in production of automobiles and other consumer durables, such as home appliances. Domestic industry shipments are expected to decline 5 percent in 1980 (Ex. 476–26).

In 1979, significantly increased demand for steel in the nonresidential construction market and for machinery, industrial equipment, and railroad equipment resulted in the third best volume year on record with 100 million tons in domestic shipments. However, metal production decined nearly 2 percent as steel mills reduced their inventories by more than 1 million tons. Steel imports also declined 24 percent in 1979, as a result of increased prices for foreign steel, which rose from $314 per ton to $400 per ton. Trigger prices, which are based on the production coats of the most efficient foreign producers (the Japanese) were instituted in 1978 to discourage sales of imported steel at less than fair value (Ex. 476–26). Thus, a Steel Tripartite Advisory Committee, sponsored by the Departments of Labor and Commerce, was formed in 1979 to address the problems of modernization and capital formation, labor and community adjustment assistance, technological research and development, international trade, and environmental protection (Ex. 476–26). The committee found that the current situation of individual steel companies in terms of efficiency, profitability, and competitiveness varies significantly. Differences in technology, location, sources of raw materials, and management have affected the current conditions of firms. The slow growth in consumption of steel products, the worldwide excess steelmaking capacity and the increasing market share of foreign producers in the domestic market have combined to give the industry as a whole insufficient financial capability and incentive to modernize operations. For example, the advent of continuous casting processes were adopted in 50 percent of Japanese steel mills by the late 1970's, but only 15 percent of American steel producers used the more efficient technique (Ex. 476–39F). Moreover, while some U.S. Steel producers are phasing out 40- to 50-year-old mills, major Japanese companies are shutting down 20-year-old facilities, which would be regarded as modern by U.S. standards (Ex. 476–430). Thus, the domestic industry is left with an aged capital stock, declining productivity, obsolescence and falling industry employment (Ex. 475–39F).

In 1979, U.S. Steel alone, which produces leaded steels, closed 15 plants with a loss of 12,500 jobs (Ex. 476–430). However, one of U.S. Steel's problems was its continued production of steel products in many plants that had long since failed to generate adequate returns on investment. The long overdue restructuring has helped steel product lines remain profitable, suggesting that further consolidation moves will occur (Ex. 476–440).

On the other hand, some major producers have not felt the impact of current market conditions as severely. For instance, Inland Steel's capacity is sufficient to enable it to participate fully in steel production when the market recovers, and its major diversification out of steel has kept the company profitable over the past years (Ex. 476–442). Bethlehem Steel, which retired 10 percent of its steel capacity after difficulties in 1974 and 1975, has excellent prospects for record profits in the mid-1980's owing to recent and projected extensive modernizations (Ex. 476–443). Republic Steel, in spite of recent decisions to delay major capital outlays, is in sound financial condition and can keep its plans to modernize among its first priorities (Ex. 476–441). Armco has performed impressively in view of recessionary tendencies in the economy and declining steel demand. Record high profits were reported in 1980, owing partly to successful diversification but also to Armco's up-to-date operation of steel facilities. Electric furnaces comprise 45 percent of Armco's production (Ex. 476–441). Jones and Laughlin, a subsidiary of LTV Corporation, is undergoing operating problems. However, these may be moderated by the expenditure of hundreds of millions of dollars for needed modernizations (Value Line, Ex. 476–441).

In order to survive profitably, the domestic steel industry must modernize. The Tripartite Commission has set the stage for steel modernization in the 1980's, with particular emphasis on modernizing the economic base and adopting the best possible technology (Ex. 475–39F). Since it is probable that the most advanced technology is also the cleanest technology, OSHA regards modernization as generally beneficial to the safety and health of workers. In addition, since retrofit technology is typically expensive and more likely to be ineffective than redesigned equipment, the 1980's would appear to be the rational time to invest in safe and healthful equipment and processes.

(iii) *Conclusion.* The decade of the 1980's is set for the revitalization of the domestic steel industry. AISI reports that the industry needs to spend $4.4 billion per year to modernize and replace productive capability (475–39). Modernization of the industry inherently involve the installation of cleaner and more productive technology. To the extent that modernization is accompanied by a safer and more healthful work place, OSHA its implementation. OSHA also emphasizes that effective and efficient allocation of resources occurs when controls are designed into new processes rather than applied in retrofit fashion. Thus, the Agency urges steel producers to anticipate potential sources of hazardous exposure to lead and other substances and to engineer such hazards out of existence during the planning phase of rebuilding.

Moreover, AISI indicates that steel operations involving the use of lead are generally intermittent, "occurring for short periods in a day, weekly or even monthly" (Ex. 475–39A, pp. 7, 8). Consequently, although the industry did not submit data relating to the overall importance of lead steel, it is likely that leaded steel operations constitute only a minor part of the total output for many individual firms. Therefore, some of the firms which would be required to make large capital outlays for compliance may decide to concentrate exclusively on non-leaded steel products. This tendency toward specialization would significantly limit the overall compliance costs to the industry.

Therefore, in accordance with the goals of the revitalization plan, OSHA concludes that within 3 years, it should be economically feasible for the steel producers to comply with the lead standard. (Depending on conditions in the industry, OSHA will consider granting a two-year extension). OSHA encourages firms to comply with the regulation as soon as possible and requires interim protection of exposed workers by means of worker rotation, respirators, or other effective measures.

The steel-related operations of wire patenting and terne metal production, which are not included within the scope of the revitalization plan, will be required to comply with the lead standard within one year. OSHA is allowing the firms included within the revitalization plans 3 years to comply because one of OSHA's concerns is promoting economic efficiency in complying with its regulations. Those firms will be able to implement more effective and efficient controls if they are allowed to be implemented in conjunction with the new investments which will be made over the next few years. It would be inefficient and ineffective for OSHA to require firms to retrofit production equipment that is going to be replaced and modified in the near future. In the case of firms involved in wire patenting and terne metal production, these considerations do not apply. In these operations, compliance can be achieved through simple modifications of existing equipment redesign or extensive retrofitting is not required.

To determine the economic feasibility for wire patenting firms to comply with this standard, estimates of the capital and operating costs of compliance are needed. These were provided by DBA and presented in the cost of compliance section above. Using those estimates and assuming a 12 percent rate of interest and a life expectancy of ten years for the required capital equipment, OSHA estimates that the annualized capital costs to this industry will now range between $1.25 million and $2.5 million. The new capital expenditures for this industry in 1977 were $79.4 million (Ex. 476-20). Thus, as these annualized capital costs represent, at most, only 3.1 percent of the total new capital expenditures in this industry, the rate of return to these firms' investments will not be appreciably lowered by compliance with this standard. DBA further supplies estimates of the annual operating costs of complying with this standard which ranges between $3 million and $5 million. Total 1977 shipments in this industry were $2,258.6 million. Thus, the annual operating costs represent, only 0.4% of the total shipments. Therefore, on the basis of the available data, OSHA concludes that this standard would impose very small costs upon the wire patenting industry. That conclusion, in turn, implies that this standard will have a minimal impact upon the price of lead coated wire, the prices of goods and services produced by industries using lead coated wire, the output and employment of firms producing lead coated wire, and the profitability of wire patenting operations, and, hence, the economic viability and health of small businesses, would not be altered by the costs of complying with this standard.

In order to determine the economic feasibility of the standard for long terne metal producing firms, estimates of the capital and operating costs of compliance were derived from data provided by DBA. Using those estimates and assuming a 12 percent rate of interest and a life expectancy of 10 years for the capital equipment required to comply with the standard, capital costs to this industry are estimated to range between $63,000 and $125,000. The estimated annual operating costs of complying with this standard range between $157,000 and $265,000. The available data indicate that only 3 companies manufacture long terne metal plate and that technological and economic efficiency dictates the use of large scale production technology. Thus, these costs should be a minor component of the total cost of long terne metal output. Another point to consider is that this product has no substitute (within the feasible price range) for automobile gas tanks and in gasoline truck tanks. Thus, this industry's costs of complying with the standard are likely to be passed on to the industrial purchaser of long terne metal plate. The effect which this passed-on cost will have upon the prices of the final goods using long terne metal plate (automobiles and gasoline tanker trucks) will be very small because the cost of the long terne metal products is only a minor component of the price of the final goods. Thus, the costs of complying with this standard will not measurably affect the prices of goods produced by industries using long terne metal plate, the output and employment of firms producing long terne metal plate, and the profitability of long terne metal plate operations.

40. Stevedoring

(a) *Uses.*

Stevedoring companies are those which arrange for the manpower to load or unload cargo from seagoing vessels. Only those stevedoring activities which require the handling of lead ore are discussed below.

(b) *Process Description and Exposure Areas*

West Gulf Maritime Association (Ex. 475-17) has indicated that a number of its member companies have been engaged in handling bulk concentrate ores of lead sulfide. Operations for its member companies consist of loading or unloading these concentrate ores to or from ships or barges with gantry cranes or mobile cranes utilizing clam buckets and industrial front-end loaders. Import ores are either dicharged directly to trucks or railcars or stockpiled in dock-side warehouses for later land transit. Export ores are received at dock-side warehouses and stockpiled in the warehouses for later loading aboard ship or barge. The number of longshoremen or warehousemen involved in the handling of concentrate ores varies according to the kind of cargo, the size of the cargo, material handling equipment, vessel compartment size/configuration, etc. Lead exposure results from the handling of lead ores. Approximately, 50,000-100,000 tons of lead ore are handled each year (Ex. 475-17) in approximately 10-20 shipments (Ex. 475-28).

(c) *Controls Currently Used*

West Gulf Maritime Association (Ex. 475-17) presented data depicting the controls used in a typical operation. Discharging is performed with a clam bucket from a vessel direct to railcars and involves 1 signalman, 1-2 machine operators, 8-10 sweepers and 1 gang foreman. The signalman gives hoisting and bucket position signals to the crane operator. Machine operators operate a front end loader in hold of the vessel to position ore for pick-up by the clam bucket. Sweepers salvage and hand shovel ore from between vessel ribs (structural members) into the clam bucket for final discharge. These sweepers are usually needed only for final cleanup near the end of the job.

Discharging can be accomplished by clam bucket from a vessel to the dock. Stockpiling in a dock-side warehouse involves the same operations as above, but can also involve another machine operator for a front-end loader to move ore from the dock apron to the warehouse. From the warehouse, the ore will eventually be moved by a front-end loader to the railcar.

Loading ore with a clam bucket from warehouse stockpile into a vessel involves 2 machine operators, 1 crane operator, 1 signalman, and 2 foremen. The machine operators use front-end loaders to stockpile the ore dumped by truck at the dock-side warehouse, and to move ore from the dock-side warehouse to the dock apron. The crane operator, directed by the signalman, operates a clam bucket to move the ore from the dock apron to within the vessel. The 2 foremen supervise the warehouse and vessel gangs.

(d) *Exposure Levels.*

West Gulf reported that initial air monitoring performed during the handling of lead sulfide concentrate and zinc concentrate with lead sulfide ore, revealed employee exposures to air lead levels ranging from 26–149 $\mu g/m^3$ (Ex. 476-7R). The highest concentrations were found for workers in the warehousing operations, for machine operators, and for sweepers. One West Gulf port, where lead and zinc concentrate ores are handled, employed an average of 1,020 longshoremen and warehousemen, during 1978 and 1979, with a nucleus work force of 119. (Ex. 475-17.) Another West Gulf port averaged 920 employees with a nucleus of 76. (Id.) However, because lead concentrates ores are handled intermittently, West Gulf estimated that only several employees in each port would have lead exposures slightly above 30 days per year. In no case were any employees exposed to lead in excess of 45 days per year. (Id.) Other sources confirmed that, usually, employees would be exposed to lead concentrates in ore for only a few days per year (Ex. 475–26, 27). However, as previously mentioned, exposure for these 30–45 days could be in excess of 50 $\mu g/m^3$.

(e) *Additional Controls.*

Stevedoring operations are mechanized and engineering and work practice controls, if properly used, should be effective in keeping lead levels to the 50 $\mu g/m^3$ limit except in certain operations where workers must physically remove the ore especially in confined spaces (shoveling, trimming, etc.). Work practices are also important tools in achieving compliance with 50 $\mu g/m^3$ lead standard. Mr. Richardson from West Gulf also noted that, during his recent visit to an unloading operation, the high moisture content of the lead concentrate resulted in no visible dusting, except during trimming with payloaders in the hold, and during spillage cleanup. In addition, he offered the following recommendations to further reduce dust exposures:

—Greater care should be exercised in crane operation. Overfilling of bucket or feed hopper should be avoided.
—The ridge on the crane bucket should be machined down so that material does not adhere.
—Refinements should continue on a workable fogging system that does not overwet the material. A fixed fogging position on the nozzle should be maintained permanently, with an on-off valve installed upstream of the nozzle.
—Spillage should be occasionally wetted as precaution against blowing dust.
—The belt sock on the railcar feed chute should be used consistently to reduce visible dust.
—Better education and supervision of stevedores may reduce the number of observed incidents of poor work practices, such as shoveling dry spillage from the vessel to the dock below where others were working.

If it is possible, payloader work should be completed in the hold before trimmers begin their shovel work. This precaution will reduce dust exposures to trimmers. (Ex. 475–28 (App. C)) Trimming operations may require the use of a respirator to achieve compliance with the 50 $\mu g/m^3$ limit.

The data submitted to OSHA indicates that improved work practices, especially material handling procedures, and limited use of respirators for some jobs will enable this industry to comply with the standard.

(f) *Conclusion: Technological Feasibility*

OSHA believes, based on the data furnished by ASARCO (Ex. 475–28) and the West Gulf Maritime Association, (Ex. 475–17) that lead levels can be controlled to 50 $\mu g/m^3$ in stevedore operations by implementing simple and relatively cost free work practices, such as avoiding excessive spillage from the cranes, cleaning up spills as soon as possible, and not allowing concurrent work to be done in the holds by the cranes/payloaders/trimmers. In addition, the use of an appropriate respirator may also be necessary to achieve compliance with the 50 $\mu g/m^3$ PEL in some of these operations where engineering or work practice controls may not be feasible or at some dockside facilities which stevedoring companies do not own.

ASARCO and St. Joe did not dispute the feasibility of work practices, presently utilized engineering controls and respirators to reduce lead levels to 50 $\mu g/m^3$ in these operations. These firms requested an exemption from the standard for these operations, indicating that stevedore companies were unwilling to utilize such controls and, to avoid compliance with the standard, may refuse to load or unload lead ores. This possibility, should it arise, is unfortunate but cannot deter OSHA from exercising its responsibility, as mandated by the Act, to develop and implement safety and health regulations to adequately protect workers. In so doing, the Agency must consider the feasibility of complying with its regulations. OSHA has determined, based on record evidence, that stevedoring operations can feasibly comply with the lead standard, and, in fact, has determined that compliance can be achieved largely through the less costly implementation of work practices in addition to engineering controls presently in use. In a few limited circumstances, e.g., clean-up operations following off-loading, these controls will have to be supplemented by respirators.

OSHA has no control over stevedoring companies' decisions to handle or not handle lead ores, but there are other, more appropriate means of resolving the problem of stevedoring companies' refusal to handle certain cargoes. But denying workers protection from health and safety hazards is not a legitimate basis for granting an exemption.

41. Telecommunications

(a) *Uses*

Telecommunications has been defined as "that industry that repairs those cables above our heads, and pulls them out from under the street, and pulls them in the street." (Tr. 172) For this remand, it is limited to that segment of the telecommunications industry which repairs, replaces, or installs lead sheathed cables above and below the ground.

(b) *Process Description and Exposure Areas*

Telecommunications involves the laying of new lead sheathed cable (Ex. 476–462), although one company reported that very little laying of lead sheathed cable is being done (Ex. 476–465); the withdrawal of old cable (wrecking); and the repair of cables by forming new splice cases or sleeves (Ex. 476–462). The last process involves opening lead sheathed cable splices by torch and sealing lead sheathed cable splice closures (sleeves) by pot wiping or torch (Ex. 475, GTE). Lead exposure results only from encounters with lead cable, the use of which is declining. This work may be done above ground (stringing cable between telephone poles) or in underground facilities (manholes).

(c) *Controls Currently Used*

Most companies use a portable blower system to control the employee's exposure and do achieve the PEL most of the time by these methods. (Ex. 475–22; 476–462) Bell Telephone currently controls exposures by using a spray containing water and a wetting agent, minimizing physical manipulation of the cable and rotating job assignments (assignments are ½ day) (Ex. 476–463;

475–22). Other companies have advocated the use of lead particle entrapment creams applied prior to carding (Ex. 475–22 & 22(a)) and also the use of a wetting spray during wrecking operations (Id.).

(d) *Exposure Levels*

The General Telephone and Electronic Corporation stated that "the nature of the telecommunications industry reduces to virtually zero any potential health hazard from lead exposure. A 'potentially' exposed employee only works with lead sheathed cable on an intermittent basis at best; it may be once a week, once a month, once a year or never." (Ex. 476–465; 475–22) A NIOSH Health Hazard Evaluation was performed at the New York Telephone Company to determine whether wiping sleeves in manholes resulted in excess lead exposures. (Ex. 476–464) The average time for completing a sleeve-wiping operation was approximately 60–150 minutes. Breathing zone samples were taken for the outside helper and at several spots inside the manhole (due to the size of the space, it was not possible to hang a personal sampler on the repairman). Nine of eleven samples taken indicated nondetectable lead levels. Two samples indicated lead levels of 14.8 and 45.2 $\mu g/m^3$. One sample was taken from above the sleeve, the other from behind the worker. When computed on a time-weighted average basis, lead exposures in cable splicing are probably below the action level.

In a typical day's work, a crew will remove and replace cable at different sites: there is no lead exposure between sites; while they are preparing manholes for work; or while the old lead sheathed cable is being replaced by non-lead sheathed cable. The company also stated that work with lead sheathed cable is an infrequent occurrence.

Cable removal operations, where lead oxide is produced, create the greatest potential for lead exposure. Exposure levels have been estimated to be between 100–200 $\mu g/m^3$ for the time periods in which the work is done. (Ex. 476–7B; 478–5) These levels should then be below the PEL of 50 $\mu g/m^3$ when measured as a time-weighted average. In addition, when cable pulling occurs under water, little, if any, exposure is expected.

(e) *Populations Exposed*

Approximately 42,000 Bell System employees are potentially exposed. However, based on the exposure data, it appears that very few are exposed above 50 $\mu g/m^3$ on an 8-hour time-weighted average basis. (Ex. 476–7B)

(f) *Additional Controls*

Telecommunication companies are already using controls such as suppressing creams, wetting agents, dilution ventilation, and good work practices, that are effective in keeping exposures below 50 $\mu g/m^3$. The random nature of lead exposures and the limited amount of time required to perform lead related tasks should keep employee exposures below the 50 $\mu g/m^3$ PEL. In addition, many repair crews consist of at least two men; alternating these employees' contacts with lead would further reduce individual exposures. Employee exposures will rarely be in excess of the PEL, however, when exposures exceed the PEL, employee rotation will be more than adequate to achieve compliance.

(g) *Conclusion: Technological Feasibility*

The industry maintained that its problems with complying with the lead standard were comparable to the difficulties associated with the construction industry, and that OSHA should exempt them from the standard's coverage (Ex. 475–22 and 22(a)).

OSHA does not agree that the similarities warrant an exemption (Ex. 476–7C). While workers may be required to move from site to site, the sites themselves are stationary and the company does know the location of each work place and has been able to determine representative exposure levels. Furthermore, the work force is highly specialized and not transient in nature, as it is the construction industry. Thus, the same employees continue to have potential lead exposures. The fact that telecommunications repairmen move from site to site and that sites infrequently have leaded cable, tends to aid employer compliance by naturally eliminating continuous worker exposure to lead.

Industry has contended that compliance with the standard would also require installing "a shower in every manhole" (Tr. 203, 206) and that this requirement rendered the standard infeasible. This fear is unfounded: the standard requires hygiene facilities to be constructed only when employee exposures exceed the PEL. Since worker rotation will assure that no employee's exposure to lead exceeds the PEL, no requirement to furnish hygiene facilities will ever arise.

(h) *Economic Feasibility*

There are no significant costs of compliance or economic impact because lead levels, on a time-weighted basis, can easily be maintained below 50 $\mu g/m^3$.

42. Terne Metal

(a) *Uses*

The iron and steel industry uses numerous non-ferrous metals to coat its products. Primary among these are—other than tin, zinc and chromium—aluminum, copper, nickel and lead. An alloy of lead and tin is used to make a coating for steel sheets; the end product is called terne plate. One of the most useful applications for terne plate is in the manufacture of sheets for roofing, where it has an exceptionally long life. Its uses also include fabricated metal parts, automobile gas tanks, and radio chassis.

(b) *Process Description and Exposure Areas*

There are two methods generally used for applying terne metal to single sheets in the manufacture of long ternes.

The flux process employs a flux of molten zinc chloride, a water solution of zinc chloride, or a solution of zinc chloride in hydrochloric acid to remove any oxides of iron that may be present and also to effect a rapid drying of the sheets. The terne pot temperatures range from 620° to 680°F. The process is carried out in a "rigging" or machine which carries the sheet through the several process steps prior to passing sheets through the molten terne metal, where the coating is applied. The sheets are then moved upward through a coating machine which contains an oil (palm oil, fish oils, mineral oils, or combinations thereof) that floats on top of the metal.

The equipment and processes involved are a coil holder followed by a payoff reel which feeds the strip into a pinch-roll unit. This, in turn, is followed by a squaring shear and a welder if the process is continuous. Cleaning may also be done.

The highest lead exposures occur after the terne alloy bath, when excess lead is brushed off of the coated steel strips or sheets. (Ex. 22, p. 268.)

(c) *Controls Currently Used*

Hoods are located over baths to provide local exhaust ventilation. Some plants have ventilated control booths for the protection of workers. Flaking at the coiler requires extensive housekeeping. (Id.)

(d) *Exposure Levels*

Exposure data were not presented to OSHA, but the Short Report estimated that exposures have been kept below 200 $\mu g/m^3$ (Id.). It is not clear that this estimate represents a time-weighted exposure. An OSHA inspection of a terne operation found levels of 210 μg/m³ prior to implementing engineering controls which included enclosing the terne pot operations and improving ventilation. After implementation of these controls, levels were reported as 48 μg/m³ and 41 μg/m³ for workers in these areas (Ex. 476–16, #TO–1).

(e) *Population Exposed*

The Short Report estimated that 100 individuals are exposed. (Ex. 22, p. 268.)

(f) *Additional Controls*

Ventilation systems may require upgrading. Ventilated booths for workers may be required. Improved housekeeping will be required. High exposure areas may require worker rotation.

(g) *Conclusion: Technological Feasibility*

Since this operation is automated, with mechanical devices moving and dipping sheets or strips, the oil which floats on top of the lead bath should help to keep lead from becoming airborne. In addition, ventilation is provided which, if properly used, will also control exposures. In fact, OSHA inspection data shows that simple engineering controls can be effectively used to achieve the PEL. (Ex. 476–16, #TO–1.) Occasionally, exposures may exceed 50 μg/m³ where only engineering controls exist and it is in these cases that worker rotation can be used to achieve compliance with 50 μg/m³. AISI also suggests the process change of using a fluidized bath, which eliminates lead exposure.

OSHA has concluded that compliance can be achieved in one year. It should be noted that the extended compliance period the Agency has provided for primary steel manufacturing is not applicable to terne metal production. Terne metal production does not require an extended compliance period for several reasons: (1) Terne metal is a steel fabrication process, rather than a steel production process; (2) steel fabrication is not included within the remodernization program established for steel producers (Ex. 475–39F); and (3) exposure levels are moderate and basic engineering controls are available to reduce these exposures.

(h) *Economic Feasibility*

See discussion in Steel Manufacturing.

43. Textiles

(a) *Uses*

Lead based dyes or finishes may be used in coloring or finishing textiles.

(b) *Process Description and Exposure Areas*

Colors with potential lead exposure include inorganic yellow pigments, comprised of lead chromates with varying amounts of lead sulfate. Chrome orange is a basic lead chromate, but it is not used in the textiles industry (Ex. 476–467). Also, chrome green is not used. Textile finishes may be lead based.

(c) *Exposure Levels*

Representatives from the American Textile Manufacturers Association, Compton and Knowles, and Monsanto stated that they knew of no problems from use of lead-based dyes in textiles (Ex. 476–471, 472, 473). The small amounts of lead which occur in trace metal effluents resulting from chromate-lead based dyes have been measured at 52 ppm.

The exposure problems the Short Report assumed to be associated with lead in textile finishing (insect protection, water proofing, fungus inhibitors) do not, in fact, exist. A NIOSH Health Hazard Evaluation performed at the A&S Tribal Industries (Ex. 476–470) found no detectable levels of lead as a result of handling camouflage netting that had been finished with an insect repellant.

(d) *Conclusion: Technological Feasibility*

Because exposure to lead appears to be negligible in this industry, it has been assumed that compliance has already been achieved or poses no problem.

(e) *Economic Feasibility*

There will be no significant compliance costs nor economic impact in the textile industry as a result of the lead standards. This is due to the fact that there are no appreciable employee lead exposures in this industry.

44. Tin Rolling and Plating

(a) *Summary*

Rolling refers to the rolling of lead-tin alloys (Metal Handbook). The plating of tin-lead alloys with copper alloys is comparable to other plating operations discussed above (see terne metal). Lead exposure in these operations results from the formation of the tin-lead alloy and not from the alloy being coated with a copper alloy. Alloying of steel is discussed in the steel section. Alloying of lead sheets has been classified as secondary lead smelting and has been discussed in the feasibility section of the final lead standard.

45. Wire Making

(a) *Uses*

Once a rod is drawn through a die it is called wire even though it may be re-drawn. It has been estimated that there are more than 100,000 applications for wire; its uses are as diverse as suspension bridge cables, musical instruments and dry cleaners' coat hangers. (Ex. 476–483).

(b) *Process Description and Exposure Areas*

(i) *Wire Making.* The simplest form of wire drawing involves coils of lime-coated wire rods which are drawn through a lubricant and then through dies which are smaller in diameter than the rods. The enormous force required to draw a rod through a die is provided by a device known as a draw block which rotates on its axis building up a continuous coil of wire. In a continuous wire drawing frame, wire (properly prepared and lubricated) is pulled through a series of dies. Between each of these dies are sheave wheels around which the wire is looped. These sheave wheels control the tension of the wire between die blocks. (Id).

(ii) *Quality Control.* The drawing of wire hardens the steel, therefore, prior to drawing, the rods must be treated to withstand the rigors of this operation. In addition, when wire of very small diameter is desired, annealing or patenting may be required after initial drawing and before final drawing. Heat treating is required to produce the precise quality, and may be done by annealing or patenting. Patenting is a heat treatment applied to rods and wire and is a term peculiar to the steel industry. The object of patenting is to obtain a structure which combines high tensile strength with high ductility. Annealing, on the other hand, refers to slow cooling of a metal from an elevated temperature and is used to soften, add toughness, remove stresses, and increase the ductility of metals. (Ex. 476–5K).

(a) *Annealing*

Controlled atmosphere annealing is the current method of annealing used by the wire industy. Both batch-type and continuous-type furnaces are employed. (Ex. 476–483).

Salt-bath annealing is used occasionally for common sizes of wire. The wire in coils is immersed for 30 minutes to one hour in gas-fired pots containing molten salt which is held at some predetermined temperature. The advantages of this process over other methods are that small amounts of wire may be quickly annealed at closely controlled temperatures without scaling the surface of the wire. This process has a somewhat limited application in wire processing. (Id).

Continous lead annealing consists of drawing the wire through a bath of molten lead heated to the proper temperature. The molten lead is contained in a shallow rectangular steel pan, about 10 to 15 inches deep, 3 to 4 feet wide, and 15 to 25 feet long. (Sometimes two pans are used, the first known as the cold pan and the second as the hot pan, and the wire is drawn through each in succession.) In practice several strands of wire are drawn through the bath by a take-up block placed at a convenient distance from the end. To keep the wire immersed in the molten lead, devices known as sinkers are used. (Id).

The principal use of lead annealing is in connection with galvanizing plants, where it is used to anneal process wire. In these plants, layouts are provided that permit the wire to be annealed, cooled, cleaned, washed, dried and galvanized or tinned, in one continous operation. Only lead bath annealing results in workers being exposed to lead. Fluidized bed and sodium nitrate baths are possible substitute process equipment for lead-bath heat treatment. Use of either of these processes would eliminate lead exposure in annealing processes. (Id).

(b) *Patenting Heat Treatment*

Metal patenting consists of heating the material to point well above the upper critical temperature, then cooling through the critical temperature at a comparatively rapid rate to a predetermined temperature to yield the desired microstructure and mechanical properties. There are several kinds of patenting and patenting may be done to wire or rod.

(*i*) *Air Patenting.* The rod is heated by passing it through alloy-steel tubes arranged in an open muffle or in an open flame without tubes and cooled by pulling it from the furnace into the open air—"O.P." (old process or air) patenting.

(*ii*) *Lead Patenting.* The wire may be cooled by passing it into a lead bath held at a relatively low temperature; this process is known as the metallic hardening process. In another process, the wire is heated in a bath of very hot lead and cooled in another bath of lead at a lower temperatue; this is the double lead process. In this last process the temperatures of both baths can be readily controlled and accurately measured, making it possible to obtain any desired structue even in rods of high carbon content, a quality not available using "O.P." patenting. This last method also forms less scale than in the other two methods. In the wire industry, both the metallic-hardening process and the double-lead process are generally referred to as "lead patenting."

(*iii*) *Stelmor Patenting.* The Stelmor process, takes rods, on a single strand basis, heats them to their critical temperature and rapidly water cools them to a predetermined temperature. The patented rods are formed into rod rings. The process compliments the higher rolling speeds of today's mills and enables heavier weight coils to be produced.

(*iv*) *Other Methods of Patenting.* Another method of patenting involves the use of electric direct-reistance heating and quenching in a molten alloy metal bath. A recent development, particularly applicable to patenting very high carbon and hypereutectoid steels, involves a double cascade quenching of the rod or wire from the austenitizing temperature.

Sources of exposures in patenting operations result from fumes escaping from inadequately ventilated baths and from dust flaking from process coils (Ex. 22, p. 260).

(c) *Controls Currently Used*

Ventilation and housekeeping controls are commonly used to control lead exposure. Vacuum cleaners are used to clean up areas where scale from dragout occurs (Ex. 476–484). Currently, U.S. Steel and Republic Steel are using the Stelmor process. This process eliminates lead from patenting. (Ex. 476–482). This process also tends to increase productivity (Ex. 476, 482).

(d) *Exposure Levels*

Exposure data indicate that lead exposure in patenting operations averages 100–200 $\mu g/m^3$ (Ex. 22 p. 260).

(e) *Additional Controls*

Improved ventilation and housekeeping will be necessary to control lead levels to 50 $\mu g/m^3$. However, like the pipe galvanizing process, the basic control is hooding of lead baths. Also, since the process is mechanized, workers may be protected by rotation or by providing clean air pulpits from which they can control equipment when necessary.

(f) *Conclusion: Technological Feasibility*

OSHA believes that lead exposure can be reduced to 50 $\mu g/m^3$ in this industry through minimal efforts consisting of improving and maintaining existing ventilation equipment, good housekeeping practices, and worker rotation within a 1 year period.

(g) *Economic Feasibility*

See discussion of Steel Manufacturing.

46. Zinc Smelting

(a) *Uses*

Zinc metal is used for galvanizing, brass and bronze products, and metal casting. In addition to metallic applications, significant quantities of zinc are consumed in pigments or other chemicals (Ex. 476–491).

(b) *Process Description and Exposure Areas*

The processing of zinc from its ore begins with the milling of the ore to prepare a concentrate that can be treated to recover zinc and its associated byproduct and coproduct metals (Id.).

The minerlogy of zinc-containing ores determines the technology and economics of the milling practice. Heavy-media separation pretreatment prior to zinc flotation has been designed into newer mills. About one-half of the mill feed can be floated at relatively coarse size with the reject fraction assaying as low as 0.04 percent zinc (Ex. 476, 491).

Flotation is the basic mineral reduction process. The general scheme for the flotation of mixed sulfide ore is: (1) Flotation of the lead copper minerals and depression of the zinc and iron minerals; (2) separation, also by flotation, of the lead-copper concentrate into separate lead and copper concentrates; (3) activation and flotation of the sphalerite from the iron and gangue minerals; and (4) flotation of the pyrite if recovery is desired (Id.).

Reduction of the zinc ores and concentrates is accomplished by electrolytic deposition from a sulfate solution or by distillation retorts or furnaces. In either method, the zinc concentrate is roasted to eliminate most of the sulfur to produce roasted concentrate or calcine (Id.).

At electrolytic zinc plants, the roasted zinc concentrate is leached with dilute sulfuric acid to form a zinc sulfate solution. The solution is then purified and piped to electrolytic cells, where the zinc is electrolytically deposited on aluminum cathodes (Ex. 476, 491). The cathodes are lifted from the tanks at intervals and stripped of the zinc, which is then melted in a furnace and cast into slabs (Ex. 476, 491).

There are three types of distillation retort plants—batch horizontal retorts, continuous vertical retorts heated by fuel, and continuous vertical retorts.

A blast furnace process for producing zinc, also known as the Imperial Smelting Process, was developed by Imperial Smelting Corporation, Ltd., of Avonmouth, England. This process is similar to the normal blast furnace practice of burning coke in intimate association with the ore to be reduced but, as in the retort process, the zinc is released as a vapor and must be condensed (Id.).

The Kivcet-CS process, developed in the U.S.S.R. and available for commercial distribution, combines the functions of sintering, blast furnacing, and slag fuming in one autogenous smelting unit. It offers the possibility of recovering, along with lead, either zinc metal or zinc oxide. The process is characterized by high metal recoveries, low environmental contamination, and low labor and capital costs compared with those of a conventional smelter (Ex. 476, 491).

Potential lead exposure occurs during the handling and storing of concentrates and charging of concentrates to the roaster. Typical operations involve the receipt of concentrates by railcar or dump truck, storage in the open or in storage buildings, moving of concentrates by front-end loader to open conveyors, drying in a rotary dryer, holding in storage bins, and charging by conveyor to the roaster. Exposures in this area are due largely to dust emissions from mechanical screens and conveying equipment, overflow from front-end loaders, and reentrainment by wind (Ex. 481).

(c) *Controls Currently Used*

Undisputed evidence suggests that the technology necessary to control lead is available. Mr. Wagner's analysis of available control technology is consistent with the practices which Bunker Hill, ASARCO, St. Joe, etc. currently employ (Ex. 481). In some cases, such as the American Chemet Co., enhanced housekeeping practices are all that would be necessary to achieve compliance with the standard (Ex. 476–501). Bunker Hill, in its statement (Ex. 475–38), agreed that improved ventilation would reduce exposures at its anode casting and welding operations. In addition, it believes that automation of the handling of zinc concentrate would reduce lead exposure levels. St. Joe's also outlined control technologies consistent with the recommendations made by Mr. Wagner and others. (Ex. 475–36)

(d) *Exposure Levels*

The level of exposure to lead is dependent on the lead content of the concentrates: Lead concentrations ore range from 0.3 percent (Ex. 481–35) to 1.5 percent (Ex. 481–19). For example, airborne lead exposures among concentrate handlers at Bunker Hill's zinc smelter averaged between 50 and 800 μg/m³, while levels at National Zinc (Ex. 481–25) and Jersey-Miniere Zinc (Ex. 481–25) did not exceed 30 μg/m³.

Other potential lead exposures occur in the roasting department: these exposures vary with the type of roaster. The highest exposures were found at Bunker Hill where open, multiple hearth roasters are used (Ex. 481–19). Lead levels there averaged between 481 μg/m³ and 2057 μg/m³. These can be compared to levels at New Jersey Zinc in the 150–200 μg/m³ range where closed, multiple hearth roasters are employed (Ex. 481–20). At National Zinc, where a fluidized bed roaster is used, no lead levels in excess of 30 μg/m³ were measured in the roasting department (Ex. 481–25).

In the electrolytic process, calcine and dilute sulfuric acid are introduced into a series of tanks for the leaching operation. Since the concentrates become wet and stay wet throughout the remaining processes, little potential lead exposure occurs (Ex. 481). In the recast process at Bunker Hill, lead exposure levels for the workers casting the anodes averaged 200 μg/m³ (Ex. 481–19) and at National Zinc (Ex. 481–25) about the same average is seen with one exposure measured as high as 1200 μg/m³. The cathode strippers in both plants have lead exposure levels that average slightly in excess of 50 μg/m³ (Ex. 481–19 & 25).

In the pyrometallurgical process, the sintering machine represents the last significant lead exposure area. Lead levels have been seen as high as 200 μg/m³ for the fume equipment operator at New Jersey Zinc (Ex. 481–20) and in excess of 50 μg/m³ for the other workers in this department. Most of the lead and cadmium is fumed off at this operation, thus little potential for significant lead exposure exists in remaining processes (Ex. 481).

Zinc fuming furnaces are operated by Bunker Hill, ASARCO at El Paso, Texas, and by St. Joe at Monaca, Pa. The Bunker Hill fuming furnace is physically located within the primary lead smelter (not far from the lead blast furnace), and levels of lead in this area have been measured in the range of 269 to 11,152 μg/m³. In fact, approximately, 65 percent of employees are exposed below 30 μg/m³ (Ex. 476–386) and 35 percent of all employees are exposed above 50 μg/m³ (Ex. 476–386). William Wagner, an expert witness on smelting, testified that "a significant portion of worker exposure to lead in this area is due to contamination from primary lead smelter activities and that it would be difficult, if not impossible, to bring this area into compliance with the 50 μg/m³ standard until the remainder of the lead smelter is in compliance." OSHA agrees that Bunker Hill's lead levels are exceptionally high due to cross-contamination. Other zinc fuming processes showed that most lead levels were below 50 μg/m³ (Ex. 481).

In a NIOSH Health Hazard Evaluation survey at the American Chemet Co., of 8 samples taken at the zinc smelter (Ex. 476, American Chemet) 6 were below 50 μg/m³. NIOSH recommended that housekeeping be used to reduce levels significantly. An OSHA inspection of the National Zinc Co. found that 360 workers were exposed below 30 μg/m³ and only 17 above 50 μg/m³ (Ex. 476–503). Based on these findings OSHA believes exposure to lead is probably not a significant problem in most zinc smelting operations (Ex. 481).

(e) *Population Exposed*

There are an estimated 2,000 production workers potentially exposed to lead in the zinc smelting and refining industry, 70 percent of whom are exposed to less than 30 μg/m³. Fifteen percent are exposed to between 30 μg/m³ and 50 μg/m³, and 15 percent are exposed to over 50 μg/m³ (Ex. 481, p. 16).

(f) *Additional Controls*

To bring zinc smelters into compliance requires that some firms to retrofit existing ventilation equipment with equipment to increase capture potential. Other firms may need to automate more processes or to rotate workers, while some need only enhance their housekeeping practices to achieve compliance with 50 μg/m³.

(g) *Conclusion: Technological Feasibility*

The record evidence indicates that most operations within most zinc smelters are in compliance, and that in those which are not fully in compliance, many of their processes are below 50 μg/m³ and some even below 30 μg/m³. Thus, compliance for the industry, as a whole, appears feasible within one year, except one difficult compliance situation exists. Bunker Hill, because the zinc smelter is located inside the primary lead smelter, may not be able to control lead levels in the zinc smelter until the primary lead smelter is controlled. Since the lead smelter has 10 years under the standard to be in compliance, it is necessary for OSHA to recognize that Bunker Hill's zinc operation may not be able to reach 50 μg/m³ in one year without respirators. But consistent with the Court's opinion, Bunker Hill would still be obligated to reduce exposure to the lowest feasible level even if ultimate compliance will take a longer time.

(h) *Cost of Compliance*

Three primary producers of zinc—ASARCO, Bunker Hill, and St. Joe Minerals—provided OSHA with written submissions on the feasibility of meeting the lead standard in their operations. Other primary producers and the secondary producers did not respond to OSHA's request for information.

Bunker Hill did not submit a cost-effective, multifaceted approach to reducing levels through a combination of engineering controls, work practices, housekeeping, and administrative controls (Ex. 475–38). Indeed, Bunker Hill did not provide actual cost estimates but it contends that compliance costs for ventilation and process automation will be required to comply with the standard. These measures, although constituting an important aspect of control technique, are typically the most expensive approaches to reducing worker exposure levels. In fact, the company was recently cited for violation of housekeeping provisions of the lead standard, which are effective in making immediate reductions in dust levels and relatively inexpensive to implement (Tr. p. 559–560). Furthermore, control of primary lead emissions, which contaminate zinc operations in the smelter, will significantly reduce the lead levels of exposure, and therefore, the amount of additional control required, and the cost of compliance attributable to zinc operations.

ASARCO provided estimates of compliance costs in its Corpus Christi, Texas, primary zinc facility and its Sand Springs, Oklahoma, secondary zinc facility. In addition, costs for the zinc department of ASARCO's El Paso, Texas, primary copper facility were provided. (Zinc dust from this operation is transported to Corpus Christi for recovery.)

ASARCO claims that the total cost of compliance will be $13,308,000 for its zinc operations. These costs include ventilation and vacuum systems and are divided between primary production ($13,002,000) and secondary production ($306,000) (Ex. 475–28). The Corpus Christi plant estimates do not consider potential changes in work practice controls, which are necessary to eliminate some of their worst exposures resulting from power sweeping (Tr. 531). ASARCO also overlooks potentially less costly solutions by omitting standby pulpits with pressurized filtered air for intermittent operations, such as sampling (Tr. 532). ASARCO did not consider the use of pressurized cabs, which are readily available for mobile equipment (Tr. 532), nor did they consider apparently simple solutions such as placing workers farther away from dusty areas by providing longer hammer handles for belt watchers, who break up concentrates by manual hammering (Tr. 532). Finally, a participant from the United Steelworkers of America suggested that a device known as a vacuum truck, which costs at most $50,000, might be able to reduce exposure levels as effectively and much less expensively than the sulfide car dumper that ASARCO costed out at $1,898,000 (Tr. p. 536).

OSHA also suggests that other methods of control could be used, such as chemical dust suppressants, traveling ventilation systems, secondary and tertiary hoods (which are currently used in Japan), and process changes, such as slag granulation in lieu of transporting molten slag (Tr. 789–791). These methods are available, effective, and economically attractive when compared with the alternatives provided by ASARCO.

St. Joe Minerals submitted a compliance cost estimate of $13 million in capital costs and $400,000 in annual operating costs (both in 1978 dollars). This estimate reflects use of "conventional control techniques" (Ex. 475–36A). St. Joe stated that this estimate originated from its prior experience in meeting safety, health, and environmental regulations, and that derivation of the figure was available in its submission to the 1977 rulemaking proceedings (Tr. p. 770). However, OSHA is wary of relying on these estimates, since they are not clearly explained and do not appear to be based on cost-effective solutions to reducing exposure.

First, there were no data presented in support of the cost estimates in the original submission. Second, these estimates were calculated on the basis of 1975 replacement costs for control systems that had been installed from 1948 through 1975. However, the economic life of the equipment was not presented. Because some of this equipment would certainly be due for relacement in the absence of the standard, the costs for newly designed controls would not fully attributable to OSHA. At most, only the difference between the controls designed to meet the 200 $\mu g/m^3$ standard and the new controls which would permit compliance with the 50 $\mu g/m^3$ standard would be attributable to OSHA. Third, the types of equipment and their functional relation to reducing in-plant lead levels are not explained. In fact, the identification of control systems is listed in abbreviated form in St. Joe's submission. Fourth, the estimate relies solely on ventilatory reductions to achieve compliance rather than a cost-effective, multifaceted approach to lower lead levels. Finally, the total costs were only $7,380,000 (Ex. 474–3(103)). The derivation of $13,000,000 from this previous estimate remains unclear. It is especially difficult to evaluate in view of the fact that the smelter will be operating at 25 percent of its capacity. However, it seems unlikely that compliance costs would nearly double with a drop in capacity of 75 percent.

OSHA estimates that the costs of compliance with the lead standard will be in the range of $3.5 to $10.5 million for the zinc industry (Ex. 481 and Tr. 345). This estimate factors in the use of a broad array of control technologies and work practices. Some of these work practices are very inexpensive or carry no costs at all (Tr. 349). Approaches such as enclosing people rather than enclosing equipment are also reflected in these estimates (Tr. 347). For instance, control rooms, especially with air-lock entry anteroom systems and boot-washing facilities could be used at St. Joe's zinc smelter (Tr. 561). The record shows that some zinc smelters are currently in compliance or near compliance with the lead standard in most of their operations. Hence, not all smelters will incur significant costs. OSHA also recognizes but does not have data to measure the value of reclamation of other metals, which will offset compliance costs for some firms in the industry (Tr. 348). Furthermore, expenditures for compliance are considered business expenses, thereby reducing the after tax burden of these firms (Tr. 349). In addition, zinc smelters are already under an obligation to control exposures to arsenic. OSHA estimated that the industry would spend $9.3 million in capital costs and $940,000 in annual costs to comply with the arsenic standard (Ex. 476–488). To the extent that resources have been allocated for this purpose, and that they will have reduced lead levels simultaneously, the costs should not be double-counted by adding them a second time. In light of these considerations, OSHA concludes that its high estimate of $10,500,000 is a reasonable assessment of the upper bound of the potential costs for the zinc industry. Annualized over the useful life of equipment, the industry is not expected to incur costs in any one year in excess of $1.9 million.

(i) *Industry Profile*

In 1967, there were 10 companies operating 18 establishments and employing 6,400 production workers in the primary zinc industry (SIC 3333). By 1977, ge there were 8 companies operating 8 facilities and employing 3,500 production workers. Value added per production worker rose from $8.85 to $16.03 per hour while average hourly earnings of production workers rose from $3.17 to $7.17 per hour (Ex. 476–20). Investments in new capital fell from $25.8 million to a low of $5.9 million in 1969, but have risen then to $39.8 million in 1977 (Ex. 476–20). Total shipments were valued at $430.7 million in 1977 (Ex. 476–20).

Since 1969, there has been a continuous decline in the production of domestic zinc coinciding with the closure of 9 smelters (Ex. 476–490). Thus, although United States demand for zinc metal over the decade has remained relatively stable, smelting capacity has declined by almost 50 percent. Smelters closed for a variety of reasons, including obsolescence, failure to meet environmental standards, and an inability to obtain sufficient concentrate feed (Ex. 476–490).

ASARCO commented that several operations closed as a result of a downturn in demand lagging the recessionary period of 1974 to 1975 and the long-run trend in substitution away from zinc in the automotive industry (Ex. 475–28). However, the industry has made steady progress in developing and promoting the use of thin-wall zinc diecastings, which are lighter in weight. Thus, zinc has begun to recapture some of the market and currently is used in 150 automotive diecastings compared with 100 in 1978. In addition, the rising costs of substitute materials, such as plastic and aluminum, have increased the competitiveness of zinc in some markets (Ex. 476–26).

Historically, the demand for zinc correlates closely with economic activity (Ex. 476–490). The major use of zinc metal is in the construction industry, which is the major market for zinc coated or galvanized products, such as structural steel, roofing, siding, guttering and duct material in air conditioning, ventilating and heating systems. Transportation accounts for the second major use of zinc metal. The largest use within this sector is diecastings for automobile components. Zinc is also used as a nonmetallic oxide in the rubber industry, production of photocopying chemicals, and paints. Zinc is most vulnerable to substitution in these nonmetallic uses (Ex. 476–490).

There are currently five domestic producers of primary zinc AMAX, ASARCO, Bunker Hill, Jersey-Miniere, and National Zinc. (Ex. 476–489). In addition, St. Joe Minerals has reactivated at 25 percent of capacity its zinc smelting operation. This decision was made because of the discovery of a high-grade zinc deposit in New York (Tr. p. 762–763). Depletion of this deposit is expected to occur within 15 years (Tr. p. 764).

The tenor of zinc ores in the United states tends to be lower than that of foreign ores. Therefore, to ensure a continuing domestic supply and to foster development of domestic low-grade ores, incentives exist to develop and implement efficient mining and extraction processes (Ex. 476–490). However, major United States companies also have substantial interests in foreign zinc mining activities (Ex. 476–49B).

Also, foreign investment by a Belgian firm in the United States zinc industry supplied capital for a joint venture to build an electrolytic, highly automated facility in Tennessee and to develop four mines. In addition, several Japanese companies and a United States oil firm entered into a 3-year partnership to explore for zinc deposits in Tennessee (Ex. 476–49B).

Pilot research in the field of zinc recovery has shown that some ores that were previously used to a limited extent or not at all as sources of zinc can become commercial sources of the metal. Specifically, the Kivet CS shaft furnace allows simultaneous smelting of lead and zinc and is ready for industrial scale application in the Soviet Union. Advantages of the process include reduced volumes of waste gas, high metal recovery, improved environmental control of emissions and lower labor and capital costs compared with conventional smelters (Ex. 476–49B).

The construction of electrolytic plants and the development of hydrometallurgical processes, which will eliminate roasting, can also produce unintended benefits, such as reduced environmental pollution. The newest plant in the United States, a $97 million joint venture of New Jersey Zinc and Union Miniere, uses a highly automated electrolytic process. Some of the plants that closed between 1969 and the present were utilizing obsolete technology and could not meet environmental standards (Ex. 476–490).

Foreign producers with more modern technology and lower labor costs enjoy competitive advantages over domestic producers. Foreign penetration into the domestic market is approaching 50 percent (Ex. 476–493), and may reach 63 percent by 1981 (Ex. 476–38(b)). However, even absent the OSHA lead regulation, this trend is expected to continue and in fact may be accelerated. Given the current depressed condition of zinc prices in spite of an international cartel active in supporting zinc prices since 1965 (Ex. 476–493), primary producers probably will continue to defer decisions concerning reinvestment in new plant and equipment and more modern technology. Perhaps the costs of such investments will induce a rise in the number of joint ventures to cover the risks of investing in the zinc industry until the development of new markets secures the future of zinc as an industrially important metal.

(j) *Conclusion: Economic Feasibility*

OSHA estimates that the annualized compliance costs in this industry will not exceed $1.9 million, which is only 0.4 percent of the industry's total value of shipments. Therefore the convergence of many factors more significant than the OSHA lead regulation will determine the future of the zinc industry. Current market conditions have resulted in depressed prices in the industry, and the strength of foreign competition is increasing as domestic producers retire obsolete, inefficient plants and deplete domestic ores. Developments of new zinc markets and modernization of technology in the industry may contribute to a brighter outlook for producers. However, if world producers ignore demand, excess supply could force prices down, resulting in lower profits. This might impel additional capacity reductions, which would reduce available supplies in the late 1980s.

OSHA recognizes that the zinc industry is operating in a depressed world market. However, the estimated annualized compliance costs ($1.9 million) are only 0.4 percent of the industry's total value of shipments based on the most recent available data (Ex. 476–20). In addition, most zinc smelters are currently in or close to compliance in most operations.

However, two smelters may pose potential compliance problems. Bunker Hill's unique situation has been addressed in a previous section (see Technological Feasibility). St. Joe contends that it cannot afford to comply with the lead standard because of adverse conditions in the zinc market. However, St. Joe has reopened its zinc smelter at 25 percent capacity because of the discovery of an ore deposit, which will be depleted in about 15 years. The decision to reopen this smelter was made after promulgation of the lead standard. Therefore, OSHA assumes that St. Joe concluded that the venture would be profitable within the context of a 50 $\mu g/m^3$ lead standard.

Authority

This document was prepared under the direction of Eula Bingham, Assistant Secretary of Labor for Occupational Safety and Health, 200 Constitution Ave., NW., Washington, D.C. 20210.

Accordingly, pursuant to sections 6(b) and 8(c) of the Occupational Safety and Health Act of 1970 (84 Stat. 1593, 1599, 29 U.S.C. 655, 657), Secretary of Labor's Order No. 8–76 (41 FR 25059), and 29 CFR Part 1911, Part 1910 of Title 29, Code of Federal Regulations is hereby amended, for the reasons set forth in the preamble, by revising Table I of section 1910.1025(e)(1).

Signed at Washington, D.C., this 13th day of January 1981.

Eula Bingham,

Assistant Secretary of Labor.

Part 1910 of Title 29 of the Code of Federal Regulations is hereby amended by revising Table I of § 1910.1025(e)(1) to read as follows:

§ 1910.1025 Lead.

* * * * *

(e) *Methods of Compliance*—(1) *Engineering and work practice controls.* * * *

Table I.—*Implementation Schedule*

Industry [1]	Compliance dates [2]		
	200 $\mu g/m^3$	100 $\mu g/m^3$	50 $\mu g/m^3$
Primary lead production	([3])	3	10
Secondary lead production	([3])	3	5
Lead acid battery manufacturing	([3])	2	5
Nonferrous foundries	([3])	1	5
Lead pigment manufacturing	([3])	N/A	5
Primary steel production	([3])	1	3
Automobile manufacturing/soldering	([3])	N/A	7
All other industries	([3])	N/A	1

[1] Includes ancillary activities located on the same worksite.
[2] Expressed as the number of years from the effective date by which compliance with the given airborne exposure level, as an 8-hour TWA, must be achieved.
[3] On effective date. This continues an obligation from Table Z-2 of 29 CFR 1910.1000 which had been in effect since 1971 but which was deleted upon the effectiveness of this section.

(Secs. 6, 8, 84 Stat. 1599 (29 U.S.C. 655, 657); Secretary of Labor's Order 8–76 (41 FR 25059); 29 CFR Part 1911)

[FR Doc. 81-1867 Filed 1-15-81; 8:45 am]

BILLING CODE 4510-26-M