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CAMP BIRD VENTURES
OURAY, COLORADO

NIOSH INVESTIGATOR:
William J. Daniels, CIH

I. SUMMARY

On October 20, 1987, the National Institute for Occupational Safety and Health (NIOSH) was requested to evaluate employee exposures to lead at Camp Bird Ventures, Ouray, Colorado. The request was prompted by findings of high blood lead levels (in excess of 50 micrograms per deciliter) among two employees who worked in the mine's fire assay laboratory. Since that time, the company had installed local exhaust ventilation and increased emphasis on respiratory protection, and was interested in determining means of further reducing employee exposures.

In December 1987, the NIOSH investigator conducted an environmental survey. During this survey, personal and area air samples were collected in the fire assay laboratory to determine concentrations of airborne lead and other trace metals. Air velocity measurements of the local exhaust ventilation systems in these areas also were made.

The results of the environmental survey revealed 8-hour TWA concentrations of 113 micrograms per cubic meter of air (ug/M^3) and 40 ug/M^3 of lead in the personal air samples collected for the assayer and scale operator, respectively. While both of these concentrations are below the Mine Safety and Health Administration (MSHA) standard of 150 ug/M^3 as an 8-hour TWA, the concentration found in the assayer's breathing zone was above the Occupational Safety and Health Administrations (OSHA) Permissible Exposure Limit (PEL) of 50 ug/M^3 as an 8-hour TWA. In addition, the concentration in the breathing zone of the scale operator was above the OSHA action level of 30 ug/M^3 as an 8-hour TWA. It should be noted that both of the employees were wearing respiratory protection at all times when in the furnace and storage rooms. Provided their respirators were properly fitted and maintained, their actual exposures would be expected to be lower than the measured values. Area air samples collected in each of the rooms comprising the assay laboratory revealed that the highest TWA concentration of lead was found in the furnace room (100 ug/M^3), followed by the storage room (58 ug/M^3), the office (46 ug/M^3), the scale room (22 ug/M^3), and the wet chemistry lab (14 ug/M^3). No other trace metals were found in significant amounts when compared to their environmental criteria.

Capture velocities for the local exhaust ventilation systems present in the furnace room, litharge dispensing area, and scale room were below the guidelines recommended by the American Conference of Governmental Industrial Hygienists.

On the basis of the data collected, a potential health hazard existed from employee exposure to lead in the fire assay operations at Camp Bird Ventures. Recommendations designed to reduce exposures are included in this report.

KEY WORDS: SIC 1041 (Gold Ores), Fire Assay, Gold Assay, Lead, Blood Lead, Litharge, Ventilation

II. INTRODUCTION

On October 20, 1987, NIOSH received a request from Camp Bird Ventures, Ouray, Colorado, to evaluate employee exposures to lead in the company's fire assay operations. The requestor was directed to NIOSH by a representative of the Colorado Department of Health following reports from a local physician of high blood lead levels among the two employees in the assay laboratory. Due to excessive blood lead levels (between 50 and 68 micrograms per deciliter), the two employees had to be temporarily removed from the work area.

On December 3, 1987, an initial/environmental survey visit was conducted at the facility. During this survey, background information related to the nature of the operations in the fire assay laboratories was obtained. In addition, air flow measurements were taken at the local exhaust ventilation system; and personal and area air samples were collected for lead and trace metals. The results of this survey were provided to company representatives by letter on March 28, 1988.

III. BACKGROUND

A. General Description of Fire Assaying

Fire assaying is a technique for separating noble metals, such as gold and silver, from their ores. The process involves the use of dry reagents and heat to bring about the separation of the metals from the ore. Although the chemical reactions involved in the fire assay process are extremely complex, the beginnings of fire assaying can be traced as far back as 2600 B.C.. Today, the process is still widely used due to its ability to concentrate small amounts of the metals from relatively large ore samples.[1].

One of the first and most critical steps in fire assaying is the preparation of the "charges". Each charge is prepared in a fireclay crucible through the addition of dry reagents or "flux" to a finely crushed sample of the ore. The reagents which were used in this operation included litharge (lead oxide) and wheat flour. The amount of litharge used was approximately 30 grams per charge. Other flux reagents which also may be used include sodium carbonate, silica, borax, and potassium nitrate.[1] The addition of the proper quantities of flux reagents is of great importance in fire assaying. The particular composition of the flux to be used in the charge is based on the assayer's determination of the oxidizing, reducing, or neutral characteristics of the ore.

The next major step is referred to as the crucible fusion. In this process, several of the charged fire clay crucibles are placed in an oven. As the temperature is raised to approximately 1600 F, the carbon contained in the flour reduces a portion of the litharge to lead droplets. These droplets then alloy with the noble metals that are released from the decomposed ore. The remaining litharge forms silicates and other compounds which mix with the slag produced from the ore. After 44 to 55 minutes, the crucibles are removed from the oven and the molten contents are quickly poured into iron molds. The lead droplets then settle through the slag to form a "button" at the bottom of each mold. After cooling, the slag is broken away from the molds using a small hammer; and the lead buttons which contain the noble metals are collected.[1]

In the next stage of fire assaying, the noble metals are separated from the lead in a process referred to as cupellation. First, the lead buttons which were obtained from the crucible fusion are each hammered into squares and placed in small containers made from compressed bone ash. These containers are referred to as "cupels". The cupels are then placed back into the furnace and the temperature is raised to 1475 F. The lead from the button quickly oxidizes into molten lead oxide, of which 98.5% is absorbed into the porous cupel and 1.5% is volatilized.(1) The cupel, which is permeable to the molten lead oxide, is impermeable to the noble metals. Therefore, when the cupels are removed from the oven, small beads of the noble metals remain in the center of each cupel. These beads are then weighed and further analyzed for their gold and silver content.[1]

B. Description of Company Operations

Camp Bird Ventures, located in Ouray, Colorado, is engaged in underground mining for gold and silver. In order to determine the potential profitably in mining certain pockets of ore, fire assays are performed on samples of the ore to determine their gold and silver content.

Two employees are responsible for performing the fire assays. These employees generally work four ten-hour work shifts per week, and occasionally, may be required to work overtime or additional work days during the week.

The fire assay operations are conducted in a laboratory located at the mine site. The laboratory consists of five interconnected rooms. The "furnace room" contains the furnace used in the fire assay process, as well as work tables for pouring the crucibles into the molds. Adjacent to this room is the "storage room", which, in addition to serving as a storage area for assaying supplies, is the area where the litharge is added to the crucibles. Adjacent to the storage room is the assay "office". This room contains a desk where assaying records are kept, as well as additional space for storage. Two other rooms are connected to the office. The first is the "scale room" where the lead buttons and gold beads are weighed and the dry reagent flux is mixed. The second area connected to the office is the "wet chemistry lab", where various tests are run on the samples.

C. Personal Protection, Administrative and Engineering Controls

Personal protective equipment worn by the employees when in the assay laboratory includes disposable full-body suits, boot covers, and half-face piece respirators with high efficiency particulate filters (NIOSH Certification Number TC-21C-152). Respirators are always worn when in the oven and storage rooms, but are frequently removed when in the scale room, office, and wet chemistry lab. The employees wear their protective suits at all times when in the assay laboratory. Smoking and eating are not allowed inside of the assay laboratory. Hand washing facilities are located in the wet chemistry lab.

Local exhaust ventilation present in the oven room included two exhaust vents coming directly out of the furnace, and an additional hood located approximately 24 inches from the front of the oven door. These ducts are vented directly to the outdoors. A general room exhaust fan is located on the back wall of this room behind the furnace. An exhaust duct also is located above the litharge bin located in the storage room. A "kitchen range" type exhaust hood is located in the scale room where the dry reagents are mixed.

As a further administrative control, the two assay lab employees rotate job duties on a daily basis. Each day, one of the employees is responsible for mixing the reagents and loading and unloading the furnace. The second employee is responsible for scale weighing and record keeping. The second employee normally would not enter the furnace room or be involved in activities which would be associated with high lead exposure.

Medical monitoring of employees was being conducted by a local physician, with advice and guidance on acceptable blood lead levels being provided by the Colorado Department of Health. The recent findings of high blood lead levels had been responsible for the installation of the local exhaust ventilation described above.

IV. MATERIALS AND METHODS

On December 3, 1987, an environmental survey was conducted at Camp Bird Ventures to determine employee exposures to lead and trace metals. During this survey, personal air samples were collected near the workers breathing zone, and general area air samples were collected at locations throughout the assay laboratory. Samples were obtained using battery-powered sampling pumps operating at 2.2 to 3.0 liters of air per minute. The pumps were attached by Tygon tubing to the collection medium (37-millimeter, 0.8 micron pore size, mixed-cellulose ester membrane filters contained in 3-piece plastic cassettes). The sampling media for the personal samples collected on the two assay lab employees were replaced approximately halfway through the work shift.

The samples were analyzed for lead using inductively coupled plasma - atomic emission spectroscopy in accordance with NIOSH Method 7300.[2] In addition, one of the samples was analyzed for 30 additional trace metals using the same analytical method.[2]

In addition to the collection of air samples, air flow measurements of the local exhaust ventilation systems were taken with a Kurz Model 441 air velocity meter.

V. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week, for a working lifetime, without experiencing adverse health effects. It is important, however, to note that not all workers will be protected from adverse health effects if their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a preexisting medical condition, and/or a hypersensitivity (allergy).

In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the evaluation criterion. These combined effects often are not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes and, thus, potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent becomes available.

The primary sources of environmental evaluation criteria for the workplace are: 1) NIOSH Criteria Documents and recommendations, 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLV's), 3) the U.S. Department of Labor/Occupational Safety and Health Administration (OSHA) occupational health standards [Permissible Exposure Limits (PEL's)], 4) and the Mine Safety and Health Administration (MSHA) standards. Often, the NIOSH recommendations and ACGIH TLV's are lower than the corresponding OSHA or MSHA standards. Both NIOSH recommendations and ACGIH TLV's usually are based on more recent information than are the OSHA and MSHA standards. Also, in some cases, the OSHA standards may be more restrictive than the corresponding MSHA standards. In evaluating the exposure levels and the recommendations for reducing these levels found in this report, it should be noted that the company is required by the Mine Safety and Health Administration to meet those levels specified in an MSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8- to 10-hour workday.

A brief discussion of the toxicity and evaluation criteria for inorganic lead is presented as follows.

A. Toxicological

Inhalation (breathing) of lead dust and fume is the major route of lead exposure in the industrial setting. A secondary source of exposure may be from ingestion (swallowing) of lead dust deposited on food, cigarettes, or other objects. Once absorbed, lead is excreted from the body very slowly. Absorbed lead can damage the kidneys, peripheral and central nervous systems, and blood forming organs (bone marrow). These effects may be felt as weakness, tiredness, irritability, digestive disturbances, high blood pressure, kidney damage, mental deficiency, or slowed reaction times. Chronic lead exposure is associated with infertility and with fetal damage in pregnant women. There is some evidence that lead can also impair fertility in occupationally exposed men.[3]

The blood lead test is one measure of the amount of lead in the body and is the best available measure of recent lead absorption. Adults not exposed to lead at work usually have a blood lead concentration less than 30 ug/dl; the average is less than 15 ug/dl.[4,5] In 1985, the Centers for Disease Control (CDC) recommended 25 ug/dl as the highest acceptable blood level for young children.[6]. Since the blood lead concentration of a fetus is similar to that of its mother, and since the fetus's brain is presumed to be at least as sensitive to the effect of lead as a child's, the CDC advised that a pregnant woman's blood lead level be below 25 ug/dl.[6] Recent evidence suggests that the fetus may be adversely affected at blood lead concentrations well below 25 ug/dl.[7] Furthermore, there is evidence to suggest that levels as low as 10.4 ug/dl affect the performance of children on educational attainment tests, and that there is a dose-response relationship with no evidence of threshold or safe level.[8] Lead levels between 40-60 ug/dl in lead-exposed workers indicate excessive absorption of lead and may result in some adverse health effects. Levels of 60-100 ug/dl represent unacceptable elevations which may cause serious adverse health effects. Levels over 100 ug/dl are considered dangerous and often require hospitalization and medical treatment.

Zinc protoporphyrin (ZPP) levels measure the effect of lead on heme synthetase, the last enzyme in heme synthesis. ZPP levels increase abruptly when blood lead levels reach about 40 ug/dl, and they tend to stay elevated for several months. A normal ZPP level is less than 50 ug/dl.[9]

B. Occupational Exposure Criteria

The current MSHA standard for inorganic lead is 150 micrograms per cubic meter of air (ug/M^3) as an 8-hour TWA.[10] It should be noted that this standard is based on the 1973 ACGIH TLV for inorganic lead. The current OSHA PEL for airborne lead is 50 ug/m^3 calculated as an 8-hour TWA for daily exposure.[11] In addition, the OSHA lead standard establishes an "action level" of 30 ug/m^3 TWA which initiates several requirements of the standard, including periodic exposure monitoring, medical surveillance, and training and education. For example, if an employer's initial determination shows that any employee may be exposed to over 30 ug/m^3, air monitoring must be performed every six months until the results show two consecutive levels of less than 30 ug/m^3 (measured at least seven days apart). The standard also dictates that workers with blood lead levels greater than 50 ug/dl must be removed from further lead exposure. The affected employee must be removed from further lead exposure until the blood lead concentration is at or below 40 ug/dl. Removed workers have protection for wage, benefits, and seniority for up to 18 months until their blood levels decline to below 40 ug/dl and they can return to lead exposure areas.[11]

VI. RESULTS AND DISCUSSION

A. Air Samples

The results of the environmental survey are contained in Table 1. As evidenced by these data, 8-hour TWA concentrations of 113 ug/M^3 and 40 ug/M^3 of lead were found in the personal air samples collected for the assayer and scale operator, respectively. While both of these concentrations are below the MSHA standard for inorganic lead of 150 ug/M^3 as an 8-hour TWA, the concentration found in the assayer's breathing zone is above the OSHA PEL of 50 ug/M^3 as an 8-hour TWA. In addition, the concentration in the breathing zone of the scale operator is above the OSHA action level of 30 ug/M^3 as an 8-hour TWA, which would also trigger several of the provisions of the OSHA lead standard.[11] It should be noted that both of the employees were wearing respiratory protection at all times when in the furnace and storage rooms. Provided their respirators were properly fitted and maintained, their actual exposures would be expected to be substantially lower than the measured values.

Table 1 also shows the results of area air samples collected in each of the rooms comprising the assay laboratory. As evidenced by these data, the highest TWA concentration of lead was found in the furnace room (100 ug/M^3), followed by the storage room (58 ug/M^3), the office (46 ug/M^3), the scale room (22 ug/M^3), and the wet chemistry lab (14 ug/M^3). Airborne concentrations in two of these rooms, the furnace room and the storage room where the litharge was added, were in excess of the OSHA standard of 50 ug/M^3. The TWA concentration of lead found in the office area, while below the OSHA standard of 50 ug/M^3, was above the OSHA action level of 30 ug/M^3. TWA concentrations in both the scale room and wet chemistry lab were found to be below the OSHA action level. It should be noted that the air samples discussed in this paragraph are "general area" air samples, and as such, do not relate directly to the OSHA standards which address "personal" exposures. However, these data do provide useful information in assessing the relative degree of airborne contamination in each of the work areas.

Table 1 also shows the results of 3 short-term air samples which were collected for periods of less than 1 hour. The purpose of these samples was to help determine the extent to which the individual activities of the assay process contributed to the overall exposure. The highest concentration (139 ug/M^3) was found in a 52-minute area air sample collected in the furnace room during cupola firing. The next highest concentration (129 ug/M^3) was found in a 28-minute personal air sample collected during the the preparation of the charged crucibles, which included the addition of the powdered litharge. The next highest concentration (40 ug/M^3) was found in a 54-minute personal air sample which included the removal of crucibles and the addition of cupels to the furnace. In this case, the employee spent the majority of the sample time in the scale room, which resulted in a reduced exposure.

One additional area air sample which was collected in the furnace room was analyzed for trace metal content. The results of the analysis revealed the primary component to be lead, at a TWA concentration of 73 ug/M^3. In addition, trace quantities of aluminum, iron, magnesium, phosphorous, and zinc were found. However, the concentrations of these contaminants were far below their respective evaluation criteria.

B. Ventilation Measurements

Air velocity measurements taken directly in front of the furnace door revealed an air flow of less than 50 feet per minute (fpm) in the direction of the local exhaust hood. While there are no standards or regulations for air flow which govern these operations, the ACGIH recommends that capture velocities for substances released at low velocity into moderately still air be at least 100 to 200 fpm, and that the upper end of this range be used for contaminants of high toxicity (e.g., lead).[12]

One factor which was responsible for the low capture velocity of the hood was the lack of a flange on the hood. Whenever possible, it is recommended that flanges be provided on hoods in lieu of plain openings. Flanges eliminate air flow from ineffective zones where no contaminants exist, and reduce air requirements by as much as 25%.[12] In addition, the distance of the hood from the oven (approximately 2 feet) would substantially reduce the capture velocity. With increasing distance from a hood, there is a rapid decrease in air velocity. At distances within one and a half times the diameter of the hood, the velocity varies almost inversely with the square of the distance from the hood. At greater distances, the effect is somewhat less pronounced.[12] Finally, the location of the hood was such that when the worker was standing at the oven door, the direction of air flow was directly across the workers' breathing zone. Hoods should not be placed in this manner since they may actually increase the concentration of contaminant in the workers' breathing zone.

Air velocity measurements were taken at the hood located in the storage room. A capture velocity of less than 50 fpm was measured at the point where the actual dispensing of litharge takes place (approximately 16 inches from the hood). This velocity is below the 100 to 200 fpm recommended by the ACGIH for operations, such as intermittent container filling.[12] As previously discussed, the higher end of this range is recommended for operations involving substances of high toxicity. The ventilation system in this room exhibited some of the the design problems that were discussed for the hood in the furnace room. These included the lack of a flange on the hood and the placement of the hood at such a distance from the point of operation so that the capture velocity would be greatly reduced.

Measurements were taken at the "kitchen range" type exhaust located in the scale room where the flux ingredients were stirred in the crucibles. Air flow measurements at the work bench surface, which was located approximately 28 inches below the hood, showed negligible air movement. At a distance midway between the hood and the bench, an air flow of less than 50 fpm was measured. The face velocity of the hood was found to be approximately 300 fpm. These measurements indicated that such a hood would only be effective at distances very close to the hood opening.

C. Personal Protection, and General Housekeeping

Observations made during the course of the environmental survey revealed some instances of improper use of personal protective equipment. One example was the use of a negative pressure respirator by an employee who had a full beard. Facial hair that lies along the sealing area of the respirator will interfere with the seal and allow contaminated air to enter the respirator. Therefore, employees with beards should not be permitted to wear respirators in a contaminated work area.[13] Also, one employee was wearing a Tyvek suit which was torn on the back. Lead dust can easily enter into the suit through the damaged area and contaminate the clothing underneath. Therefore, suits with tears or showing excessive wear should not be used.

Visible dust accumulation was present on shelves and ledges in the storage and office areas. This condition indicated a need for improvements in housekeeping, since dust accumulation represents a secondary source of lead contamination in the area. It was noted that employees stored their coats and jackets in the office area of the assay lab. Since this area was found to have an airborne concentration of lead just slightly below the OSHA PEL, contamination of this clothing with lead is probable. In order to avoid the spread of lead to other parts of the facility and to employee's homes, street clothing should not be permitted in lead-contaminated areas.

VII. CONCLUSIONS AND RECOMMENDATIONS

As evidenced by the results of the environmental survey, potential exposures for the assayer and the scale operator, while below the MSHA standard, were above the OSHA PEL and action level for airborne lead, respectively. Although legal compliance with the OSHA standard is not required, it is considered to be the more appropriate evaluation criteria for the purposes of this survey because it is based on more recent toxicological information,. Furthermore, in addition to specifying PELs for airborne exposure, the OSHA lead standard also contains specific provisions dealing with mechanical ventilation, respirator usage, protective clothing, housekeeping, hygiene facilities, employee training, and medical monitoring.[11] The implementation of the provisions of this standard will help to ensure that the employees blood levels are maintained within acceptable limits, and help ensure that they are protected against any potential adverse health effects of lead exposure.

Due to the length of the OSHA lead standard, it will not be repeated in detail in this report. In lieu of this, a copy of this document has been provided to the employer. However, in order to assist the employer in implementing the key provisions outlined in this document, a brief overview is presented below which addresses these provisions as they relate to the findings of this survey.

A. Mechanical Ventilation

While local exhaust ventilation systems were present in the furnace, storage room, and scale room, both visual observations and measurements of air flow velocities revealed several problems in their design and function which would limit their effectiveness. This was verified by the relatively high lead concentrations found in both the personal samples for the assayer and scale operator, as well as in the general area samples collected in the furnace room, storage room, and office area.

The short-term samples identified two key operations which contributed significantly to the airborne lead concentrations. As would be expected, the area with the highest lead concentration was in the furnace room during crucible and cupel firing when lead would be expected to be volatilizing. The next highest area of exposure was in the storage room when powdered litharge was dispensed into the crucibles, during which time lead dust can be released into the air. Due to the fixed locations of these contaminant sources, both would be amenable to control through local exhaust ventilation.

Emissions from the furnace room, in particular, could be controlled more effectively by the movement of the existing hood to a position directly above the oven door. Not only would this increase the effectiveness of the present hood, but it would eliminate the chance of drawing the emissions across the workers' breathing zone during loading and unloading of the furnace. However, since leakage of fugitive emissions might occur from other areas of the oven, the use of a canopy hood over the furnace, which would take advantage of the heated air rising from the oven to help capture the emissions, might present even a better alternative to emissions reduction. In order for a canopy hood to function effectively, it is necessary to eliminate sources of cross drafts that would interfere with the effective operation of the hood.[12] The use of side panels or curtains might effectively eliminate such drafts and increase the efficiency of the hood. A diagram of a canopy hood along with design parameters is included in Appendix 1.

The second area in which more effective local exhaust ventilation would be beneficial is in the lead dispensing area in the storage room. The current ventilation system does not provide for adequate air flow to capture lead dust at the point where it is dispensed into the crucibles. This allows the dust to escape into the environment. More effective control of this process could be achieved if the existing ventilation system was modified to increase the capture velocity at the work area. One method of accomplishing this would be to increase the fan size or fan speed; however, while increasing air flows, this method would lead to unnecessary power consumption.[12] A more efficient utilization of the existing air flow could be achieved by placement of the hood closer to the area where the lead is dispensed, and enclosing the area of contaminant generation as much as possible.

The hood located in the scale room proved to be largely ineffective due to its low capture velocity at any distance away from the immediate opening of the hood itself. The construction of a partial enclosure around the rear and sides of the hood might increase the efficiency of the hood somewhat. However, in order to obtain effective capture velocities, a larger exhaust fan motor may also be required.

In order for any local exhaust ventilation system to function effectively, provisions must be made to supply a sufficient amount of makeup air to replace that which is being exhausted. A lack of make-up air will create a negative pressure in the building which increases the static pressure that the exhaust fans must overcome.[12]

Periodic testing of all local exhaust ventilation systems is necessary to ensure their effective functioning. As a minimum, such systems should be tested every three months, or following any major modification.[11] A complete discussion of specific details regarding ventilation system testing, as well as information regarding the design, construction, and operation of local exhaust ventilation systems, is contained in the ACGIH Industrial Ventilation, A Manual of Recommended Practice.[12]

B. Air Monitoring

Despite the presence of engineering controls, periodic monitoring for airborne lead is needed to ensure that these controls operate effectively. Air monitoring can also be used to pinpoint the need for further employee protection (i.e., respirators) in certain areas or during certain procedures. When airborne exposures are found to be above the OSHA action level of 30 ug/M^3, as was the case in this survey, the standard calls for repeat monitoring every six months. This monitoring should be continued until such time as concentrations are found to be below this level in two consecutive measurements conducted at least one week apart.[11] Employees should be informed of the monitoring results.

C. Respiratory Protection

Due to their inherent limitations, respirators should not be considered a primary means of employee protection. A more appropriate means of exposure control in this instance would be properly designed engineering controls; i.e., local exhaust ventilation. However, the use of respiratory protection is a suitable means of exposure control in the event that engineering controls can not feasibly reduce the exposure levels. They may also be used as a backup to existing engineering controls when substances of high toxicity are present. In order to ensure the effective use and function of the respirators, a comprehensive respiratory protection plan should be put in place. Such a program is outlined by the American National Standard Institute in the ANSI Standard Z88.6-1984.[14] The program should include a written standard operating procedure which addresses respirator selection, training, fitting, testing, inspection, cleaning, maintenance, storage, and medical examinations. A detailed discussion of these key program elements is provided in the NIOSH Guide to Industrial Respiratory Protection, a copy of which has been provided to the employer.[13]

Assuming proper maintenance and fitting, the respirators worn by the employees during the survey should have significantly reduced their actual exposures. However, the effectiveness of the respirator to face seal on the employee with the beard is questionable. In lieu of removal of the beard, a powered air-purifying respirator with a loose fitting hood or helmet might provide an alternative form of respiratory protection, which would provide an adequate protection factor at these exposure levels.[13]

D. Personal Protective Clothing

Wherever lead dust is present, their is a possibility that the employee's skin and clothing may become contaminated. This can lead to subsequent inhalation or ingestion of the lead, which can substantially increase the employees overall absorption of lead. In addition, lead contamination on skin or clothing may be transported to other areas of the facility, and possibly to the worker's homes where secondary exposure of coworkers or family members can occur. In one recent study, blood lead levels were found to be markedly higher in household members residing in homes of workers with occupational lead exposure compared to members of homes of people not occupationally exposed to lead.[14] In order to prevent secondary lead exposure, the use of personal protective equipment is required. While the disposable boot covers and full body suits which were worn by the employees in the assay lab appeared appropriate, gloves should be worn when handling the litharge powder. Also, as previously noted, increased emphasis is needed to ensure that the clothing remains effective. This should include daily visual inspections of the garments for tears or excessive wear, with new disposable suits being provided to the employees at least weekly.

E. Hygiene Facilities and Practices

A separate change room, free from lead contamination, should be provided to the employees to store their "street" clothing. Street clothing should be stored separately from clothing worn during work. If available, showers should be taken at the completion of the work shift to remove any lead that may have reached the employee's skin. Clothing which is worn at work, should not be worn home. Instead, employees should carry necessary personal clothing and shoes home separately, and clean them it carefully so as not to contaminate the home.[11]

Food, beverages, or tobacco should not be used or stored in lead contaminated areas. These items can become contaminated with lead, and cause subsequent absorption of lead through ingestion or inhalation during eating, drinking, or smoking. Employees should also continue to eat their lunch in a lunchroom separate from the assay lab. All protective clothing should be removed prior to entering the lunchroom, and hands and face should be thoroughly washed.

F. Housekeeping

Housekeeping plays an important role in reducing lead exposures. Dust which has accumulated on surfaces can be re-introduced into the air thereby increasing airborne lead exposures. Also, dust accumulated on chairs or work surfaces can cause unnecessary contamination of the employees protective clothing. Therefore, all surfaces in the assay lab should be kept as free as practicable of the accumulation of lead dust. Vacuuming is the preferred means of removing lead dust. Dry or wet sweeping should not be used except in areas where vacuuming is not feasible. A regular housekeeping program should established to ensure that all areas are periodically cleaned.

G. Medical Monitoring

While the previously discussed recommendations have been aimed at preventing or minimizing lead exposure, medical monitoring plays a supplemental role in that it ensures that the other provisions of the program have effectively protected the individual. The OSHA standard for inorganic lead places significant emphasis on the medical surveillance of all workers exposed to levels of inorganic lead above the action level of 30 ug/M^3 TWA. Even with adequate worker education on the adverse health effects of lead and appropriate training in work practices, personal hygiene and other control measures, the physician has a primary responsibility for evaluating potential lead toxicity in the worker. It is only through a careful and detailed medical and work history, a complete physical examination and appropriate laboratory testing that an accurate assessment can be made. Many of the adverse health effects of lead toxicity are either irreversible or only partially reversible and therefore early detection of disease is very important.[11]

The OSHA lead standard provides detailed guidelines on the frequency of medical monitoring, the important elements in medical histories and physical examinations as they relate to the lead, and the appropriate laboratory testing for evaluating lead exposure and toxicity. This standard should be consulted by plant management and the local physician for guidance in carrying out an ongoing medical monitoring program.[11]

In summary, a comprehensive program is necessary for controlling lead exposures during the assay operations. While the company has put into place several key elements of an exposure prevention program, ongoing attention is needed in all of the areas previously discussed in order to effectively reduce the risk of adverse health effects.

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X. AUTHORSHIP AND ACKNOWLEDGEMENTS

Report Prepared By:	William J. Daniels, CIH, CSP Industrial Hygienist NIOSH - Region VIII Denver, Colorado
Originating Office:	Division of Surveillance, Hazard Evaluations & Field Studies Hazard Evaluation and Technical Assistance Branch Cincinnati, Ohio
Laboratory Analysis:	NIOSH - Measurement Support Branch Cincinnati, Ohio

XI. DISTRIBUTION AND AVAILABILITY OF DETERMINATION REPORT

Copies of this Determination Report are currently available upon request from NIOSH, Division of Standards Development and Technology Transfer, Information Resources and Dissemination Section, 4676 Columbia Parkway, Cincinnati, Ohio 45226. After 90 days the report will be available through the National Technical Information Services (NTIS), Springfield, Virginia. Information regarding its availability through NTIS can be obtained from the NIOSH publications office at the Cincinnati, address. Copies of this report have been sent to the following:

A. Camp Bird Ventures, Ouray, Colorado
B. Mine Safety and Health Administration - Region VIII
C. Colorado Department of Health
D. NIOSH Regional Offices/Divisions

For the purposes of informing the affected employees, copies of the report should be posted in a prominent place accessible to the employees, for a period of 30 calendar days.

TABLE 1

RESULTS OF ENVIRONMENTAL SAMPLES COLLECTED FOR AIRBORNE INORGANIC LEAD DURING FIRE ASSAY OPERATIONS

Camp Bird Ventures, Ouray, Colorado

December 3, 1987

SAMPLE TYPE	SAMPLE DESCRIPTION	MINUTES SAMPLED	LITERS SAMPLED	TWA CONCENTRATION LEAD (ug/M3)
Personal	Assayer (Morning)	240	528	117
Personal	Assayer (Afternoon)	244	537	107
			113*	
Personal	Scale Operator (Morning)	235	517	36
Personal	Scale Operator (Afternoon)	235	517	45
			40*	
Area	Wet Chemistry Lab - On lab bench, east side of room	511	1124	14
Area	Storage Room - On shelf, east wall of room	505	1111	58
Area	Furnace Room - On equipment table, east side of room	500	1100	100
Area	Scale Room - On shelf, east side	502	1104	22
Area	Office - On shelf, middle of room	491	1080	46
Short-term Samples				
Personal	Assayer - Prepared charges containing litharge	28	84	129
Personal	Assayer - Removed crucibles and added cupels to oven	54	162	40
Area	Furnace Room - During cupola firing	52	140	139

Evaluation Criteria - Inorganic Lead

MSHA - 150 ug/M^3, 8-hour TWA

OSHA - 50 ug/M^3, 8-hour TWA

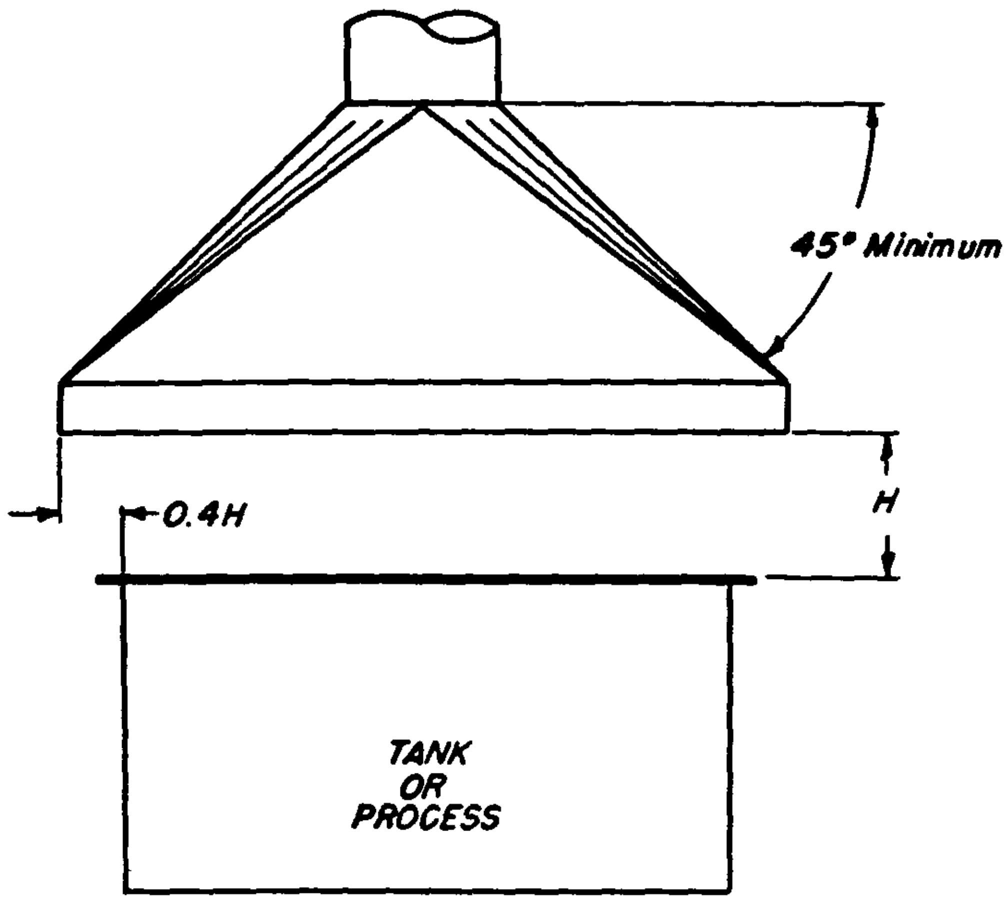
Abbreviations and Key

TWA - Time-weighted average

ug/M^3 - micrograms per cubic meter of air

* - Indicates a calculated 8-hour TWA. All other values are expressed as TWA's for the period of sample collection.

DIAGRAM 1



Not to be used where material is toxic and worker must bend over tank or process.
Side curtains are necessary when extreme cross-drafts are present.

$Q = 1.4PHV$	for open type canopy.
	P= perimeter of tank, feet.
	V= 50-500 fpm. See Section 4
$Q = (W+L)HV$	for two sides enclosed.
	W & L are open sides of hood.
	V= 50-500 fpm. See Section 4
$Q = WHV$ or LHV	for three sides enclosed. (Booth)
	V= 50-500 fpm. See Section 4

Entry loss = .25 duct VP
Duct velocity = 1000-3000 fpm

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