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**MEDICAL SURVEILLANCE AND BIOLOGICAL MONITORING  
OF LEAD EXPOSED EMPLOYEES**

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Employee health protection is an employer responsibility. The multi-faceted aspects of employee protection from the potentially harmful effects of inorganic lead sometimes stress the relationships of several employer units. These include supervision and management, safety, operations and maintenance, engineering, environmental health, environmental management, and occupational medicine.

The administrative aspects of program development are going to be discussed. My presentation today is to emphasize the opportunity for cooperation by all of the employee health components in developing an optimum surveillance and protection program.

References to biological monitoring may be confusing. I would like to try to clarify some of the terminology.

**Clinical Monitoring** refers to the physical examination which includes the review of the history and the hands-on examination.

**Medical Monitoring** is sometimes called "health effects monitoring" and is the standardized assessment of measurable biological functions which is a part of most comprehensive physical examinations. This would include the standard blood chemistry monitoring for liver, metabolic, kidney, and musculoskeletal abnormalities, as well as such tests as the electrocardiogram and pulmonary function. These are compared to a population normal as well as to the individual's baseline values.

**Biological Monitoring** is sometimes called "biochemical effects monitoring" and is the evaluation of specific environmental exposures through measurements of the agent or its metabolites in biological samples. These results are compared to reference values known as biological exposure indices (BEI).

**Environmental Monitoring** is the evaluation of exposure by sampling of the workplace environment for known or suspected hazardous agents. These results are compared to the published threshold limit values (TLV or PEL).

Much of the concern in the workplace is related to increasing public awareness regarding lead as a public health hazard. There is a general recognition that as many as 4 million children in the United States are at increased risk of lead poisoning, and that children have a greater sensitivity to the harmful effects of lead than do adults. The incomplete development of the blood-brain barrier in the very young child increases the risk of lead entry into the developing nervous system until around 3 years of age. This can result in prolonged neuro-behavioral problems. Children absorb and retain more lead in proportion to their weight. Iron deficiency, a condition more likely to occur in young children, increases the absorption of lead from the gastrointestinal (G.I.) tract. Since lead freely crosses the placenta, the fetus is at greatest risk. In fact, it is uncertain just how low maternal blood lead should be to avoid any threat to the developing fetus. There is increasing evidence of some developmental effect on the nervous system in infancy or perhaps in utero of blood lead levels even below 15 microgram per deciliter (mcg/dl). Several studies of non-occupationally exposed adults have shown that blood lead levels of 20 Mg/dl is not unusual. The average blood lead level in the United States population is stated to be about 10 mcg/dl before the legislated removal of lead from gasoline which began in 1976. Even the 10 mcg/dl population average is about three times higher than the average level found in some remote populations, and may be as much as 30 times higher than the theoretical level calculated for pre-industrial humans.

Until recently, population screening was often done by testing for erythrocyte protoporphyrin, commonly assayed as zinc protoporphyrin (ZPP). Lead inhibits the ferrochelase enzyme, which results in iron being unable to be incorporated into the protoporphyrin ring. Zinc has a greater affinity for protoporphyrin than iron in the absence of ferrochelase and, hence, increased amounts of ZPP are formed. This ZPP reaches a steady state in the blood only after the entire population of circulating red blood cells has turned over. This takes about 120 days; hence, the ZPP level lags behind the blood lead level and is an indirect measure of long-term lead exposure. A disadvantage of ZPP screening is that it is not sufficiently sensitive at the lower levels of lead exposure. Data from the Second National Health and Nutritional Examination Survey indicated that 58 percent of 118 children with blood lead levels above 30 mcg/dl had ZPP levels within normal limits. While ZPP level is still useful, it is not considered

as good a screening test as the blood lead. The normal levels for ZPP are usually below 35 mcg/dl. There are diseases which may cause a falsely elevated level, so the results should be interpreted with clinical correlation and knowledge of the blood lead level.

Florida requires the reporting of children's blood lead levels of 15 mcg/dl or higher. In 1989, 28 states and the District of Columbia required reporting blood lead levels in children. Seventeen of these states required reporting blood lead levels of 25 mcg/dl or higher.

In 1991, the U.S. Department of Health and Human Services released a strategic plan for the elimination of childhood lead poisoning as a public health problem over a 20-year effort. During 1992, there was funding for an effort to build a national surveillance system for monitoring children's blood lead.

While we all recall the stories of the inter-city lead poisoning epidemic in toddlers when they teethed on the window facings of wood painted with lead paint, there was the notion that by restricting the lead content of paints, which occurred in 1977, the problem would be eliminated. There are, however, a number of other sources of lead exposure in children, not the least of which is lead that may be brought home on the garments and tools of parents from the workplace.

We also have a greater recognition of the potential for adverse reproductive effects in both males and females. These findings have influenced the development of lead standards with regard to surveillance recommendations.

There are more than one hundred different occupations in which workers may be exposed to lead. Some of these are shown in Exhibit 1. Not only may lead dust and lead oxide fumes be inhaled, but lead particulates may be ingested in food, beverage, and smoke. If a proper shower and clothing change is not provided, it is possible to bring lead home on the skin, shoes, and clothing, and inadvertently expose family members. When inorganic lead enters the body, it is not metabolized but is directly absorbed, distributed, and excreted. Inhaled lead is completely absorbed from the lower respiratory tract. Only about 10 or 15 percent of the lead ingested in the G.I. tract is absorbed, but this amount increases to as much as 50 percent in children and pregnant women and, if iron or calcium deficiency or fasting nutritional problems exist, then even greater quantities may be absorbed.

## **Exhibit 1. Some Sources of Lead Exposure**

Auto Repairs  
Battery Workers  
Construction Workers  
Gas Station Attendants  
Glass Manufacturing  
Lead Miners  
Pipe Fitters  
Plumbers  
Policemen  
Printers  
Reconstruction Workers  
Ship Builders  
Smelters and Refiners

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Once in the body, lead is distributed mainly in three compartments: the blood; soft tissues which include kidney, bone marrow, liver, and brain; and mineralizing tissues which are bones and teeth. About 95 percent of the total body burden of lead in adults is contained in the bones and teeth. About 99 percent of the lead in the blood is associated with the red blood cells (erythrocytes). The remaining 1 percent is in the plasma, where it is available for transport to other tissues. If the lead in the blood is not retained, it is excreted through the kidneys or through biliary clearance into the G.I. tract. The half-life of lead in blood is about 25 days, in soft tissues about 40 days, and in non-labile bone more than 25 years. After a single exposure, a person's blood level may begin to return to normal, but the total body burden will stay elevated. Since the body accumulates lead over a lifetime and releases it slowly, even small doses over time may cause harm. A major one-time exposure to lead is not necessary for serious lead poisoning.

We have been doing lead determinations at the Kennedy Space Center (KSC) for several years and, as shown in Exhibit 2, the numbers have significantly increased since 1986.

## Exhibit 2. Number of Employees in Surveillance Program

<u>Year</u>	<u>Number</u>
1986	1
1987	4
1988	6
1989	6
1990	48
1991	60
1992	255 (to 11/10/92)

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We looked at our 1992 data in mid-August and found that there had been 171 blood lead tests requested on workers. The average blood lead was less than 5 mcg/dl, with a range from 0 to 24 mcg/dl. With such a low average in a workforce presumed to have been tested because of some workplace exposure, we felt that we needed to more closely confirm that we were monitoring the right worker group. There has been in place for several years a close communication between the two divisions of our department. When a lead worker's physical examination was requested, the name of the worker, his employer, and the worksite information was sent to our Environmental Health Division for confirmation that:

1. This workplace had previously been identified as a possible lead exposure environment.
2. This worker had been identified as an employee in that environment and that environmental data had been obtained to confirm that there was a need to have this person entered into the Lead Surveillance Program.

Likewise, when requests were made to the Environmental Health Division for investigation or surveillance of a possible lead environment, that information was communicated to the Occupational Medicine Division along with a list of employees who were identified to be placed in the Lead Medical Surveillance Program. The concern intensified within EG&G because of the identification of new work in lead/paint removal and lead abatement projects.

The surveillance program at the Kennedy Space Center has shown several areas where lead exposure is above the permissible exposure level. These are sandblasting of leaded paint in semi-enclosed or enclosed areas, welding, and grinding of lead-painted surfaces in enclosed or semi-enclosed areas, cable splicing of lead sleeves inside manholes or under canvas enclosures, and target practice on partially enclosed outdoor ranges. Numerous other operations have identified lead in the environment, but at levels below the permissible exposure level.

The effort to get all possibly exposed workers into the surveillance program has brought the number to 255 workers through November 10, 1992. The results of the biomonitoring are shown in Exhibit 3.

### **Exhibit 3**

**1/1/92 to 11/11/92**

#### **255 Employees in Surveillance Program**

Average Blood Lead	4.59 mcg/dl (0-24)
Average ZPP	20.38 mcg/dl (9-61)

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In addition, 21 employees alleging possible exposure but who do not work in a lead environment have been evaluated. Those results are shown in Exhibit 4.

#### **Exhibit 4. Testing of "Non-Lead" Workers**

**21 Employees**

Average Blood Lead	3.43 mcg/dl (0-13)
Average ZPP	15.76 mcg/dl (10-52)

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While we have no specific explanation for the fact that our worker blood lead levels are so low in our surveillance program, we generally attribute this to a combination of factors. The most important is probably that this particular area of Florida has very low natural exposure to environmental leads from drinking water, automobile emissions, etc.; that many of the buildings and rapid growth in the communities have occurred since the mid-1970's; and that our worker protection programs at the Space Center have been effective. We have looked closely at the laboratory where our blood lead and ZPP levels are determined. The same lab has been used for nine years. It has all of the appropriate certifications, and we are confident in the accuracy of the results.

Because of the low levels in our employees, we have suggested that in our Hazardous Paint Removal Program and Lead Medical Surveillance Program we use 25 mcgs/dl as the action level.

Our program has been written to indicate that employees will be notified of actual blood lead level if their blood lead exceeds 25 mcgs/dl, and the Environmental Health Division will be notified in order to evaluate the employees' work practices and other non-work sources of possible exposure. A medical examination and consultation will be performed on any employee found to have a blood lead exceeding this action level. It should be noted that the Occupational Safety and Health Administration (OSHA) Lead Standard recommends 40 mcgs/dl as the action level. We have also proposed that the medical removal level be established at 40 mcgs/dl (60 mcgs/dl in the OSHA Lead Standard), and that employees be considered for removal from exposure when their blood lead is above this level. Each case will be evaluated by the Medical Director or Deputy Medical Director to determine if the employee is at increased risk of material impairment to health from exposure to lead prior to a determination with regard to either removal or return to employment in a lead environment exceeding the action level.

We believe that this very conservative approach is justified by our knowledge of the low blood lead levels in our workforce, but an individual decision would be made on each employee with the recognition that our job not only is to protect the health of the employee, but also to assure that every employee can continue to work safely.

