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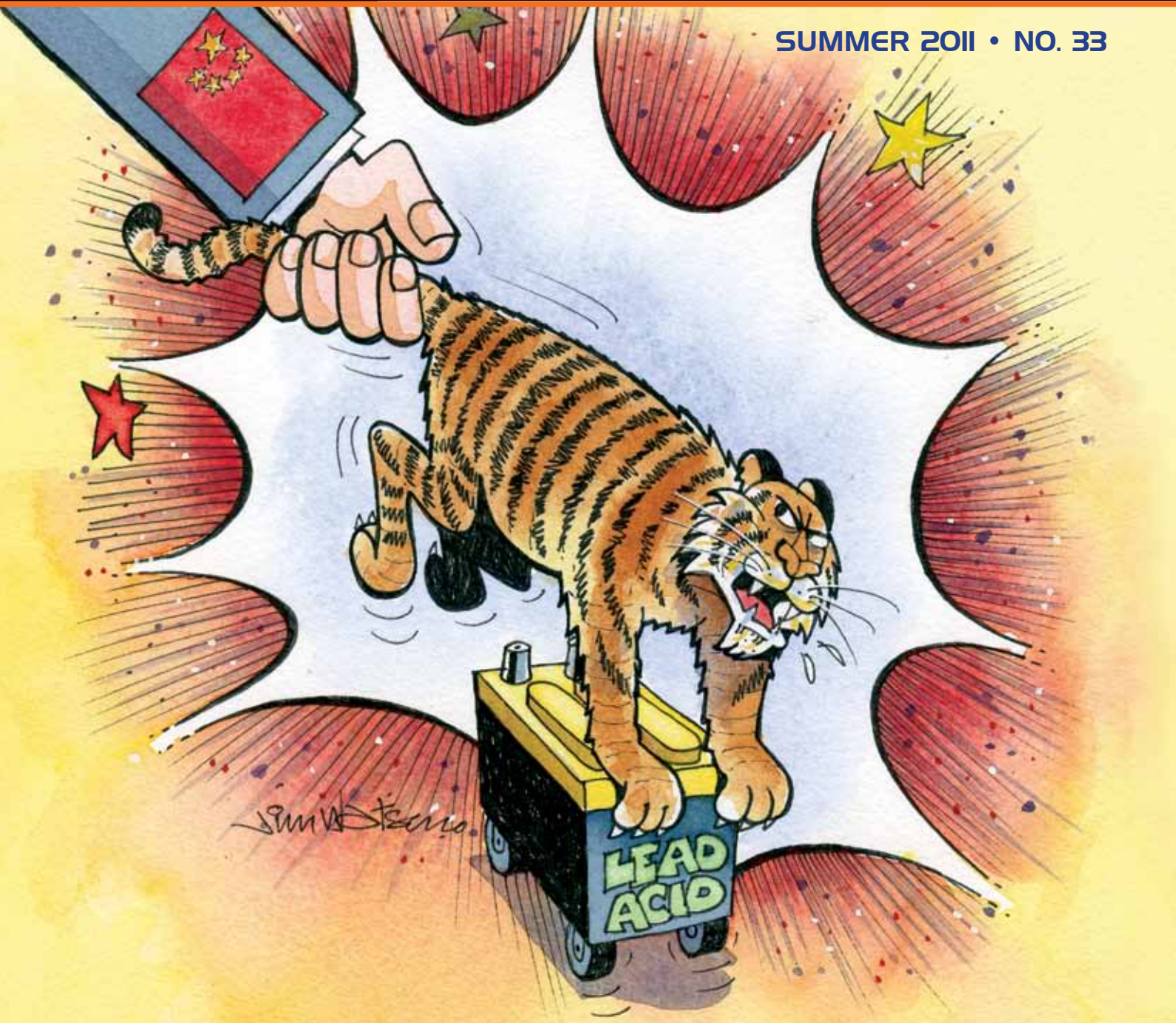


# Cleanliness—
## key to low blood lead levels

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# Cleanliness—key to low blood lead levels

As the Chinese Government cracks down on lead contamination, and California OSHA considers how low to set its new blood lead limit, consultant Dan Askin, of ESCA Tech reviews current practice on how to ensure employees' blood levels stay low.

In light of the current battery plant closings in China, and the anticipated revisions of the CalOSHA Lead Standard, the importance of industrial hygiene has become more apparent than ever. Throughout the world and domestically, I have witnessed factories spending hundreds of thousands of dollars on expensive air cleaning systems and water treatment equipment only to see those same plants overlook the importance of some of the least expensive components of a blood lead control program.

In the next few pages, I will outline how a simple yet methodical program can stop the lead dust created in the manufacturing process from contaminating the workers, their families and the residents of the community surrounding the facility.

Most countries have health and safety regulations that govern the control of worker's exposure to lead. Given the complexity of this subject, this article is not intended to be a guide to compliance with all of these regulations. The objective is to provide a review of the relevant aspects of a blood lead control program and to stimulate discussion of the subject as well as hopefully instigate improvements in your plant's blood lead control program.

Before we get into the actual program, it will be useful to have a better understanding of how lead enters the body in the first place.

- **You can inhale it**
- **You can eat it**
- **You can absorb it through your skin.**

**Inhalation:** The lungs are very well designed to take oxygen out of the air and put it into the blood stream. They are also effective in removing lead from the air and putting it into the bloodstream.

The efficiency of inhaled lead dust is size dependent. Respirable size particles between about 0.01 and 10 microns are efficiently collected in the lungs where they remain until they are completely absorbed into the blood stream. It takes about a day and a half to three days for a lead particle to completely move

from the lungs into the blood.

The larger particles, generally10 micron particles and up are mostly removed by the nasal hair and the cilia, (the cilia are those little hairs that line the throat). This is one of the body's mechanisms to clear inhaled dust and dirt out of the body. Unfortunately, what happens is a lot of this material winds up being swallowed, which gives the lead a new opportunity to be absorbed.

**Ingestion:** When lead is swallowed some of it will be absorbed in the intestines along the way. How much is absorbed depends on the solubility of the lead in the gastric juices and how long it has been since the person's last meal. When a worker comes to work without eating first, the body will absorb more of the lead they ingest than the worker who had a good meal first. When lead is not diluted by food it has more contact with the walls of the intestine where it is absorbed more quickly and thoroughly.

Lead that's on the skin can be both ingested and inhaled. If I wipe my nose with lead on my fingers, I will inhale some and swallow some. When I grab my respirator and pull it off my face what I'm doing is creating a vacuum at the instant I break the face seal. Lead from the dirty edges of the mask are then vacuumed straight into my mouth and then inhaled or swallowed. By this simple mistake I can have most of my daily dose very quickly. One should always exhale when a respirator is being removed.

Diet has a huge effect on the efficiency of lead absorption. A diet high in fibre and calcium helps reduce the amount of lead absorbed. When you have adequate calcium in your diet the amount of lead that your body can actually absorb is significantly less. In order to efficiently take in calcium and put it to work, you need vitamin D. There is strong evidence that calcium and Vitamin D supplements are beneficial. All the major nutrient minerals also interfere with the absorption of ingested lead.

Lead's toxicity is due to the fact that the body can't tell the difference between lead and calcium. Calcium has many uses in the body including building bones and teeth as well as critical biochemical reactions at the cellular level. When too much lead is present it can interfere with, or interrupt all of the important functions calcium performs in the body. It does this because the body can randomly substitute lead for calcium whenever lead is available.

***Lead's toxicity is due to the fact that the body can't tell the difference between lead and calcium. When too much lead is present it can interfere with, or interrupt all of the important functions calcium performs in the body.***

Fruits and vegetable fibres go a long way in reducing the absorption of ingested lead. The importance of a healthy diet cannot be overemphasized. We have also learned that it is beneficial to teach nutrition to our workers. It was surprising how many people were never taught how to eat a healthy diet.

**Skin Absorption:** The amount of lead that can be absorbed through the skin is significantly less than can be absorbed by inhalation or ingestion. Lead on the skin can be inhaled or ingested by the worker at any time, day or night and it can also be transferred to others.

If you take a look at the structure of the skin there is a layer of dead skin cells on the outside that serves as a barrier between the internal body and the outside world. These dead skin cells are dry and have a very high surface area. This results in an extremely high capacity to hold lead dust. Underneath this layer, you have the living skin. The sweat ducts and hair follicles start in the living skin and penetrate the outer dead skin layer. The sweat ducts and hair follicles provide a pathway for lead to enter and exit the body. In addition to the lead dust that accumulates on the skin surface your body continuously excretes lead in your sweat onto the skin.

Lead is not efficiently absorbed through the skin unless the skin is damaged; the lead form present is water soluble or it is combined with any of the chemicals that can push lead into the skin. Sweat is acidic and can dissolve additional lead on the skin. This water soluble lead can then be reabsorbed through the sweat ducts and hair follicles. Unless the lead on the skin is frequently and thoroughly washed away, it will provide a continuous source of exposure via inhalation, ingestion and skin absorption.

Removing perspiration before it dries on the skin is also beneficial, provided it is done in a sanitary way. Clean, single use towels are effective at removing some of the lead in sweat before it can be ingested, provided you can keep the towels clean until they are used. Sponge type sweat bands are also effective. What does not work is letting the worker wipe sweat off with their shirt sleeve or with a rag they carry with them all day.

### Blood Lead Control Program Elements

Now let's look at how to minimize how much lead can enter the body by reviewing the four main elements of an effective blood lead control program.

- **Controlling airborne dust**
- **Using appropriate personal protective equipment**
- **Teaching and enforcing mandatory personal hygiene practices**



**Mum always said, "Don't pick your nose, chew your fingernails, etc… especially true if you work in the lead industry.**

- **Maintaining a frequent and thorough housekeeping schedule**

An effective Blood Lead Control Program limits the dose each worker can receive to a quantity less than their capacity to excrete lead. It also limits the amount of the intake that is absorbed. In order to appreciate the full importance of this we need to understand what is called the tolerable dose.

***What is a tolerable dose of Lead?***

The World Health Organization (WHO) has determined and recommends a maximum tolerable dose for lead. It's called the "Provisional Tolerable Weekly Intake". Their current recommendation for lead is 25 micrograms (mcg) per kilogram (kg) of body weight per week. So for a 100 kg (220 pound) person, 2,5 milligrams (mg) of lead a week is considered the tolerable dose. That tolerable weekly dose translates to 350 micrograms (mcg) in a 24 hour period. Let's put that in perspective. If you cut a 100 milligram Aspirin tablet into 300 pieces and throw 299 of them away the 1 piece left weighs about 350 mcg.

For a 50 kg (110 lb) person, the tolerable dose is half this amount and for a child weighing 20 kg, you're talking 70 micrograms. That's not very much. The current target of US battery manufacturers and smelters is to keep all blood lead levels below 20 mcg/dL (1.0 $\mu$m/L), which is well below the current OSHA limit. For new hires, we are looking to keep them below 10 mcg/dL.

The tolerable dose is different than the total intake. Only a portion of the total intake is absorbed. Some ingested and inhaled lead can be spat out before it has the chance to be absorbed. Some of the ingested lead will pass directly through the system without being absorbed. The tolerable dose is the maximum amount of lead a person can absorb without an increase in their blood lead level or total body burden of lead.

***The body doesn't like lead very much, so it finds lots of ways to get rid of it. Every excretion path available to the body is used to eliminate lead.***

This tolerable dose value is really the amount of lead that a human can excrete. If the absorbed dose of lead exceeds this amount, then the extra lead causes the blood lead to go up and the overflow is placed by the body into storage. If the daily absorbed dose is less than this value, then the body can excrete old lead that day causing a reduction in the total body burden of lead.

The body doesn't like lead very much, so it finds lots of ways to get rid of it. Every excretion path available to the body is used to eliminate lead. Lead is excreted in urine, faeces, sweat, saliva, mucus, breast milk, ear wax, dead skin cells, hair, fingernails, and toenails. The kidneys can remove between about 25% and 50% of the total amount of lead that is excreted every day. In order for them to operate efficiently we need to keep our workers well hydrated to the point where their urine is nearly colourless.

## Controlling Airborne Levels

***How can the amount of airborne lead be reduced?***

The first step is to go through the operation and identify every source of lead emissions. The best place to start is with the molten lead and the visible dust. Then we want to rank them as far as their contribution to each person's total exposure. Then we eliminate, enclose, isolate, and /or ventilate them. After you take care of the visible emissions, then you can worry about the ones that you can't see.

Other than sloppy personal hygiene and very high airborne lead levels, where we see higher blood lead levels correlates with the very small, respirable size (less than 2.5 micron) airborne particles from exposure to molten lead. Looking at that over the years, what we've concluded is the really small particles, when inhaled, are absorbed with almost 100% efficiency.

In smelting, soldering and burning operations where the molten metal temperatures are high, the average particle size is very small. In secondary smelting for example, about 50% of the airborne lead is respirable

size and more than 25% is less than 1 micron. In most battery operations the average particle size is 15 microns with about 12% respirable size. About 5% of the airborne lead in battery operations is less than 1 micron.

With respect to molten lead, at temperatures above 425ºC (800ºF) the lead begins to evaporate and form the very small size lead particles that are so easily absorbed. At temperatures above 540ºC (1000ºF) the quantity of small particles generated becomes very great and the quantity emitted continues to increase with increasing temperature.

With respect to visible emissions, it takes a lot of lead particles to make them visible to the eye, so we have to eliminate or control all of the visible emissions. Dust doesn't magically appear. Dust always has an origin. The origin of each source needs to be identified. There is also a time element associated with the source. Is it continuous or intermittent?

For each source of dust or fume on our list we want to assign a priority for controlling it and select a control option. For each source you have 4 options.

**Eliminate:** ***Can the dust source be completely eliminated?*** For example, every time a battery plate is picked up dust is generated. Is it necessary to pick it up so many times? If the source cannot be eliminated, can the amount of dust generated be reduced? For example, workers can be taught to pick up and set plates down gently. It may not be possible to immediately eliminate all of the dust on the floor, but if it is kept wet, then the source is eliminated for as long as the floor stays wet. If it is necessary to transport materials outdoors between buildings they must be fully wrapped, contained and enclosed so the dust cannot be released outdoors.

**Enclose:** Another choice is to enclose the source so the dust cannot escape the enclosure. For example, on an automatic plate stacker, every source except the plate loading area and the group discharge area can be enclosed.

**Isolate:** In some operations the operator can be isolated completely from the dust by placing them in a control room or booth. For example, the oxide mill operator should be spending the majority of his time in a pressurised control room with a filtered air supply and only leave the control room to feed lead and collect oxide samples. Another example of isolation is called a Green Screen. Factories should plant trees, saw grass or whatever tall vegetation grows well in the local soil between them and their neighbours. These plants will filter and remove lead dust from the air that's leaving the site.

It is also necessary to identify all of the outdoor sources which can affect the neighbours. This includes dust collectors, outdoor storage piles, any lead dust on the ground as well as any dust that leaves the plant, whether it is through a window, door or stack. To reduce the impact on neighbours, we use a wet vacuum or a sweeper with high efficiency filters to keep the paved areas clean. Sanitary handling procedures for removing dust from the collectors and during filter changes are required.

Outdoor storage piles are becoming a thing of the past, but until they can be moved indoors, they can be sprayed with papier-mâché. Papier-mâché can be made cheaply in a mix tank by mixing together 50 kg of waste paper with 15 000 liters of water. This is a very inexpensive way to enclose outdoor storage piles.

After we have eliminated, reduced, enclosed or isolated as many of the sources as possible, it will be necessary to ventilate the ones that remain.

**Ventilate:** This is the most expensive control method and involves detailed engineering. The key to successful exhaust ventilation is close capture. Once you have identified each source

**No matter what kind of respirator you use, if the seal between face and respirator is poor it serves little use.**

on a machine or operation with respect to its location and timing, exhaust air must be collected as close as possible to the source. This generally means the air entry into the exhaust hood needs to be within 2 inches (5 cm) of the point where the dust originates.

Exhaust air is completely ineffective when the hood is located more than 12 inches (30 cm) from the source. Exhaust air works

best when it is combined with a full or partial enclosure to reduce the amount of exhaust air needed. Another component of an effective ventilation system is the supply air. Mechanical air supply is required so that the air flow patterns in the building are consistent from day to day and are independent of the outdoor weather.

### Personal Protective Equipment

A blood lead reduction program uses personal protective equipment (PPE) including gloves, respirators, work clothes and shoes. None of these items can ever be allowed to go home and each worker must have a minimum of two sets of the washable clothing items. One set to wear each day while the second set is in the laundry. If the plant uses an outside laundry service with weekly deliveries, this means each worker needs 5 or 6 sets of work clothes. Of all the PPE available, the respirator is one of the most important pieces of equipment you can provide your workers.

**Respirators:** A good respirator that properly fits each person does 2 things. First, it provides a final filter for every breath the worker takes. Second, it keeps the worker's hands away from their face and thus reduces ingestion.

On the previous page, we have a negative pressure full-face respirator, and below, we show 2 types of powered air-purifying respirators (PAPR). A PAPR maintains a positive pressure inside the face piece or hood. I prefer to wear a PAPR when I'm doing dust collector maintenance. In the plant I prefer to wear a half mask negative pressure respirator except when working around high temperature molten metal and then I prefer a full face respirator. The same filter type is used for lead, arsenic, cadmium and sulfuric acid mist. In the US this filter is designated as a P100 filter. They are tested to HEPA standards (at least 99.97% efficient at 0.3 microns) and are color coded purple.

It is important that each person is physically able to do the job while wearing a respirator. This can be determined during a pre employment physical or by reviewing the person's answers to a simple health questionnaire.

If the respirator is not properly fitted to the worker, it will not be effective. People need to be trained in how to use a respirator for the maximum benefit. Negative pressure respirators leak. They leak at the face seal.

When I worked in a lead smelter in the late 70's, respirators came in one size. It should have been labeled: NOT YOUR SIZE! I'm kind of long in the face and the mask was too small for me. Years later, I actually had a chance to measure the amount of leakage on the respirator I wore in the smelter with a face fit test. While wearing it I was breathing 2% filtered air and 98% unfiltered air that leaked around the face seal.

***Even where the airborne levels are very low, sloppy personal habits will defeat every blood lead control program.***

Negative pressure respirators have to be sealed to the face. This means no facial hair. A day's growth or even a little stubble is enough to hold the mask away from the face just far enough that none of the air goes through the filters and the worker breathes only unfiltered air.

You need to provide the correct size face piece and train each person on how to put it on correctly so first time, every time, it is sealed to their face. This is done with a respirator face fit test. The simplest and most cost effective fit test involves challenging the seal between each worker's face and their respirator mask with an irritant smoke. The worker will have an involuntary coughing reaction to any leakage showing when and where the face seal is leaking. This is an essential part of the respirator program.

**Paper Dust Masks:** In work areas where the airborne lead levels are low (< 20 mcg/cubic metre) and there is no molten metal present, high efficiency respirators are not needed. In these situations, I still use and recommend a paper dust mask. While these filters are only about 50% efficient for lead dust and less than 10 % efficient on molten metal fumes they accomplish a few things.

They provide a continuous reminder that a toxic material is present.

They provide some protection from an accidental cloud of dust.

They keep the hands away from the nose and mouth.

### Implementing a Mandatory Personal Hygiene Program

Even where the airborne levels are very low, sloppy personal habits will defeat every blood lead control program. We encounter blood lead problems in locations where there is no airborne lead and people are only handling finished castings. This is because their personal hygiene is so bad that they manage to ingest too much lead every day. Even where air lead levels are high, the combination of good personal hygiene and a good respirator program can reduce blood lead levels. Where the lead in air levels are low, good personal hygiene will reduce the blood leads even further.

Management has several responsibilities with respect to the Personal Hygiene Program.

- **To provide a work environment where it is possible for the workers to do their job without being covered with lead dust**
- **to train them how to work cleanly**
- **to provide each worker with the proper tools to clean up**
- **to teach the worker how to wash up and to take a shower**
- **to supervise and enforce all of these cleanliness rules.**



**How to wash up— you need a big basin and to be thorough.**

**Clean Work Habits:** The way each job is done will have a large effect on how much airborne lead is generated and how much lead each worker gets on their clothing and skin. Items need to be handled and moved gently, empty pallet boards need to be quickly vacuumed and then lightly sprayed with a water mist to keep the dust wet while it is being moved. While the cleanliness of each job is related to how well each work station is designed for the task to be done, it is still necessary to teach each worker clean work habits.

**Cleaning Up:** The wash station is critical to the success of a blood lead control program. We need hot and cold running water, skin cleaner, fingernail brushes, towels, a large sink and a mirror. People need to wash their hands, arms, face and neck every time they leave the plant floor and especially before eating, drinking or smoking. Since we need our workers to be well hydrated, the exception to this rule is the water fountains in the plant. For supervisors who can't go to the main wash room before every trip to their office we need to provide either sinks at multiple locations around the plant or provide pre-moistened skin cleaning towelettes in their offices.

The most common mistakes we see are sinks that are too small and not enough sink space for everyone to wash up at the same time. The person needs to wash all the way up his arms, to wash his face, his neck and his hands. If the sink is small then he can't get his elbows wet and he can't wash properly.

The proper approach to wash up is detailed and requires training of the workers. When you arrive at the wash station you need to first roll up your sleeves and then prewash your hands. Since you are going to use your hands to wash your arms face and neck it is best if they start out clean. The skin cleaner needs to be worked under the fingernails. Each finger needs to be washed individually. You need to make sure every millimetre of your hands; front and back are washed and use a finger nail brush.

***A thorough cleaning of the skin and hair in the shower at the end of the shift eliminates 16 hours of lead exposure every work day and eliminates lead exposure over the weekend.***

After your hand prewash, it is time for the serious and thorough washing of your face, arms and neck. First, wet your arms, neck and face and spread the skin cleaner over the entire surface of your hands, then your arms, neck and face. Then scrub with your hands. Then after you rinse and dry you are ready for break or the shower to go home. It is best to leave your shirt sleeves rolled up as they are dirty and you can roll them down again when it is time to re-enter the plant.

Washing lead from the skin and hair is not quite so simple. Lead is difficult to wash off. Lead is heavy, sticky, difficult to wet and holds a static charge. All of these properties make it adhere strongly to your skin, clothes, shoes, gloves and respirator.

Picture what happens when you spray water onto lead dust. What you find is the water does not penetrate the dust easily to get the dust wet. Lead also holds a large static charge. While this ability to hold a charge is one of the reasons lead makes such a good battery, it also helps lead stick to the skin, clothes and other surfaces. Lead particles are small and they get trapped in the pores of the skin and in the fabric of clothing and gloves. Soluble lead can migrate through the skin. Then there is the fact that water soluble forms of lead are the most easily and efficiently absorbed by the body whether they are inhaled or ingested.

Efficient removal of lead requires special cleaners designed to overcome its adhesive nature. Lead, like Calcium, reacts with most soaps, detergents and surfactants to form soap scum (picture bath tub rings). When this happens, what you wind up doing instead of washing off the lead is to glue it to the surface you are trying to clean. You need to make sure the cleaners selected do not dissolve lead and make it easier to absorb and they do not contain any of the surfactants that cause lead to migrate through the skin.

**Effective Lead-Removing Cleaners.** Skin cleaners vary widely in their ability to remove lead. Typical industrial skin cleaners remove between 30 and 70% of lead from the skin. This

is why specialty cleaners have been developed for lead that removes 98+ % of the lead on the skin. It is also important that the skin cleaners do not dissolve the lead. Water soluble forms of lead are more quickly absorbed and they can also be troublesome to remove in the waste water treatment process.

A thorough shower is essential to achieving reduced blood lead levels and they have the largest benefit for those people who actually use an effective skin cleaner in the shower room and wash their entire body. It is not only dust from the plant that needs to be washed off at the end of the day, but also the lead that is in their sweat. Just getting wet under the shower doesn't work.

A thorough cleaning of the skin and hair in the shower at the end of the shift eliminates 16 hours of lead exposure every work day and eliminates lead exposure over the weekend. If the workers are taking lead home with them on their hair or skin, then they don't get a break from lead exposure when they leave the plant and they have something extra to give to their children.

**Lead Testing:** The best training tool for proper and thorough wash up is the test for lead on the skin. Using these test kits is the best way to train workers to wash properly. They use colour change technology to change the colour of the lead so it is visible. They are inexpensive with some tests available for less than $0.25 per test. The skin test for lead enables the worker to see not only how much lead is present, but where it is. With these tests you can show them when they didn't clean the back of their hands, their fingernails, between their fingers, their neck or their arms.

Lead testing is an essential management tool that helps reduce surprises when the blood lead test results come back; when health and safety officials visit to collect samples and to help each worker develop confidence that they are clean and not taking any lead home. These tests are not done for every worker every day. They are most effective when used as part of the initial training and then to spot check people on their way into the lunch room or after their shower.

To assure adequate cleaning of respirators and work clothes, these same lead test kits can be used to test the cleanliness of the respirators and work clothes after they are washed.

Blood lead testing frequency should be based on the person's last measured blood lead level and the amount of airborne exposure they have in their job. A tiered approach is the best. The higher an individual's lead level, the more frequently we check it.

However, unless it's a follow-up confirmation test, we rarely sample more than once a month. My personal opinion is that blood lead levels should be measured 4 times a year in lead exposed jobs. For the office, sales and other people not directly in contact with lead, testing once or twice per year is normally sufficient. New workers should be tested before they start work and then once a month for the first 4 - 6 months or until it is established they can manage their exposure.

It is also necessary to have a quality control program in place for both the blood sample collection and the analysis. To verify the lab's accuracy it is recommended that one duplicate sample be collected for every 50 blood samples. You should require the lab to confirm with a duplicate analysis any blood lead result greater than 25 mcg/dL. It is appropriate to request the laboratory to supply you with a copy their Quality Control Program and results as well as their results from the Proficiency Testing Program. Finally, the blood sample room needs to be kept extremely clean and we need to assure that the stick site is cleaned thoroughly with a highly efficient lead removing skin cleaner.

Personal air samples are collected periodically to measure the total airborne exposure each worker receives during the day. An individual's airborne lead exposure level is not a good indicator of their blood lead level. This is due to two factors.

The first reason is the total airborne level does not provide any information on how much of the airborne dust is in the respirable size range that is most efficiently absorbed. The second is that poor work and personal hygiene habits have a larger impact on blood lead levels than total airborne lead. This is especially true when respirators are being used. Personal air samples do provide important information on measuring the effectiveness of controls in the plant and help in identifying workers with bad work and hygiene habits.

**High lead vs. low lead individuals:** So after you have taken these steps to reduce how much lead each worker inhales and ingests, you will still have a group of people who have blood lead levels higher than their coworkers doing similar jobs. These people generally have some little habit that causes them to ingest extra lead.

Back in the 80's there was a man we will call Arnold who worked in the warehouse of a lead plant. His airborne exposure was very low but his blood lead level was not. Arnold was

a generally clean person who followed all of the health, safety and hygiene rules. He wore a PAPR all day and still his blood lead would not come down. Arnold never missed a chance to wash his hands and he always washed his hands, arms and face. He didn't take any shortcuts with his personal hygiene. He never touched anything without his gloves. He handled his gloves properly. He washed thoroughly before lunch.

Finally we decided to follow and observe him for a full day to try and determine when, where and how he was getting his lead dose. After Arnold washed he opened each door on the way to the lunch room with his elbow, so he wouldn't get his hand dirty. In the lunchroom he wet a paper towel and wiped the table where he was going to eat. Then he set his lunch onto clean paper towels. Then, as Arnold has done before every meal in his life he wiped his hands on his pants before he sat down. So despite all his training and all of the help the hygiene team could offer, Arnold had been eating a lead sandwich for lunch every day without ever thinking about it. In three months after Arnold changed his lunch menu his blood level dropped to a reasonable level.

We find something else when we observe high lead vs. low lead individuals. High lead people at rest frequently sit with their hands on their laps where they pick up the lead off their work clothes. They sit this way in the lunch room and in the office. Low lead people at rest generally sit with their forearms, not their hands, resting on their laps.

Another sign that points to people who have or will have blood lead problems is the cleanliness of both their work clothes and work station. If there is visible lead dust on the stomach area of their work shirt, they always seem to have a higher blood lead than their coworkers without this accumulation of lead. The worker who does not keep their work station clean by frequent vacuuming or wash down will have a higher lead level than their coworker who works clean.

When you get lead dust on your clothes you are exposed to the same dust twice. The first time is when the dust is generated and gets onto your clothes. Then you carry this dust around all day and it becomes a continuous source of exposure.

**The Rules.**

**No consumables are allowed in the plant.** No cigarettes, chewing tobacco, gum, candy or cosmetics. In lead process areas, smoking, eating, and drinking are out of the question. People who have desks that they return to directly from the plant are considered contaminated. No eating, drinking, or smoking in offices that are exposed to lead by having lead dust tracked into them from the plant. Eating and drinking are only allowed in the lunchroom except for access to water fountains around the plant (in low lead areas). Smoking is only allowed outdoors.By the way, we also don't like wallets, keys or personal cell phones in the plant either. We provide secure lockers so they can stay out of the plant.

***The importance of management support of the blood lead reduction and hygiene programs cannot be over stressed.***

The importance of management support of the blood lead reduction and hygiene programs cannot be over stressed. The job of teaching and enforcing personal hygiene cannot be delegated to the plant nurse or safety officer. Front line managers and supervisors must accept their responsibility to teach and enforce this program if the program is to be successful. Upper management also has a critical role in this program to provide the necessary resources and to require that these programs are maintained and implemented each and every day.

**Maintaining a frequent and thorough housekeeping program:** Just as proactive managers are vital to the success of a personal hygiene program, they are also pivotal to the effectiveness of the plant's housekeeping program.

The tools and the proper lead removing cleaners to keep the work areas, work stations and workers clean in the plant must be provided and used. The most important of these are the central vacuum system, the wet floor scrubber and the wet wash down system. In a lead processing operation, battery manufacturing plant or smelter, there is no substitute for using a central vacuum system for dust collector maintenance and to keep the plant clean.

Vacuum needs to be provided at every work station to clean up through the day and to clean dust accumulations within the equipment.

The wet floor scrubber or the central vacuum system is used to keep the aisle ways clean so the fork trucks aren't throwing lead dust into the air all day. In wet process areas such as the pasting department or battery breaker, keeping surfaces washed clean helps the worker stay clean all day.

We need the lunchroom, locker room, break rooms and offices to be kept spotless. This includes the production offices and control rooms on the plant floor. Use only smooth, non-porous surface finishes in these areas. All surfaces should be coated or

covered with paint, varnish or plastic laminate so they are easy to clean. Stainless steel is also easy to clean. Lunchrooms need to be cleaned after every break: after morning break, after meal break, after the afternoon break and after shift change. Every time the workers come back into the lunchroom it should have been cleaned since it was last used. Locker and break rooms are cleaned at least once per shift change. Offices are cleaned at least once per day.

Lunch Room cleaning should include the floor, tables, chairs and counters between every break. We also need to clean the vending machines, including the buttons, the dispensing area and the tops of the machines. We need to clean the handles of microwaves and refrigerators and anything else the workers touch.

**Respirator laundry:** We used to see a lot of difficulty in issuing clean, dry respirators. Respirators can be cleaned in a clothes washer. Semi automatic respirator washing and drying equipment is also available that can further minimise labour costs in the respirator laundry. In the U.S. you can buy a large capacity clothes washer for less than US$500 and wash 30 half mask or 15 full face respirators every 30 minutes.

We mark each respirator and filter with the employee's number so they get the same respirator back. To clean, you first remove the filters, then place the respirators in a laundry bag (the type used to wash sweaters). They go through a wash cycle with lead removing respirator detergent followed by a rinse and then a sanitising cycle. Then they are removed, drained and dried. We also use lead spot tests to test the respirators coming out of the laundry for residual lead. We make sure only clean respirators are issued.

**Working dress:** The work uniforms need to cover as much of the skin as possible. The only exposed skin should be the hands, neck and face. Hats can be used to reduce the amount of lead dust in the hair, but then they also need to be washed.

***We don't want any lead going home. Lead's not something you really want to share with your children.***

The clothing laundry must be able to deliver work clothes with very low residual lead levels. Our primary concern is the amount of available lead (lead that can be transferred to the skin) that is retained after washing. Most commercial laundries have never considered the need to achieve low lead levels in work uniforms. Most use detergents that are good for washing hospital sheets but unfortunately what works well for the hospital isn't the best choice for the battery plant.

Many laundry detergents can make the clothes appear clean to the eye while leaving too much lead dust in the fabric. We have encountered washed work clothes that looked clean but contained more than 2% lead by weight. The chemical spot tests are also useful in testing the cleanliness of the clothes after washing. They should also be tested after drying to make sure they aren't getting dirty again in the dryer.

We always wash the towels and wash cloths for the showers in a separate washing machine. You can't put work clothes and towels in the same washer and expect to get acceptable lead levels on the towels. We also use separate dryers. We frequently encounter clothes dryers that are thoroughly contaminated with lead dust. The clothes dryers need to be cleaned periodically. There is airborne lead in the laundry room from handling the dirty work clothes. This lead then gets pulled into the dryer by the blower and begins to accumulate in the dryer.

In addition to providing each worker with a clean uniform every day, we have found it beneficial to provide clean socks to wear in the plant every day. Socks that are worn all day in the plant, inside the lead work shoes and in the locker room can become highly contaminated. We don't want this lead going home or being washed in the home washing machine.

**The Hygiene facilities:** We want everybody clean before lunch, before breaks and we especially want them clean before they go home. We don't want any lead going home. Lead's not something you really want to share with your children. This means that we need to get everyone clean in a couple of minutes before breaks and in 10 minutes or less at the end of the shift.

The first rule is to have separate locker rooms for clean personal clothes and dirty work shoes and clothes. Each worker has 3 lockers. When the worker arrives, he places his lunch and other personal items into his personal locker. This locker can be in the lunch room, but the best arrangement is to have two sided

lockers, with one side opening into the clean locker room and the other side into the lunch room.

Next, the person leaves all their street clothes and shoes in their clean locker and puts on their clean work uniform. They then proceed to the dirty side locker room where they pick up their work shoes. It is useful to provide a pair of sandals for them to wear for walking between the locker rooms.

**Clothes cleaning station:** The OSHA standard requires before leaving the production floor you either vacuum clean the clothes or go through an Air Shower to blow the dust off the clothes. The vacuum station is not as effective as an Air Shower and you need a helper to vacuum the back of the clothes, but they are significantly less expensive.

**The Air Shower:** An air shower uses high velocity air to shake the clothes and knock off the dust. The air is recirculated within the air shower through a HEPA filter and is discharged through nozzles at a speed of 9,000 feet per minute (45 meters per second). What an air shower will do is significantly reduce the amount of dust that's taken into the lunch room. With respect to dust removal, air showers blow off the loose dust, and that is the dust of interest in keeping the lunch room clean.

**Shoe cleaning:** There are three commercially available shoe cleaning methods. There are wet boot cleaners, dry vacuum shoe cleaners and then there are tacky mats. There are two (2) types of tacky mats, the disposable and the permanent variety. The disposable type comes in pads of 60 sheets and when they get dirty you tear off a layer and throw it away. The permanent type gets washed periodically to maintain the surface adhesive.

The first place shoe cleaners should be considered is the entrance to the nurse's office and the room where blood samples are collected. The room used for blood sampling needs to be as lead free as is reasonably possible in a lead plant. The other place they are beneficial is at the entrance to the lunchroom.

**Respirator Storage:** We need a clean place to store the personal protective equipment during breaks near the entrance to the wash up facilities. These can be shelves where the person picks up their clean respirator at the start of the shift and can store it during breaks.

**Wash Up Locations:** We need wash up facilities around the plant, not just in the locker room. Often where we need a remote sink, there is no drain. For these wash stations we install a pump for the waste water. Although we discussed sinks earlier, there are two additional things to consider.

***In theory, a Blood Lead Control Program is quite simple. Limit the dose to an amount less than the individual's ability to excrete it.***

Sinks should be placed in the worker's path. If we confront them with the sink, then they have to make a conscious decision not to wash. If the sinks are off to the side then the worker has to make a conscious decision to wash. Second is to have sufficient washing capacity to allow everyone to clean up quickly. If there is not enough room for everyone to wash up, some workers will skip washing.

**Lunch Rooms:** The lunch room needs separate sinks for washing the hands and for washing dirty dishes. The hands can get dirty again between the wash room and the lunch room. Many plants will also supply pre-moistened towelettes on the lunch tables. The lunch room as well as the locker rooms should have a positive pressure, filtered air supply and shoe cleaning mats.

**Shower Rooms:** At the end of the shift everyone needs to shower thoroughly. First, the dirty clothes and protective equipment are turned in for cleaning. Then the workers need to proceed into the shower room. It is best to locate the shower room between the clean and dirty locker rooms so that the only way a person can get to the clean locker room is through the shower. They can wear their sandals back through the shower room so they are back in their clean locker for the next day. After their shower they can pick up their street clothes and personal items in the clean locker room and go home.

In theory, a Blood Lead Control Program is quite simple. Limit the dose to an amount less than the individual's ability to excrete it. Of course in practice this involves a lot of attention to detail along with the proper hygiene facilities and equipment. It is not possible in this format to discuss every possible aspect or cultural variation of a blood lead control program. It can take 2 to 3 times as long for a blood lead to go down as it took it to go up in the first place. It is important to keep in mind the best way to bring down blood leads is to prevent them from going up in the first place. But regardless of the starting blood lead level, the blood lead control program is the same.

My objective here has been to outline the best practices on implementing and maintaining a blood lead control program. There is still much to learn about how blood leads can be kept low. If we share a common professional interest in blood lead reduction and control, I look forward to hearing from you via email, phone or at an industry conference.

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