

# **Safety and Health Practices for Working with Metallic Mercury**

First Edition - October 19, 1985

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## **Introduction**

Twenty years ago we asked Dr. Woodhall Stopford if he would prepare a supplement to the newly required Material Safety Data Sheet (MSDS). The Occupational Safety and Health Administration (OSHA) developed the MSDS for all hazardous materials used in industry. Dr. Stopford worked at Duke University's Department of Industrial Toxicology. We felt that a more practical and in depth presentation would be more helpful to our customers. Since then we have sent copies of his work with all of our mercury shipments.

After reviewing the information presented, we feel that the work is still accurate and beneficial. We therefore will continue to distribute the supplement. We acknowledge that some of the information may be considered outdated, however, the overall presentation remains accurate and helpful for all that use mercury in the workplace.

Sincerely,

Eve L. Metzger  
Vice President,  
Bethlehem Apparatus Co. Inc.

## **The Toxicity of Metallic Mercury**

### **Acute Mercurialism**

When mercury is inhaled in milligram quantities, acute toxicity can result. Such exposures are invariably associated with work in a confined, mercury contaminated space with little ventilation or with the heating of mercury such as in home amalgamation efforts, welding of contaminated surfaces or spills of hot mercury. After a delay of a few hours, a metal fume fever can result with symptoms of nausea, abdominal cramps, diarrhea, muscle aches, fever and an elevated white blood cell count.

With higher exposures, one can also see symptoms of pulmonary irritation with chest tightness, a cough and shortness of breath. X-rays of the chest in this disorder disclose an interstitial pneumonitis and pulmonary function tests show restrictive changes as well as a diffusion defect for oxygen. Survivors can develop chronic shortness of breath as well as interstitial fibrosis of the lungs.

Possibly more common than pulmonary toxicity is the finding of inflammation of the mouth. Shortly after an acute exposure, the mouth and gums can become red and sore. Within a few days one can experience a metallic taste as well as further inflammation of the gums, loosening of the teeth, ulcers of the mouth and a blue line at the gum margins. Occasionally, a tremor is noted and less commonly one finds bloody diarrhea as well as transient liver and kidney abnormalities.

### **Toxicity from Chronic Exposure**

#### **Neurologic Toxicity**

In industry the earliest finding that might be noted from chronic exposure to moderate levels of metallic mercury is that of a tremor. It is initially seen as a fine, postural tremor noted only when the arms are outstretched. With greater exposures or exposures of longer duration, the tremor increases in amplitude and becomes coarse. In addition, it appears to be aggravated by intentional activities such as writing or picking up a cup of coffee. As the severity of the tremor increases, it can be interrupted by clonic-like jerks of one or more extremities. In the severest cases, these jerks progress to involve the entire body.

Sometimes, associated with a moderate tremor there is difficulty in performing fine movements, incoordination, difficulty with gait and even hoarseness associated with ataxia of the vocal cords.

If mercury exposure continues to the point of the development of a significant tremor, a state of erethism can sometimes be found. Affected workers become easily upset and embarrassed, irritable and sometimes quarrelsome. They lose self-confidence and often have a feeling as if they are being watched. If they think they are being watched, their tremor might increase in severity. They

often have difficulties sleeping or have nightmares. Some tend to be drowsy and fall asleep on the job. Often there is an associated depression and loss of memory. Rarely there are hallucinations, delusions or mania. If an individual is removed from exposure soon after manifesting eresthismic symptoms, all findings and complaints can resolve over a period of months without any further intervention.

With extreme exposures to metallic mercury, one can find concentric constriction of the visual fields, poor night vision and red-green color blindness, problems which can resolve with treatment by chelating agents. A more common eye problem is the finding of mercurialentis, e.g., a brownish discoloration of the anterior capsule of the lens. Such a defect occurs only after chronic exposure to mercury and can be present without any evidence of mercurialism.

Individuals who have severe mercurialism can also have symptomatic defects of other sensory organs. These include a high frequency hearing loss, symptoms of vertigo, ringing in the ears, loss of balance and a partial loss of smell sense.

In workers with severe mercurialism secondary to inorganic mercury exposure, one can sometimes find disorders of the spinal cord and peripheral nerves including a syndrome resembling amyotrophic lateral sclerosis, disorders of the sensory nerves and a Parkinsonism-like syndrome of stiffness and rigidity of the extremities.

### **Oral Toxicity**

A common manifestation of chronic exposure to excessive levels of mercury vapor is the finding of gum disease. The gums initially become swollen and boggy and later retract. In individuals who have pre-existing pyorrhea, evidence of infection can be aggravated. In severe cases there can be loosening of the teeth with bony re-absorption of the jaw. The gum disease can be brought under control with good oral hygiene even if exposure to mercury continues. Individuals who have jaw involvement can have improvement if they are taken out of exposure and treated with braces.

### **Kidney Toxicity**

Once it enters the body, inorganic mercury is primarily stored in the proximal tubules of the kidney. It is not unexpected, therefore, that the earliest signs of kidney damage would be manifested by a disorder of the proximal tubules. These tubules are involved with re-absorption of nutrients and substances that are normally filtered into the urine, but are usually conserved by the body. With proximal tubular disease secondary to mercury, one can find abnormal amounts of glucose, phosphate, amino acids and small molecular weight proteins in the urine.

Unfortunately, studies of renal tubular disease are difficult and often proteinuria from a glomerular injury is the first manifestation of kidney toxicity

secondary to excessive absorption of mercury. On biopsy of an individual with such a problem one finds evidence of a membranous glomerulonephritis in association with proximal tubular injury.

## **Chronic Inorganic Mercurialism**

Inorganic mercury is unusual in that it is relatively rapidly lost from the body. In a worker with early manifestations of mercury toxicity of any organ, improvement and complete resolution of the problem is almost invariably noted when the worker is removed from exposure for a period of time. If excessive exposure continues in the face of obvious clinical problems, or if there are recurrent exposures and toxicity, manifestations of mercurialism can become chronic. Manifestations can include tremors, paralysis, loss of memory and chronic renal disease. Over the past 20 years cases of chronic inorganic mercurialism have only been reported sporadically and have only been noted after exposures that have been severe, uncontrolled and prolonged.

## **Surveillance Programs for Industry**

### **Pre-employment Examinations**

A pre-employment examination program is needed to identify and restrict certain individuals from potential exposure to mercury. Exposure is contraindicated in those individuals who have problems which might be either aggravated with mercury exposure or confused with findings of mercurialism and thus hinder the effectiveness of a medical monitoring program. Problems which would restrict employment would include:

- Alcoholism
- Chronic kidney disease
- Known allergy to mercury

If protein is found in a urine specimen, but there is no evidence of chronic kidney disease, the individual can be employed once the underlying problem has been corrected. Individuals with evidence of gingivitis (gum inflammation) should be under the care of a dentist prior to employment. Tremor and psychologic problems should be documented.

### **Work Environmental Monitoring**

There has always been difficulty in correlating measured exposure levels to mercury vapor with biological measurements of mercury absorption except when data is analyzed on a group basis. Most studies that correlate biological levels with air levels are based on area vapor measurements. However, when there is a potential exposure to metallic mercury, personal contamination can result with the formation of a micro-environment of mercury vapor around the worker's breathing zone which is several times higher than that of the general work environment. If work clothes are brought home, contamination of the

home can result in exposures that continue for a greater period than the work day, as well as exposures to family members.

Environmental monitoring should include daily area mercury vapor levels at all work sites with a direct reading mercury vapor meter and periodic time-weighted average breathing zone measurements made with a gold foil monitor (3M) or a portable personal sampling pump connected to a Hopcalite tube.

## **Biological Monitoring**

Urine mercury levels are useful both for estimating exposures as well as body burden since most inorganic mercury that is absorbed is deposited in the kidneys prior to excretion. Urine mercury levels tend to vary from person to person with similar exposures as well as from time to time in the same individual. When individual workers are examined on a group basis, however, urine mercury levels correlate well with average exposure levels as well as the incidence of mercury-related problems.

In order to make urine mercury determinations more reflective of an individual's exposure, efforts have been made to decrease this variability in measurements. By making urine mercury determinations on the same day each week and the same time of day, the variability seen in any one individual's urine mercury determinations can be decreased. Corrections for urine concentration either by using the excretion of creatinine or urine specific gravity can also decrease variability between urine mercury determinations. Corrections for variability in urine concentration can be avoided by using the first voided specimen on arising for analysis.

Determinations of mercury in whole blood are better indicators of current exposure than urine mercury determinations. In man, the initial half-life for loss of mercury from blood is also fairly short, being approximately 5 days. There is an excellent correlation between blood mercury levels and average area mercury vapor levels or breathing zone mercury vapor levels.

## **Medical Monitoring Program**

Some individuals can excrete milligrams of mercury per liter of urine without any evidence of ill-effect while others might excrete less than 300 ug/l and have evidence of an adverse effect from mercury exposure. Because of this variation in susceptibility, only a detailed medical monitoring program can identify those individuals who are having adverse effects from mercury exposure. Such an examination should include a complete history emphasizing neurological and psychological complaints as well as a complete physical examination with emphasis on the oropharyngeal and neurological components of the examination. Certain physiological studies are indicated. Periodic tests of strength can be made with a simple grip gauge. The severity of a tremor can be documented. An important part of the medical examination is a close assessment of kidney function. One simple way is to quantitatively assess total protein excretion. Urine glucose and albumin levels can easily be checked with an indicator strip. Periodic blood tests to assess kidney function should be performed.

## Preventive Measures

### Work Practices and Housekeeping

Metallic mercury that is spilled on a floor surface is available not only for vaporization, but for tracking into all parts of the facility with resultant exposure to workers who might normally not be exposed to mercury vapor. To prevent this type of contamination, floors should be sealed with an epoxy sealer and periodically washed with a trisodium phosphate solution to remove all small particles of mercury. More obvious spills of mercury should be vacuumed up into a water trap at the time of the occurrence of the spill. The vacuum should be appropriately exhausted or filtered to prevent further mercury exposure. An alternative method of picking up a mercury spill is to use a copper pad filled with zinc filings to amalgamate the mercury.

In areas where the working surface can not be sealed, either a solution of calcium polysulfide in a wetting agent or a 20% solution of ferric chloride can be sprayed onto the surface. This treatment will adequately suppress mercury vapor production until the surface is disturbed.

Smoking should not be allowed in mercury exposure areas. Furthermore, tobacco products should not be kept in shop areas. Cigarettes can readily absorb mercury vapor and therefore should not be brought into an area where mercury is used. Furthermore, cigarettes can be readily contaminated by being laid down on a work surface or by being smoked prior to washing one's hands. The cigarette can then readily volatilize any mercury present giving excessive exposure not only to the smoker, but to anyone near him.

### Personal Protection

In addition to creating an excessive micro-environmental level of mercury vapor around a worker's face, personal contamination can also lead to excessive absorption through the skin. To help prevent skin contamination, not only should adequate cover-alls be worn, but either gloves or a thiosulfate-containing barrier cream should be worn to protect the hands. Hands should be washed before smoking or drinking. With exposures to levels of mercury vapor less than  $0.5 \text{ mg/m}^3$ , a silver-impregnated dust mask (3M) can be worn. With higher exposures a chemical cartridge respirator (Mersorb-MGA) should be used. Accumulation of mercury containing dusts on the outside of mercury vapor absorptive masks can also lead to the rapid breakthrough of these masks and excessive mercury exposure to the worker above and beyond what he would receive without wearing the mask. A frequently changed dust filter in front of the cartridge can prevent this problem. While working in an environment with a very high concentration of mercury vapor, a full face mask should be worn to prevent excessive absorption of mercury vapor through the cornea with resultant capacities of the cornea and lens.

Underwear and socks can absorb mercury excreted in sweat and, in turn, make this mercury available for re-absorption either through the skin or the

respiratory tract. Although relatively minor, re-absorption of mercury from sweat can be prevented by changing underwear and showering at the end of each work day.

## Engineering Controls

One of the major ways of decreasing workers' exposure is by the adequate use of ventilation. In a stagnant environment, even at 0°C, a dangerous exposure situation to mercury vapor can result. As the temperature increases, the vapor pressure of mercury increases quite rapidly such that at 30°C there is an approximately 6-fold greater vapor level than at 0°C under the same conditions. Adequate general ventilation is mandatory. During the summer months, increased ventilation is required, but this can usually be obtained by using natural ventilation by opening all doors and windows. Under some circumstances it is easier to use air conditioning to keep the temperature down and vapor levels under control without any drastic changes in ventilation. High volume local exhaust ventilation of point sources of mercury vapor, such as contaminated ovens, can greatly decrease the over-all ventilation requirements of a facility as well as prevent excessive local work area levels of mercury vapor. Makeup air requirements can be decreased by filtering recirculated air through mercury absorbing activated charcoal filters.

## Administrative Controls

In situations where engineering controls are inadequate to control a mercury vapor exposure, administrative controls can be used to decrease worker exposure and, thus, worker ill health. Excessive biologic levels of mercury are not an indication of mercury poisoning. Although biologic results can be used as an indication of excessive absorption and, thus, the need for improved work practices, personal hygiene, engineering controls or personal protective measures, they should only be used with caution as a basis for administrative actions. If a medical examination discloses both evidence of absorption of mercury and abnormalities that might be related to this absorption, administrative action should be taken. The employee should be put into a low exposure area until the abnormality clears and evidence of excessive absorption had disappeared. If abnormalities persist, further medical evaluation is needed in looking for other etiologic reasons for the abnormalities.

## Effluent Controls

Mercury can present an environmental hazard through inappropriate discharges of process or wash water, venting of contaminated air or disposal of mercury contaminated solid wastes. Waste water contaminated with mercury can be adequately decontaminated prior to discharge with activated charcoal (Calgon). Other systems are available based on the sulfide deposition of mercury or by reverse osmosis. Mercury absorbing activated charcoal can also be used to treat vented air contaminated with high levels of mercury vapor. Work room air should be vented away from intake vents. In order to avoid disposing of mercury-contaminated solid wastes, such wastes should be sent to a facility equipped to recover mercury.



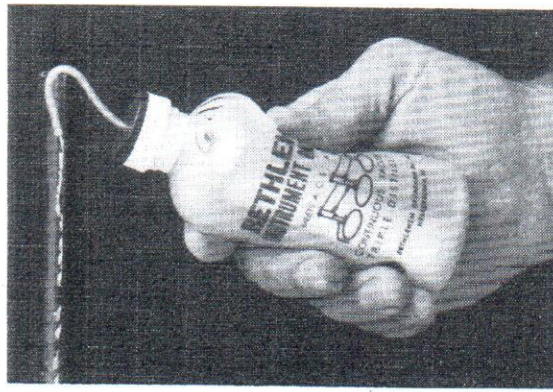
## Summary

Metallic mercury exposures, when excessive, can produce various neurologic, oropharyngeal and renal problems which can resolve spontaneously once exposure has stopped. With unusual exposures that are prolonged beyond the first clinical manifestation of mercurialism, chronic problems can develop. Under this situation, a number of the findings, including constriction of visual fields, a Parkinsonism-like syndrome and evidence of combined motor neuron disease can develop. However, these findings can be reversed by the use of appropriate therapy.

Often there can be personal contamination of a worker with exposure through the skin and airways that can not be detected by routine air measurements. For this reason, a biological and medical monitoring program is required to detect early manifestations of mercurialism and intervene at the time when only administrative controls are required to resolve the problems. There is a large variation in a worker's susceptibility such that biological levels of mercury by themselves should not be used as a basis for moving a worker to a low exposure situation. With adequate work practices, personal protection, housekeeping and engineering controls, chronic exposures can be kept to a minimum with most of the hazards to workers eliminated.

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