GUIDELINES TO PHYSICIANS IN CONDUCTING MERCURY MEDICAL SURVEILLANCE PROGRAMS

PAMPHLET 156

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1. INTRODUCTION

1.1 SCOPE

These guidelines are provided to physicians or other qualified health care providers to provide detailed information and guidance in the conducting of medical surveillance programs for employees potentially exposed to mercury.

These guidelines are meant to supplement Section 4 of Institute Pamphlet 125 - Guidelines - Medical Surveillance and Hygiene Monitoring Practices For Control of Worker Exposure In Mercury in the Chlor Alkali Industry. (Reference 7.22). Pamphlet 125 provides guidelines for medical surveillance and industrial hygiene practices for control of occupational exposure to mercury that are not addressed in this pamphlet.

1.2 RESPONSIBLE CARE

The Institute is a Chemical Manufacturers Association (CMA) Responsible Care® Partnership Association. In this capacity, the Institute is committed to: Fostering the adoption by its members of the Codes of Management Practices; facilitating their implementation; and encouraging members to join the Responsible Care ® initiative directly.

Chlorine Institute members who are not CMA members are encouraged to follow the elements of similar responsible care programs through other associations such as the National Association of Chemical Distributors' (NACD) Responsible Distribution Program or the Canadian Chemical Manufacturers Association's Responsible Care® Program.

1.3 DEFINITIONS

ACGIH	American Conference of Governmental Industrial Hygienists
Ceiling	The concentration that should not be exceeded during any part of the working exposure
CNS	Central nervous system
g	grams
Hg	Chemical symbol for mercury
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit (Regulations established by OSHA); the maximum concentration that a worker can be exposed to for a prescribed period of time (TWA; STEL; Ceiling)
STEL	Short Term Exposure Limit; the concentration to which a worker can be exposed continuously for a short period of time (typically 15 minutes)

TLV	Threshold Limit Value (guidelines developed by ACGIH); the maximum concentration that a worker can be exposed to for a prescribed period of time (TWA; STEL; Ceiling)
TWA	Time Weighted Average (based on 8 hour work day and a 40 hour work week)
U-Hg	Urinary mercury
Fg/g crt	Micrograms per gram of creatinine
Fg/L	Micrograms per liter
Fg/m^3	Micrograms per cubic meter

1.4 DISCLAIMER

The information in the pamphlet is drawn from sources believed to be reliable. The Institute and its members, jointly and severally, make no guarantee and assume no liability in connection with any of this information. Moreover, it should not be assumed that every acceptable procedure is included or that special circumstances may not warrant modified or additional procedures.

The user should be aware that changing technology or regulations may require a change in the recommendations herein. Appropriate steps should be taken to ensure that the information is current when used. These recommendations should not be confused with federal, state, provincial, municipal or insurance requirements, or with national safety codes.

1.5 APPROVAL

The Institute's Board Committee on Mercury Issues approved Edition 1 of this pamphlet on October 7, 1998.

1.6 REVISIONS

Suggestions for revision should be directed to the Secretary of the Institute.

1.7 REPRODUCTION

2. ABSORPTION, DISTRIBUTION, AND EXCRETION

2.1 ABSORPTION

Inhalation of mercury vapor is the most important route of uptake for elemental mercury. Approximately 80% of inhaled mercury is retained. Oxidation of elemental mercury (HgE) to divalent mercury (Hg^{++}) is a critical event. Divalent mercury is much less likely to cross cell membranes. The oxidation of elemental mercury to divalent ionic mercury takes place very quickly after absorption, but some elemental mercury remains dissolved in the blood long enough to be carried to and pass through the blood-brain barrier and the placenta. Because of the short transit time from the lung to the brain, the majority of the mercury vapor may arrive at the brain unoxidized.

Mercury that becomes oxidized after passing the blood-brain barrier may become "trapped" in the CNS, accounting for the very slow clearance of a fraction of the initial burden. Liquid metallic mercury is poorly absorbed by ingestion. Uptake via the skin of metallic mercury vapor is only 1% of uptake via inhalation. (References 7.3, 7.11, 7.14, 7.17, and 7.19)

2.2 DISTRIBUTION

Inhaled Hg vapor absorbed through the pulmonary epithelium into blood in part is oxidized to divalent mercury in the red blood cells and the remainder is transported to all tissues. The kidney is the chief depository of mercury after administration of elemental mercury vapor or inorganic salts. Significant amounts can be transported to the brain after exposure to elemental mercury vapor.

Although the kidney accumulates the highest concentrations after elemental mercury vapor exposure, the nervous system is the most sensitive target organ to this form of the element. (References 7.31, 7.32, and 7.33)

2.3 ELIMINATION

Urine and feces are the principal routes of elimination and the urinary route dominates when exposure is high. Determination of biological half-life of inorganic mercury in various body compartments, including kidneys and brain, is a very complex issue. The best estimate is that after short term exposure to elemental mercury vapor, there is a first rapid phase of elimination of the majority of the burden, with a half-life of the order of days, followed by a slower second phase with an average half-life elimination of one to two months. The half-life turnover in brain is expected to be even much longer. Inorganic mercury in the brain has been detected years after cessation of exposures in miners and dentists indicating a very long half-life for at least a small fraction of the initial burden. (Reference 7.12)

The level of mercury in blood is an indicator of recent (days) exposure to mercury. Urinary excretion of mercury is reflective of the gradual accumulation of mercury in the kidney over the preceding months. Although the kidney burden is presumably related to mercury concentrations in other tissues, these relationships are as yet undefined.

3. EXPOSURE

3.1 OCCUPATIONAL EXPOSURE

Long term exposure to mercury vapor is encountered in occupational settings and in cases where the metal has been inadvertently or inappropriately handled at home. Confounding sources of mercury can be traced, among other things, to dental amalgam restorations and dietary fish intake. Atmospheric levels of mercury in the workplace can be reduced by good housekeeping practices.

Attempts to establish predictive relationships between airborne, urinary and blood mercury are complex and subject to debate. (References 7.17, 7.20, 7.25, and 7.28) For a sense about the order of such relationships, some authors estimate that occupational exposures to about 40 Fg mercury/m^3 of air corresponds to urinary levels of about 50 Fg/g of mercury of creatinine and to blood levels of about 15-20 Fg mercury/L, on a group basis, and under constant exposure conditions. *(Reference 7.34)*. It must be emphasized however, as exposure variability and fluctuations are far from exceptional, that assuming a linear correlation among the different measurements under all circumstances can be grossly misleading.

In this pamphlet, except for the table in Section 5.2 and the discussion in Section 5.5, measurements of mercury in urine are reported in micrograms per gram of creatinine because most references discuss findings using this method. Reference 7.22, (Section 5) has an extensive discussion of measurements of mercury in urine via the various methods. The reader must make an adjustment in the interpretation of the values if a different reporting method is used.

Overexposure to mercury vapor gives rise to neurological effects with initially a fine high frequency intention tremor and neurobehavioral impairment. In occupational settings where chlorine is in contact with mercury, a part of the mercury vapor can be transformed in the atmosphere to mercury chloride and absorbed in this form. In most of today's chlor-alkali facilities, chlorine is well controlled and absorption in this form is usually not a problem. Proteinuria may be an effect of mercuric mercury absorption and be produced through the formation of mercuric-mercury-induced autoimmune glomerulonephritis in some susceptible, overexposed workers. (Reference 7.13)

Occupational exposure limits include:

- ACGIH 8-hour TLV-TWA level of 25 Fg/m^3
- OSHA 8-hour PEL-TWA of 100 Fg/m^3

In addition to the above the Chlorine Institute recommends the following limits:

- STEL of 150 Fg/m^3
- TWA of 50 Fg/m^3

Exposure to atmospheric mercury vapor in excess of 100 Fg/m^3 (8-hour TWA) and urinary mercury levels in excess of 150 Fg/g creatinine are associated with highly increasing risk of developing the classical neurologic signs of mercury intoxication and proteinuria.

Repeated incidents and episodes of peak over-exposure may determine chronic long term neurological effects. Subtle effects may be observed for intermediate level of exposure. **(**References 7.1, 7.2, 7.10, and 7.17).

3.2 NON OCCUPATIONAL EXPOSURE

The following are among the non-obvious "off the job" sources of mercury:

- **Inadvertent Contamination within Home**

  Inadvertent contamination of households (e.g carpets, furniture), with contaminated street clothes or work clothes and shoes. Contamination of households can also result from the misuse of mercury taken home from the job.

- **Fish diet**

  Fish is a dominant source of human exposure to organic mercury; this is a source of interference when testing mercury in blood unless inorganic and methyl mercury are analyzed separately since methyl mercury concentrates in red blood cells while inorganic mercury concentrates in plasma. Methyl mercury excretion in urine is very limited so its contribution to the overall body burden may be less apparent when considering only urinary excretion.

- **Dental fillings**

  Silver amalgam contains 50-60% of mercury. Mercury is released from amalgam restorations in the mouth as vapor. Ingestion is increased by chewing and is correlated with the number of dental fillings. After insertion or removal of multiple fillings, urinary mercury may increase over the next several weeks.

- **Skin lightening creams and soaps**

  Although they are no longer allowed in the United States, they may still be encountered. They have been applied overnight to give dark skin a lighter tone by pigment inhibition. Such soaps contain 3% mercuric iodide creams may contain 1-5% ammoniated mercury.

- **Therapeutic agents**

  Some therapeutic agents (e.g., nose drops preservatives, diuretics (obsolete), antiseptics, soft contact lenses solutions (e.g., thimerosal)), may contain mercury. There are still some uses for antiseptic mercury ointment in selected dermatological conditions.

- **Other Categories**

  Although some of these other uses may be restricted or prohibited within the United States or elsewhere, the use of mercury in these applications may still be encountered.

  - Medical instruments - e.g., thermometers, blood pressure sphygmomanometers
  - Paints - antifouling and mildew proofing additives
  - Pesticides - applied to seeds or bulbs to retard fungus growth
  - Hobbies - Photography, taxidermy
  - Gold searching
  - “Altenative medicine” (unregulatd “remedies”

4. HEALTH EFFECTS

4.1 BIOCHEMICAL INDICATORS OF EFFECT

No test is available that allows monitoring of the exposed individual in relation to early biochemical reversible alterations. Some early biochemical effects observed are of doubtful clinical significance and are appreciated only when entire groups of people are considered. Although of experimental interest, these molecular epidemiology markers are not apt to monitor individual effects (e.g., lysosomal acid hydrolyses = N-Acetyl aminoglucominidase, NAG). (References 7.4 and 7.9)

4.2 CLINICAL EFFECTS (References 7.5, 7.6, 7.16, 7.21, 7.22, 7.23, 7.24 and 7.27)

Pertinent effects of mercury exposure can be local or systemic, consequent to acute or chronic exposures.

4.2.1 Local Effects

4.2.1.1 *Irritant*

- Mercury salts can cause dermatitis.
- Mercury vapors are irritating to the respiratory tract
- Massive exposure due to an emergency condition such as a large spill or fire may lead within hours to bronchiolitis, chemical pneumonia, acute pulmonary edema and even renal tubular necrosis. Irreversible pulmonary sequelae are possible after acute manifestations.

4.2.1.2 *Allergic*

- Allergic contact dermatitis can ensue with exposure to metallic mercury and its salts

4.2.2 Systemic Effects

4.2.2.1*Acute* Metal fume fever

4.2.2.2*Subacute* (Hg in urine > 500 Fg/g creatinine; Hg in blood >200 Fg/l)

- Encephalopathy
- Renal tubular impairment

4.2.2.3*Chronic* (prolonged, repeated overexposure; repeated U-Hg serial readings above 75 Fg/g creatinine, or isolated but multiple cycles of U-Hg above 75 Fg/g creatinine; frequency and gravity of symptoms increasing with repeated peaks of above 100 Fg/g creatinine)

- Encephalopathy
- Cerebellar Syndrome
  Intentional tremor
  Ataxia, dysarthria
- Tremor
- Peripheral neuropathy
  Sensory-motor nerve disturbances
  Guillan Barré syndrome
- Oral cavity
  Gingivitis, stomatitis, sialorrhea, gingival pain
  Ulceration of lips and oral mucosa
  Mercurial line along the gingival margins
  Metallic taste, tooth loss
- Nephropathy
  Nephrotic symptoms
  Autoimmune glomerulonephritis

During chronic exposure to elemental and inorganic Hg by inhalation, the critical organ is the central nervous system. Symptoms such as anorexia, weight loss, tremors, and insomnia are well correlated with different degrees of exposure. The kidney becomes the critical organ following ingestion or skin absorption of inorganic mercury salts with possible development of proteinuria and an autoimmune nephrotic syndrome.

4.2.3 Tremor

Tremor is the most evident clinical sign and is a constant observation in all cases of mercury intoxication. It is both static and intentional, and is greatly enhanced by emotional stimuli. Initially it is imperceptible, but it becomes progressively evident, with complex

movements such as writing, buttoning and unbuttoning a shirt and threading a needle. Initially, it is observed at the corners of the mouth. At rest it can be observed involving the eyelids and when the arms/hands are extended. It is aggravated by stress, fatigue, and chronic alcohol consumption (ethilism). Should exposure and absorption continue, tremor will become coarse, with tonic-clonic spasms, at times so violent as to drive the patient off the bed during sleep. (References 7.15, 7.18, 7.26, 7.29, and 7.30)

Asynergies, diadochokinesis, and nystagmus (cerebellar symptoms) will then appear. In most protracted and severe cases of intoxication, neurological symptoms may mimic Parkinson's-like rigidity and involuntary myoclonic and choreic movements.

Measures of neuropsychological function that assess cognitive, visual and motor skills such as the 'Grooved pegboard test' have been reported to be informative in experimental settings. Grooved pegboard is a visuomotor task that also requires manual dexterity. Although this is not a direct measure of tremor, the score to completion of the task is slowed by the presence of a tremor.

4.2.4 PSYCHOLOGICAL CHANGES (References 7.15, 7.29, 7.30)

The most characteristic symptoms of mercury toxicity are the psychological alterations known as "erethism", featuring mood changes, a switch from extroversion to neuroticism and shyness, depression, irritability, emotional instability, anxiety, insomnia, and hypochondriac concerns. "Erethism" is described more as an idiosyncratic reaction to mercury exposure rather than a dose related symptom complex. Memory and concentration deficit will ensue only at a later time, should exposure and absorption continue. Numerous studies have been conducted in an attempt to correlate urine mercury levels with neuropsychological effects and findings have been inconsistent as to the ability to discern individual discrete cases.

Performance of mechanical and visual memory tests, psychometric ability and personality are well correlated with the number of times/year, over the last 10 yrs, in which U-Hg exceeded 75 Fg/g crt. (Reference 7.10). Repeated peaks of overexposure and cycles of high urinary excretion should therefore be properly considered.

4.3 REPRODUCTIVE HEALTH CONCERNS

Organic mercury and, to some degree, elemental mercury readily pass the placental barrier and are recoverable in maternal milk. It remains an open question whether mercury vapor can adversely affect fetal development in absence of frank signs of mercury intoxication. In occupational settings where chlorine is used, part of the mercury vapor can in theory be transformed in the atmosphere and absorbed as an aerosol of divalent mercury which can be deposited in the placenta where, in theory, it may cause damage that may lead to adverse effects to the fetus.

To prevent adverse pre-and post-natal development effects, appropriate counseling as per currently accepted hazard communication programs should be provided to the pregnant and/or breast-feeding worker concerning mercury health and exposure issues.

5. MEDICAL SURVEILLANCE PROGRAM

A Medical Surveillance Program should be established for employees, including contract employees, who have the potential for exposure to inorganic mercury as determined by air sampling or biological monitoring. Sections 4 and 5 of reference 7.22 provide additional information.

Participation should be on the basis of job classification or an appropriate alternate method. The medical examinations should:

(1) be performed by a physician experienced in addressing occupational medicine and mercury related issues.

(2) include pre-placement, annual periodic, and exit-from-program exams for all participants.

(3) include employees who may have been exposed to relatively large quantities of mercury during an emergency such as a massive spill or fire.

5.1 MEDICAL EXAMINATIONS

The medical surveillance program is meant to detect adverse effects of exposure as early as possible, at a stage where they are still reversible, so that exposures can be controlled and serious permanent adverse effects prevented. The physical examination program should be integrated with industrial hygiene and biological monitoring information.

The examining physician should consider a description of the affected employee's duties; the employee's representative airborne and biological exposure levels; and, respiratory and other required protective equipment to be used.

The physical examination should include work and personal history updates and verification of pertinent symptomatology and clinical end points. These include, acute (severe respiratory irritation with chest pain and dyspnea) and chronic conditions (stomatitis, excessive salivation and digestive disorders; headaches, insomnia, irritability, mood swings and timidity; tremors of eyelids, lips, tongue, fingers and extremities; fatigue, muscle weakness and weight loss.)

Ancillary tests include routine urinary mercury determination, and /or blood mercury determination in selected circumstances. Quantitative analysis of (urogram) urinary protein may be desirable in specific cases. (e.g. positive urine dipstick test result). Other general tests such as pulmonary function and routine blood chemistry panels are to be administered as per examining physician`s judgment. The medical surveillance program is also an opportunity for one to one counseling and health education on pertinent mercury related hygiene matters.

5.1.1 Pre-placement

The physical exam is aimed at ascertaining possible alterations of organs and systems particularly susceptible to the action of mercury (CNS, oral cavity, kidneys, skin, respiratory system). Within a basic history and physical examination protocol (including pertinent ancillary tests), particular interest should be paid to the neurologic exam, testing visual-motor coordination and the microscopic examination of urine sediment.

The initial medical and occupational history will then include inquiry for previous exposure to mercury (both occupational and non-occupational), personal habits, and history of present or past oral, gastrointestinal, respiratory, skin, renal, central nervous system and psychiatric disorders. Any current pre-exposure health problems which may be exacerbated by inorganic mercury or potentially attributed to inorganic mercury exposure once the worker has been employed, should be identified.

5.1.2 Periodic

The frequency of the periodic examinations are left to the discretion of the physician in consultation with the employer. The Chlorine Institute suggests a follow-up exam after six months from hire or placement be considered. Thereafter an annual frequency should be considered. Medical surveillance frequency may be changed at the physician's discretion in individual cases, or if employees develop signs and symptoms or if warranted by an unusual event.

5.1.3 Post Emergency Situation

In the event of the potential for a significant exposure due to an emergency condition (e.g. major spill or fire), the potentially exposed person(s) should be examined by a physician knowledgeable about the acute effects of exposure to mercury. Selective analysis of mercury in blood to determine whether exposure occurred and the severity of such exposure should be considered.

5.1.4 Exit From Program

When an employee is removed from work exposure to mercury, an exit physical should be provided, whenever possible, to ascertain that no adverse health effects have developed potentially related to inorganic mercury. If biological monitoring studies show elevated urine mercury levels, additional urine mercury samples may be obtained on a periodic basis until they have fallen within an acceptable range.

5.2 BIOLOGICAL MONITORING - MERCURY IN URINE

Biological monitoring is an integral part of the medical review and surveillance program. Biological monitoring of the urine is a readily available, noninvasive method for monitoring subchronic and chronic exposure to Hg. Notwithstanding some limitations, urinary mercury excretion, U-Hg, is still the best exposure test available.

Biological monitoring will complement, but will not substitute for industrial hygiene exposure assessment and will follow the schedule indicated in the recommended testing protocol for urine mercury as discussed in Section 5.5 of Reference 7.22. Urinary mercury excretion is usually adjusted for urine dilution by using either specific gravity, or creatinine concentration, as a weighting factor. See Section 5.5.1 of Reference 7.22 for further information.

U-Hg excretion is troubled by a remarkable and yet not well understood interindividual variability (for same exposure circumstances) and intra individual variability (both during the same day and from day to day in the week) even when exposure conditions are considered constant. (References—7.35, 7.36, and 7.37). Part of this variability can be reduced by standardizing sample collection and (e.g., collect samples at the same time of day, and at the beginning of the work week).

Urine samples should be analyzed by a laboratory which is proficient in mercury analysis subject to quality control procedures. La Centre de toxicologie due Quebec, in a letter dated June 25, 1997, advises of interference with the detection of mercury when using routine test materials in individuals that have abnormally high levels of iodine.

High levels of iodine may be due to medications such as radiopaque dye used for medical diagnostics and typically administered by hospitals. Some over the counter medication that contain iodine include the following:

- Antifungal/anti-bacteria agents
  Betadine, Tincture of iodine, Lugol's solution, Iodochlorhydroxyquin cream, and Vytone cream

- Expectorants
  Pima syrup, Iophen-C; Iophen-DM, Pediacof Syrup, Tusson-DM

- Combat intestinal parasites
  Yodoxin (iodoquinol)

The Institute recommends that at least 48 hours be allowed between the last use of any iodine containing pharmaceutical and the collection of a urine sample to allow for the iodine to be cleansed from the body.

The following points should be considered when reviewing biological monitoring results:

(1) Average group levels are more indicative of environmental exposure than individual levels.

(2) Hygiene and medical interventions should never be based solely upon a single elevated urine mercury level. Appropriate action is justified when this finding is consistent with prior or subsequent results.

(3) Assign importance to the micro environment (contamination of hands and clothing) and to meticulous personal hygiene. The statements below are taken from Sections 5.2 and 5.3 of Reference 7.22.

Proper Work Practices

The concentration of vapor within the breathing zone of a person whose clothing, hair, or skin is contaminated with small quantities of elemental mercury may be significantly elevated above ambient background concentration in the general work environment. In addition, shoes and/or clothing contaminated with mercury transported into clean areas including those away from work may result in additional exposure to the employee or possibly family members. As a result, contaminated materials, whatever they may be, should be isolated and kept at the workplace.

Food, cigarettes and other tobacco products can absorb mercury from the air. To prevent these items from being sources of mercury exposure, they should be prohibited from areas where mercury may be present.

Personal Hygiene

Skin, hair and clothing contaminated with mercury can be significant sources of exposure to vapor. Therefore, high standards of individual cleanliness and personal hygiene should be prescribed and maintained.

Hands should be washed thoroughly and, if necessary, scrubbed with a soft brush before eating or smoking. Fingernails should be kept clean as mercury under the nails can be a source of exposure when hands are brought near the nose and/or mouth. Employees who have a potential for exposure to mercury should shower and shampoo at the end of the work shift.

Measuring mercury concentration near clothing, hands and hair of new employees before and after showering is useful in training new employees in the development of good personal hygiene habit.

(4) Urine samples with a specific gravity outside the 1.010-1.030 range or a urinary creatinine outside the 0.5-3.0 g/L range are not normally considered valid samples. In dilute urine samples, creatinine will result in an under reporting of the mercury level.

(5) Increasing U-Hg trends above 50 ug/g creatinine, confirmed U-Hg serial readings above 75 ug/g creatinine, or multiple cycles of isolated U-Hg readings over 75 ug/g creatinine are indicators that medical review along with industrial hygiene investigation are appropriate.

(6) U-Hg excretion is an indirect indicator of internal dose, which correlates to a certain extent to increasing frequency and gravity of symptoms and increasing surveillance attention, investigation and action.

For practical purposes, five different levels can be identified:

1. No intervention

2. Surveillance

3, 4 and 5. Action at increasing levels of importance

Biological Monitoring for Hg	Correlating Clinical Effects	Preventive Actions
1st Level: U-Hg<35 Fg/g-crt or 50 Fg/L	No clinical or sub-clinical effects are expected to occur.	No intervention necessary.
2nd Level: U-Hg 35-75 Fg/g-crt or 50-100 Fg/L	Some subclinical minimal effects may be observed when comparing groups of people (e,g. urinary enzymes). (Reference 7.9)	A formal medical surveillance program is instituted for homogeneous exposure groups or job classes.
3rd Level: U-Hg >75-100 Fg/g-crt or 100-130 Fg/L	Slight alterations of some clinical tests may be elicited in selected individuals. Some increased risk of subclinical and neuropsychiatric effects but no signs of overt toxicity.	Medical surveillance frequency may be increased for selected individuals; risk assessment and control reviewed.
4th Level: U-Hg >100 Fg/g-crt or 130 Fg/L	Increased probability of symptoms and signs of toxicity; initially subclinical and reversible effects.	Temporary removal considered; referral for further diagnostic workup/therapy; risk assessment and control/corrective action verification.
5th level: U-Hg > 150 Fg/g-crt or 200 Fg/L	Reversible effects may progress to impairment in the absence of action.	Temporary removal mandatory.

5.3 MERCURY IN BLOOD

Although biological monitoring of the urine is a readily available, noninvasive method for monitoring the subacute, subchronic and chronic exposure to Hg, the level of Hg in blood is a better indicator of recent (days) Hg exposure.

As a result, selective blood analyses may be useful in particular circumstances to assess whether acute exposures are biologically significant or whether apparent signs of neurotoxicity are related to mercury over exposure or to confirm if workers have been exposed to an occasional peak of Hg vapor. Otherwise, blood concentrations decay too rapidly to be used for estimation of cumulative exposure.

References 7.25 and 7.28 discuss the relationship between mercury in blood and mercury in urine. It is suggested that urinary mercury level of 50 Fg/g crt is associated with a mercury in blood level of 16-20 Fg/l.

The following should be kept in mind with regard to blood sampling:

1.) Mercury speciation (total mercury vs. inorganic mercury) is important in blood sampling and of negligible importance in urine sampling. Interference from dietary methyl-mercury exposure can make it difficult to evaluate exposure to low concentrations of inorganic mercury by means of blood analysis.

The problem of confounding exposures is not so important when analyzing urine, as only a very small fraction of absorbed methylmercury is excreted in urine. To overcome the problem, it would be necessary to analyze mercury in plasma or analyze both inorganic mercury and methyl-mercury. The problem of mercury speciation is much smaller when analyzing urine, as methylmercury is excreted in urine to only a very limited extent.

2.) Choice of anticoagulant is critical to avoid contamination by mercury compounds used as preservatives.

3.) Significant hemolysis should be controlled for if mercury levels in plasma and red blood cells are to be differentiated.

5.4. WRITTEN OPINION

The physical examination is concluded by a physician's written opinion as to:

a) The ability of the affected employee to perform the work with the appropriate personal protective equipment including respiratory protection. Any limitations in the ability of the employee to perform the work or use any necessary personal protective equipment should be discussed.

b) Whether the employee has any medical condition that would place him/her at risk of health impairment from exposure to Hg.

c) If the routine medical surveillance and non-routine medical review (first screening level) reveal objective signs compatible with Hg absorption, referral to an appropriate specialist may be considered for verification (second level). More complex diagnostic procedures or referrals to third level specialists such as a specialist in Occupational Neurology may be required for more complex cases.

5.5 TEMPORARY REMOVAL

To a certain extent, there is a great inter-individual and intra-individual variability in urinary Hg excretion which is not a mathematical predictor of appearance of clinical effects. Temporary removal from the job is not, therefore, a bureaucratic-mechanical decision; it may be considered in the proper context of safety, hygiene and medical considerations. No temporary removal should take place without medical review, but not all medical reviews necessarily coincide with temporary removal. It should be pointed out that U-Hg is a better

group vs. individual predictor of exposure. On an individual basis, other determinants must be considered such as individual susceptibility, differential diagnosis of symptoms and signs.

Medical review is prompted by:

- New employee with consecutive urine mercury levels >= 50 Fg/g-crt (70 Fg/L)
- Isolated, reconfirmed peaks of U-Hg >100 Fg/g- crt (130 Fg/L)
- Repeated serial readings or repeated peak-cycles of elevated U-Hg excretion (e.g. above 75 Fg/g- crt) [100 Fg/L] in employees employed more than one year.
- Development of pertinent signs and symptoms of absorption

Temporary removal is prompted by:

- Development of adverse health effects consistent with overexposure to mercury in any of the above circumstances

After removal, there are two phases of urinary excretion of mercury: The first phase averages two days and accounts for 20-30% of excretion. The second phase has a half-life of 70 days. Within one year of initial exposure, the urinary mercury values are more indicative of the metal accumulated in the kidney rather than of workplace exposure levels. This explains why in intermittent exposures high urinary excretions can occur during a period of non exposure.

It should be pointed out that U-Hg cannot be used to assess the internal dose in the critical organ (brain), because the average life of Hg deposited there is much longer than any other organ. (Brain uptake of Hg is very slow, but the half life of brain Hg clearance is about one year.)

6. CONTRACTORS

Contract employees should be subject to the same medical surveillance criteria that are applied to the company's employees.

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8. APPENDIX

CHECKLIST

This checklist is designed to emphasize major topics for someone who has already read and understood the pamphlet. Taking recommendations from this list without understanding related topics can lead to inappropriate solutions. Place a check mark (**/**) in the appropriate box below.

Yes	No	N/A		
9	**9**	**9**	1.	Does the facility have a medical surveillance program for employees and contractors potentially exposed to mercury (5)?