INDUSTRIAL HYGIENE LABORATORY TESTS AS AN ADJUNCT TO MEDICAL CONTROL OF OCCUPATIONAL DISEASES*

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INTRODUCTION

This outline was prepared for lecture notes to medical students who would mainly be in general practice.

If properly used, both air and urine tests provide essentially the same information—the severity of exposure to the poison in question. Industrial hygienists and physicians alike have been slow to make use of many advantages offered by chemical urine analysis.

These advantages are: Under normal conditions, they picture accurately employees' exposure to many toxic substances as well as does atmospheric analysis; they represent total absorption from all sources (inhalation, ingestion and skin absorption); the effects of solubility in body fluids is gauged by urinary excretion of many elements; and exposure in many cases can be evaluated after it has ceased by delayed urinary excretion of toxic substance. Last, but not least, only the absorption of a chemical element can cause an increase in excretion of that same element in body fluids.

The chief disadvantages are: Toxic substances may cause injury in passing through the body in chemically detectable amounts; excreted poison is only approximately proportioned to excreted concentrations and often there is a delayed response in increased excretion with start of absorption or exposure because chemicals may be partly stored in the body to some extent. The variation in urinary concentration caused by varying fluid intake can be reduced by adjusting the specific gravity to a medium value. Many industrial chemicals have not been studied relative to ratio of excreted amounts and atmospheric exposure. All such data should be published to expand the industrial hygienist's ability to use this valuable tool in exposure evaluation.

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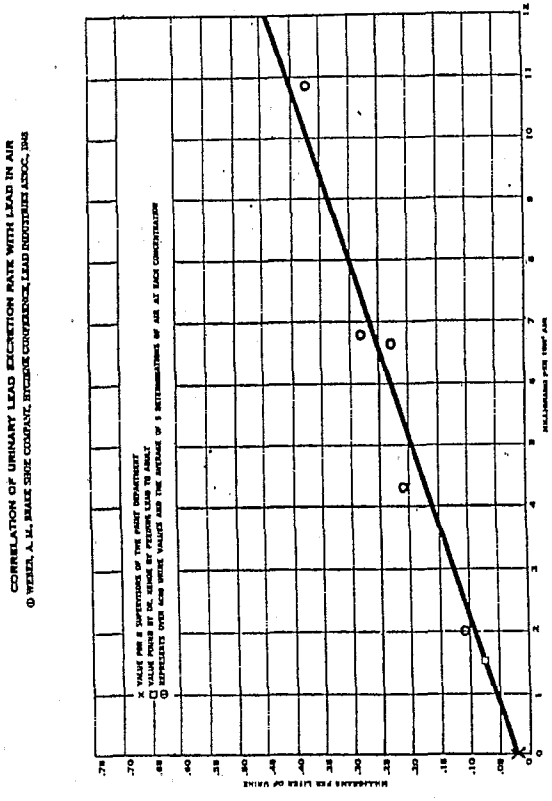
**Industrial Hygienist—Humble Oil & Refining Co.



LABORATORY TESTS

This discussion is based on the assumption that the physician sees the patient after the exposure to the industrial environment and there is no prior information of value: on the patient, the materials to which he was actually exposed, the concentrations of atmospheric contaminants, and amount of skin contact he had in carrying out his normal work.

We want to discuss briefly the laboratory tests that can be made on specimens to help to differentiate occupational diseases from those diseases that may be due to non-occupational agents or factors. It must be kept in mind that to cover such a broad subject in the short period available that the interpretation must be limited to reaction of normal healthy workers.

1. *Material:* Inorganic inert dust; silica, asbestos, etc.

   Tests: There is no known specific chemical or physical laboratory test for pneumoconiosis diagnosis. The most characteristic physical and chemical properties of these dusts are their inertness; therefore, there are insignificant products excreted that have been identified as those associated with exposure, with the exception of asbestos bodies.

2. *Material:* Lead compounds.

   Tests: Urinalysis is specific.
   Blood analysis is specific.
   Porphyrin is helpful but not specific.
   Stippled cell count is helpful but not specific.

   Method: Dithizone colorimetric.
   Normal range: 0.00-0.08 mgm. lead per liter of urine.
   0.00-0.07 mgm. lead per 100 cc. of blood.
   Significant range: 0.08-0.15 mgm. lead per liter of urine.
   0.07-0.12 mgm. lead per 100 cc. of blood.
   Dangerous range: >0.17 mgm. lead per liter of urine.
   >0.12 mgm. lead per 100 cc. of blood.

   Remarks: Look at the attached chart for correlation between urinary values for lead and atmospheric value as found by a large industrial company's medical division. If patient has serious kidney impairment, results are not accurate. Interpretation of urinary values in light of specific gravity is helpful.

3. *Material:* Mercury and its compounds.

   Tests: Urinalysis is specific.
   Blood analysis is specific.

   Method: Dithizone and electroprecipitation.
   Normal range: 0.00-0.10 mgm. per liter of urine.
   Significant range: 0.10-0.2 mgm. per liter of urine.
   Dangerous range: >0.25 mgm. per liter of urine.

   Remarks: Mercury is more readily excreted than lead. The ratio of excreted mercury to absorbed mercury is higher than in the case of lead.

4. *Material:* Cadmium.

   Tests: Urinalysis is specific.

   Method: Dithizone.
   Normal range: 0.00-0.05 mgm. per liter of urine.
   Significant range: 0.05-0.07 mgm. per liter of urine.
   Dangerous range: >0.07 mgm. per liter of urine.

   Remarks: The industrial usage of cadmium has been limited; therefore, there is not much data on correlation of cadmium in the environment to urinary values.

5. *Material:* Nickel—only nickel carbonyl.

   Tests: Urinalysis is specific.
   Analysis of hair is specific.

   Method: Colorimetrically with potassium dithioxalate.
   Normal range: 0.00 mgm. nickel per liter of urine.
   Significant and dangerous range: Any detectable amount of nickel in urine.

6. *Material:* Solid arsenic compounds.

   Tests: Urinalysis is specific.
   Analyses of hair and fingernails are specific.

   Method: Gutzeit.
   Normal range: 0.00-0.02 mgm. per liter of urine.
   Significant range: 0.03-0.04 mgm. per liter of urine.

Dangerous range: >0.05 mgm. per liter of urine.

Remarks: Arsenic may be found in the hair for several months after exposure has ceased.

7. *Material:* Arsine.

Tests: Urinalysis is specific.
Analyses of hair and fingernails are specific.

Method: Gutzeit.
Normal, significant and dangerous ranges: Any detectable arsenic in urine, hair, and fingernails following exposure to arsine signifies danger.

8. *Material:* Manganese.

Tests: Urinalysis is specific but only positive while exposure is continuing.
Blood analysis is specific and shows manganese longer than urine does after exposure ceases.

Method: Colorimetric by strong oxidizing agent.
Normal range: 0.00-0.01 mgm. per liter of urine.
Significant and dangerous range: >0.010 mgm. per liter of urine.
In blood normal range: 0.012-0.015 mgm. per 100 ml.

9. *Material:* Copper.

Tests: Urinalysis is specific.

Method: Colorimetric with ammonium hydroxide.
Normal range: 0.00-0.034 mgm. per liter of urine.
Significant range: 0.04 to 0.1 mgm. per liter of urine.
Dangerous range: >0.1 mgm. per liter of urine.

10. *Material:* Chromium.

Tests: Urinalysis is specific.

Method: Colorimetric with hemotoxylin or 5-diphenylcarbazide.
Normal range: nil.
Significant range: Any detectable amount in urine.

11. *Material:* Radioactive compounds: radium, uranium, thorium, etc.

Tests: Urinalysis is specific.
Exhales active gas: radon, thoron, etc.

Method: Geiger counter.
Normal range: nil.
Significant and dangerous range: Amount indicating daily exposure of 10^{-9} curies per cubic meter of air.

Remarks: Uranium of itself is one of the most toxic elements.

12. *Material:* Fluorides.

Tests: Urinalysis is specific.

Method: Thorium nitrate titration.
Normal range: 0.00-3.00 mgm. per liter of urine.
Significant range: >3.0 mgm. per liter of urine.
Dangerous range: >5.0 mgm. per liter of urine.

13. *Material:* Carbon monoxide.

Tests: Blood analysis for carbon monoxide—hemoglobin is positive and specific.

Method: Pyrotannic acid and reagent of sodium hyposulfite, saponine with sodium oxalate.
Normal range: 0-10 per cent in smokers.
Significant range: >20 per cent carbon monoxide hemoglobin.
Dangerous range: >35 per cent carbon monoxide hemoglobin.

14. *Material:* Benzol.

Tests: Urinalysis for inorganic/organic sulfates is specific within four hours after exposure ceases.

Method: Barium sulfate precipitation.
Normal range: 85-95 per cent urinary sulfate as inorganic form.
Significant range: >85 per cent urinary sulfate as inorganic form.
Dangerous range: >70 per cent urinary sulfate as inorganic form.

Remarks: Specimen should be collected at end of work period within four hours after exposure has ceased.

15. *Material:* Trichlorethylene.

Tests: Urinalysis for trichloracetic acid.

Method: Reaction of Fryiwara.
Normal range: 0.0-5.0 mgm. per liter of urine.
Significant range: 5.0-50 mgm. per liter of urine.
Dangerous range: >50 mgm. per liter of urine.

Remarks: All hydrocarbon of aliphatic series having three chlorine atoms on a carbon atom metabolizes to give trichloracetic acid. It is excreted at maximum of 2-3 days after exposure and up to 14 days in detectable amounts.

16. *Material:* Carbon disulfide.

Tests: Urinalysis and analysis of exhaled air are specific for 24 hours after last exposure.

Method: Cupric acetate in ethanol.
Normal range: nil.
Significant and dangerous range: Any amount.

17. *Material:* Phenols, aniline, xylidine, and organic nitrates.

Tests: Urinalysis is specific for unchanged compounds.

Method: Appropriate for specific compounds in small amounts.
Normal range: nil.
Significant and dangerous range: Any detectable quantity.

18. *Materials:* Toluene and/or Styrene.

Tests: Urinalysis for hippuric acid, but it is not specific. Blood analysis is specific for these solvents if collected within 24 hours after last exposure.

Method: Ether extraction and nitrogen determination.
Normal range: 0.5-0.9 grs. per liter of urine.

Remarks: Urinary hippuric acid correlates well with atmospheric exposure.

19. *Material:* Organic amine.

Tests: Blood examination for Heinz Bodies.

Method: Stain and microscopic examination.

20. *Material:* Naphthalene.

Tests: Urinalysis for naphthol glucuronate.

21. *Materials:* Organic insecticides.

Tests: Urinalysis for organic chloride.

Method: Ether extraction and combustion.
Normal range: nil.
Significant range: any detectable amount.
Dangerous range: >10 p.p.m.

Remarks: Any detectable increase or unusual amount of organic chlorides should be investigated.