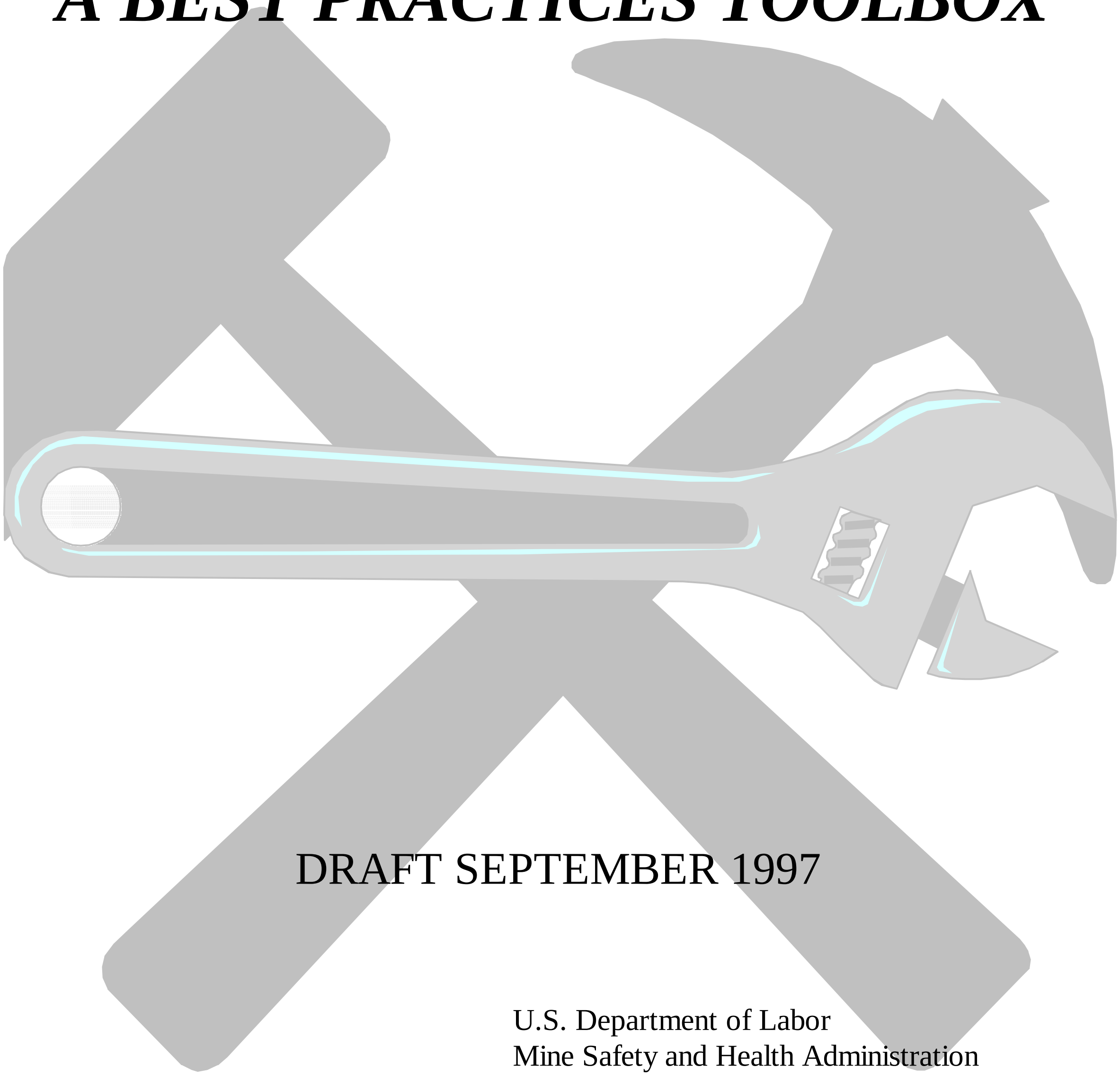
CONTROLLING MERCURY HAZARDS IN GOLD MINING: A BEST PRACTICES TOOLBOX



DRAFT SEPTEMBER 1997

U.S. Department of Labor
Mine Safety and Health Administration

BEST PRACTICES:

EMPLOYEE HYGIENE FACILITY

I. Introduction

Clothing worn by employees who work with or near mercury-contaminated equipment and work surfaces can become contaminated with mercury. This potentially contaminated clothing should never be worn home for laundering or stored in the same lockers used to hold employees' street clothes. MSHA has identified situations in which employees' personal motor vehicles and their homes have been contaminated with mercury because good industrial hygiene practices were not followed. The purpose of the employee hygiene facility is to limit employees' exposures to mercury and to prevent mercury from being transported from the employee's work environment to their autos, homes and personal belongings. This is accomplished by providing a place to shower and by isolating street clothes from sources of mercury such as contaminated work clothes and tools.

II. Building Materials

Building materials that have a porous surface can, over time, become contaminated with mercury vapor. These contaminated surfaces will be a secondary exposure source if they are not properly cleaned or treated. Since most construction products are porous, it is best to select a material that provides a smooth finished surface that can be easily sealed and cleaned. The following considerations should be given when selecting building materials for the portions of the cyanidation plant containing mercury:

C Wood, carpeting, wallboard or any other material which are not suitable for making a continuous crack-free, non-absorptive surface should not be used in the construction of any structure that will be exposed to elemental mercury.

C Walls should be constructed of either cinder block or concrete and sealed with an epoxy paint.

C The floor should be concrete and treated with a non-slip epoxy paint. Cracks between floor sections should be filled with an epoxy compound containing a fine aggregate. The epoxy compound should have enough elasticity so that cracks will not form due to movement of the concrete slab.

C The same epoxy compound can be used as a coping against the walls of the building. This will create a 1-inch lip where the floor meets the walls, thereby minimizing seepage of mercury between these two surfaces.

III. Location and Interior Layout

mercury vapor or to determine contamination of an area or objects.

Area airborne monitoring can be done using the same sampling techniques described above for personal exposure monitoring. In addition, there are two types of hand-held instruments that can be used to obtain instantaneous airborne concentrations of metallic mercury vapor. Bacharach Instrument Company* makes a mercury vapor analyzer that is based on ultra-violet (UV) absorption principle. It has a sensitivity of 0.01 mg/m^3 and is accurate within +/- 5 percent. Since the mercury vapor detector depends on the absorption of UV radiation by the sample, it will be affected to some extent by any substances that have a greater absorption of UV light than does normal air. Commonly encountered substances are vapors of various hydrocarbons, water vapor, sulfur compounds, and particulate, such as smoke. The advantage of the UV instrument is that it can be used continuously in relatively high concentrations of mercury vapor (less than 1.0 mg/m^3) whereas the gold film instrument requires periodic regeneration of the gold film. The disadvantages of the UV instrument are that the instrument must be zeroed between samples and its sensitivity. Arizona Instruments Inc.* makes a gold film mercury vapor monitor that is based on mercury's ability to alter the resistance of a gold film. The instrument's sensitivity is 0.003 mg/m^3 and the accuracy is +/- 5 percent at 0.100 mg/m^3. Ammonia and acid gases are the principle chemicals that interfere with the operation of the instrument. The instrument is also temperature sensitive. The advantage of the gold film instrument is its sensitivity and its ability to automatically zero itself between each sample.

III. Surface Sampling

Wipe samples are used to determine the effectiveness of equipment decontamination procedures and clean-up protocols used for the hygiene facility and lunch room. This type of sampling involves swiping a 100cm^2 area with moist filter paper. The wipe sample is placed in a vial and submitted to a laboratory for analysis. The results are presented in either micrograms or milligrams of mercury. These results should be used only to determine the presence or absence of mercury. Also, there are commercially available surface test kits for evaluating surface contamination. They can be used as indicators of the presence or absence of mercury on various surfaces. Scrape samples can be used to determine the presence of mercury on equipment and other surfaces, such as concrete and paint. These samples can be analyzed in-house using the following procedure:

- Place approximately three grams of sample inside a funnel flask,
- Seal the flask and connect it to a mercury vapor analyzer,
- Heat the flask to approximately 140^{o}F, and
- Determine the presence or absence of mercury vapor by sampling with the mercury vapor analyzer.

* ***No specific brand-name product is required to be used under Mine Safety and Health Administration (MSHA) regulations. MSHA provides product information solely as a service to the general public. Reference to any specific product by trade name, trademark, manufacturer, or otherwise in this report does not constitute or imply its endorsement, recommendation, or favoring by MSHA.***

BIOLOGICAL MONITORING[48]

I. Biological Monitoring

Biological monitoring assesses the internal exposure of an individual.[49] That is, it measures the amount of an agent actually absorbed into the body. For elemental mercury, the assessment is made by measuring the amount of this constituent in the blood or urine. Measurement of mercury in urine is the recommended biological monitor for workers exposed to metallic mercury in lieu of mercury in blood. The reason is that the latter reflects exposure to organic mercury as well as metallic and inorganic mercury. Thus, blood tests can be influenced by the consumption of fish containing methyl mercury. This is not the case for urine tests. Persons without occupational or unusual environmental exposure to mercury rarely excrete more than 5μg/g creatinine in their urine.[50]

There are a number of variables that must be considered in the collection and interpretation of the sampling results. For example, excretion of mercury from the body fluctuates considerably, independent of exposure; therefore, individual findings cannot be used to determine the intensity of exposure or the presence or absence of mercury toxicity. The program should be under the direct supervision of a medical doctor who is familiar with the toxicity of elemental mercury. Together, the company and physician should establish criteria on which corrective action will be taken based on an individual’s biological monitoring history.

The ACGIH recommends that the level of mercury in the urine not exceed 35μg adjusted for creatinine.[51] Accordingly, any employee who was found to have exceeded this level (35 μg hg/Cr) should be removed from the source of mercury contamination until levels return below that level. The purpose of the biological monitoring program should be explained to all the affected employees. The employees should receive their monitoring results as soon as practical. The results should be explained to them so the employees have a complete understanding of what they mean as it relates to their health and well-being.

II. Medical Surveillance

Medical Surveillance measures the end health effect of an exposure to a toxic substance and offers early detection of a problem. Employees who will be working with mercury should be given an initial medical examination that can be used as a baseline for future health evaluations. The examination should consist of a complete medical history and symptom questionnaire, with emphasis on:

- The nervous system.
- The kidneys.
- The oral cavity.
- The lungs.
- The eyes.
- The skin.

ENDNOTES

1. Hamilton, A. Industrial Poisons of the United States. The Macmillan Company, New York, 1925.

2. American Conference of Governmental Industrial Hygienists (ACGIH). Documentation of Threshold Limit Values. Cincinnati, Ohio. 1996.

3. National Institute for Occupational Safety and Health. A Recommended Standard for Occupational Exposure to Mercury. DHEW (NIOSH). Publication No. 73-11024. 1973.

4. National Institute for Occupational Safety and Health. Report to Congress on Workers' Home Contamination Study Conducted Under the National Institute for Occupational Safety and Health. (NIOSH). Publication No. 95-123. September, 1995.

5. Ibid.

6. 30 CFR §§ 56/57.5001.

7. See Appendix A for a list of Technical Support Reports.

8. The Gold Institute. World Gold Mine Production 1995-1999. Washington, DC. August, 1996.

9. U.S. Geological Survey. Mineral Commodity Surveys 1997. Gold. February 1997, Reston, VA.

10. The Gold Institute, op. cit.

11. U.S. Geological Survey, op. cit.

12. U.S. Geological Survey. Mineral Industry Surveys. Annual Review (Gold) 1995. February 1997, Reston, VA.

13. Throughout this document, the term "gold mines" is meant to include silver mines which also produce gold.

14. U.S. Geological Survey. Annual Review (Gold). op. cit.

15. U.S. Geological Survey. Mineral Industry Surveys. Precious Metals in April 1997. June 2, 1997, Reston, VA.

16. U.S. Geological Survey. Annual Review (Gold). op.cit..

17. U.S. Geological Survey. Precious Metals in April 1997. op. cit.

Graphic Image Number 1:
General Cyanidation Process Flow Sheet

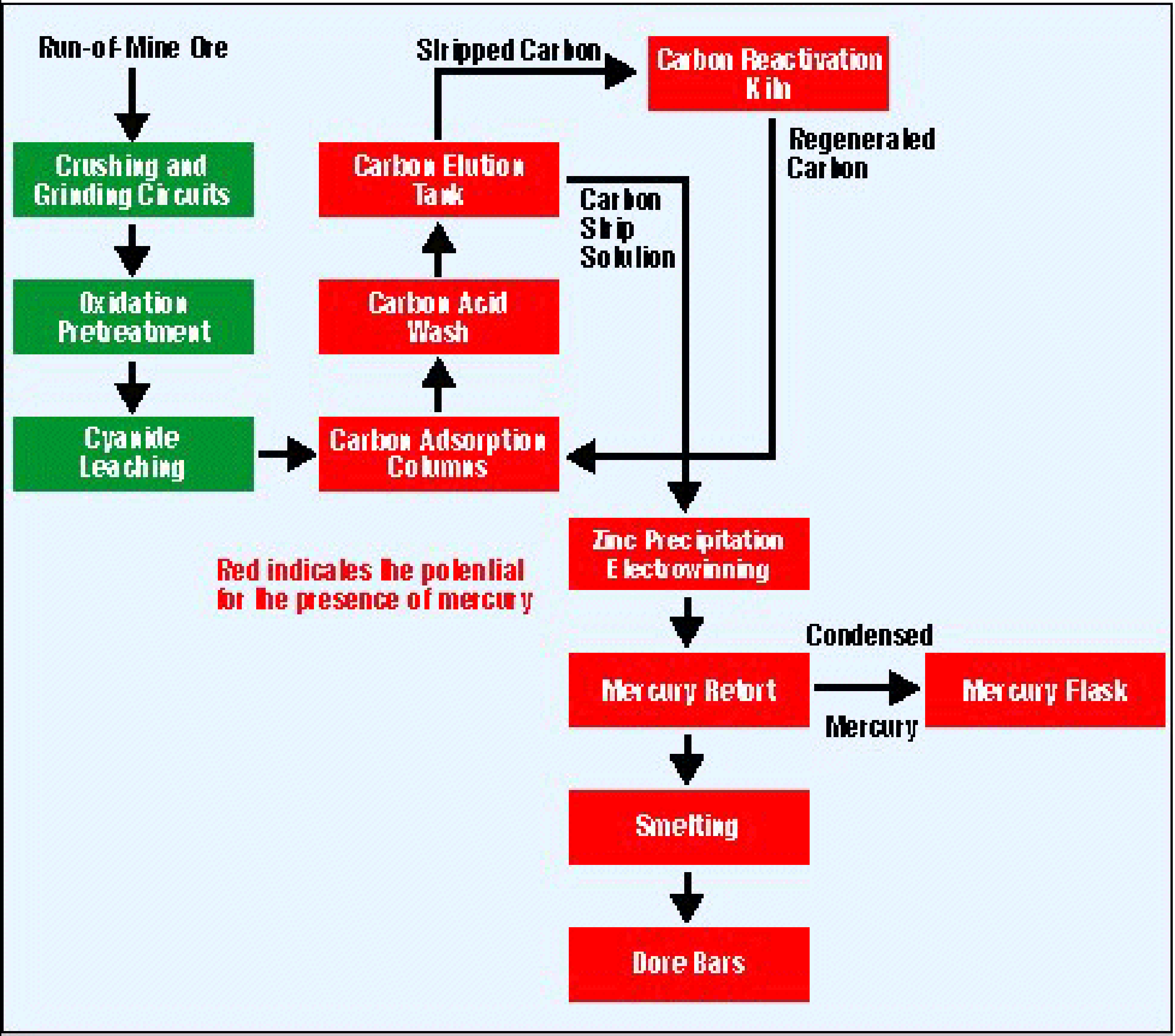
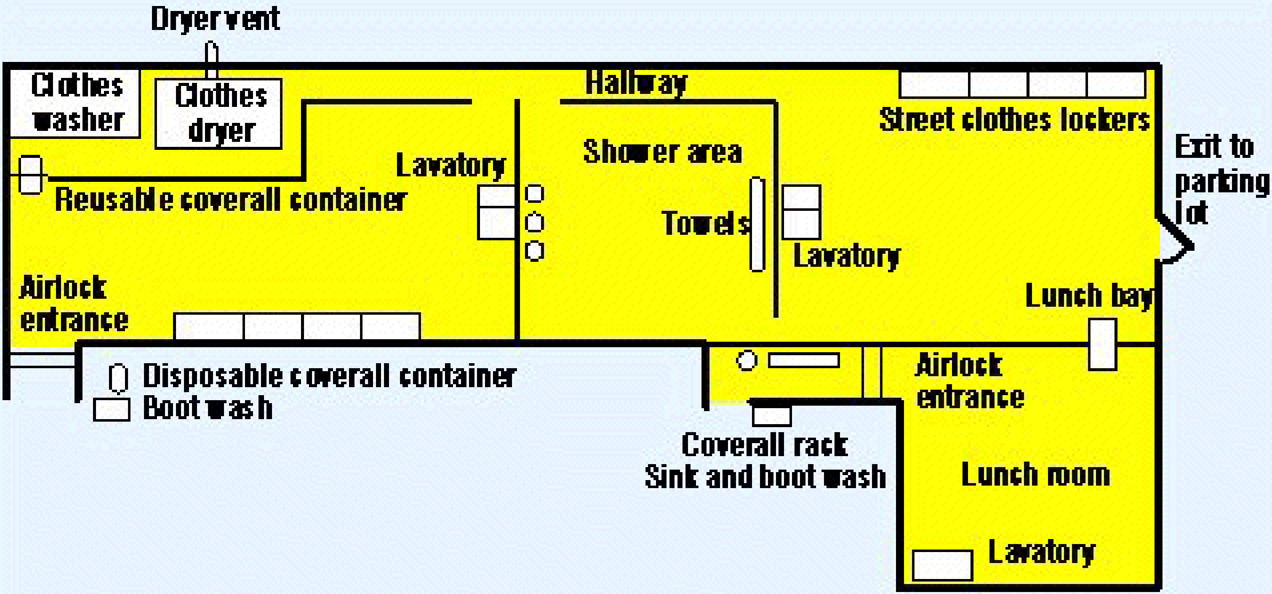


Figure 1.—General cyanidation process flow sheet

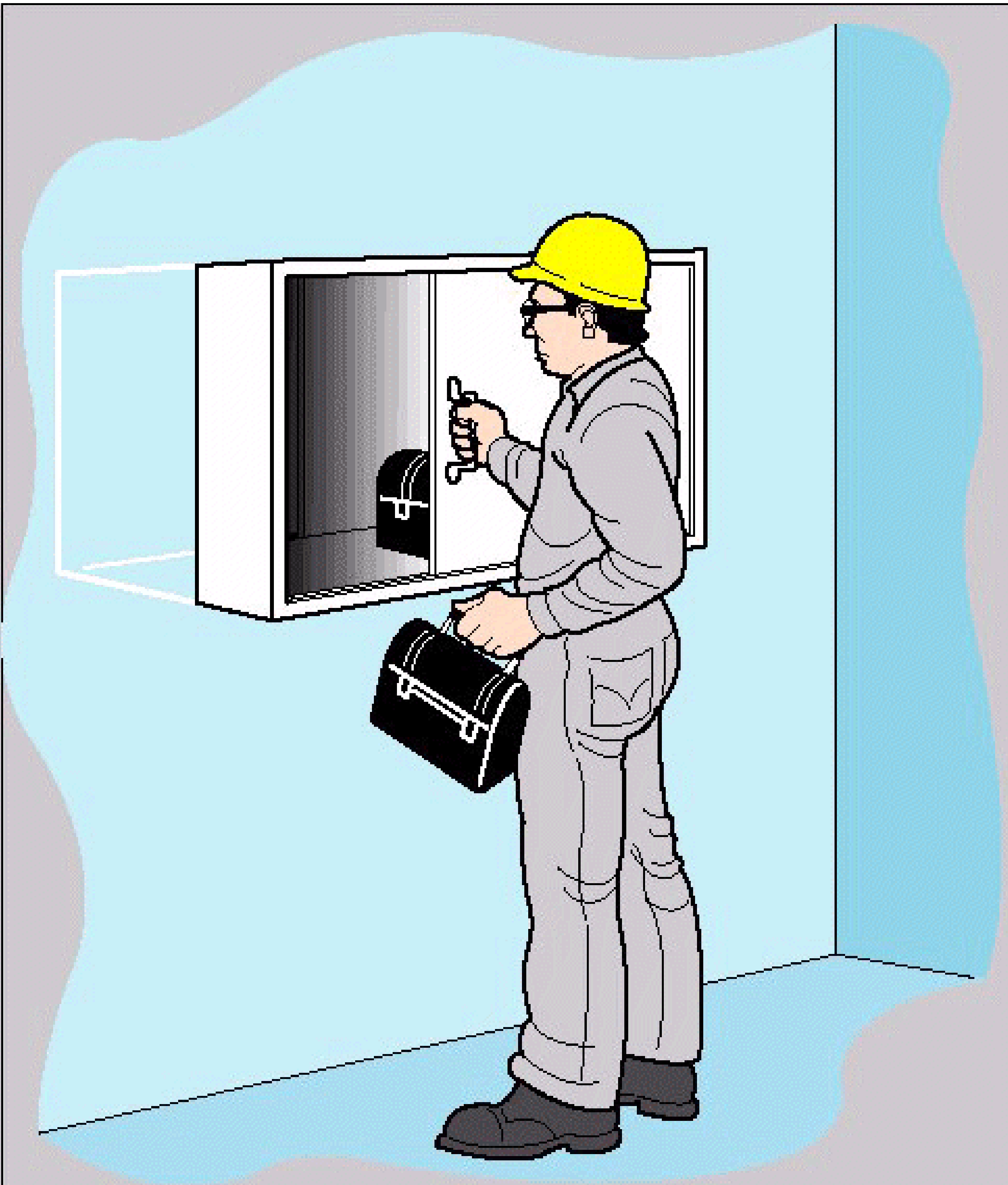
Graphic Image Number 2:
Employee Hygiene Facility and Lunch Room



Designed by: M. Lynham
MSHA, Denver Safety & Health Technology Center, Toxic Materials Division

Figure 2.—Employee hygiene facility and lunch room

Graphic Image Number 3:
Lunch Bay



Designed by: M. Lynham
MSHA, Denver Safety & Health Technology Center, Toxic Materials Division
Illustration by R. Duran and F. Bigio

Figure 3.—Lunch bay

Graphic Image Number 4: Static Pressure Gradient for the Hygiene Facility and Lunch Room

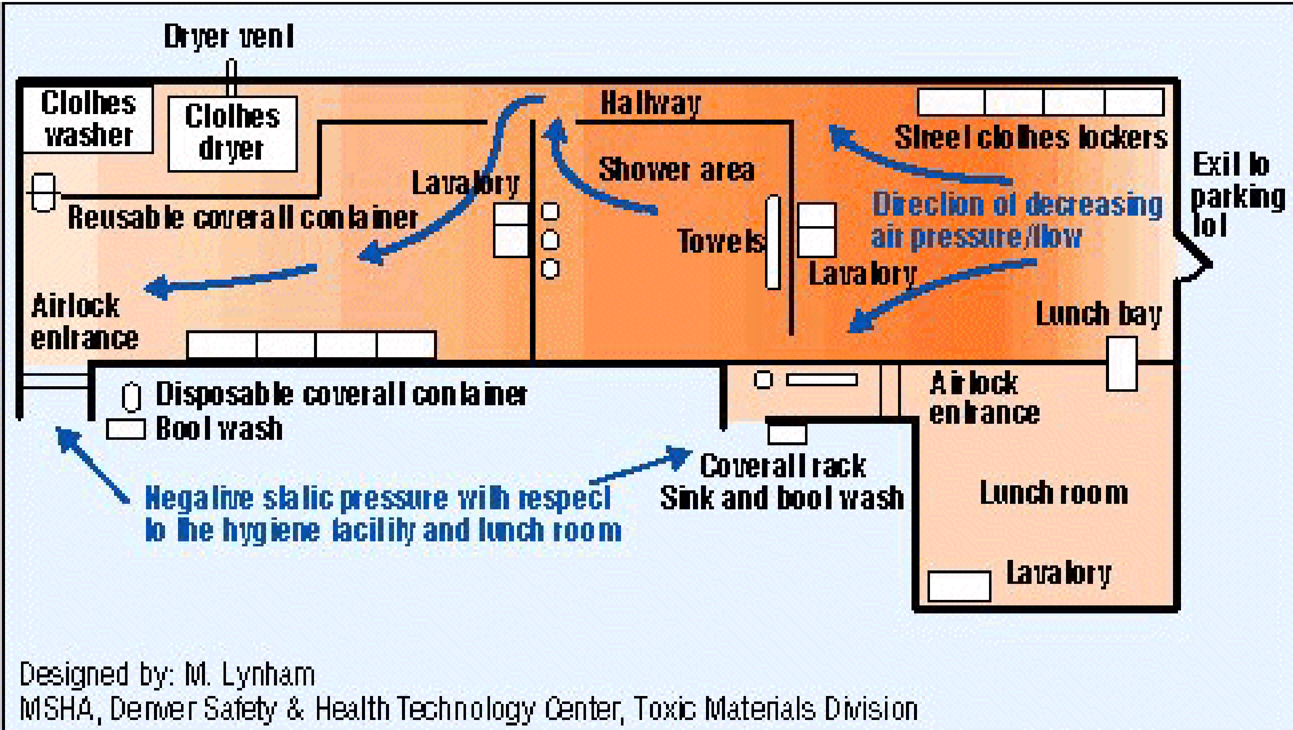


Figure 4.—Static pressure gradient for the hygiene facility and lunch room

Graphic Image Number 5: Refinery Building

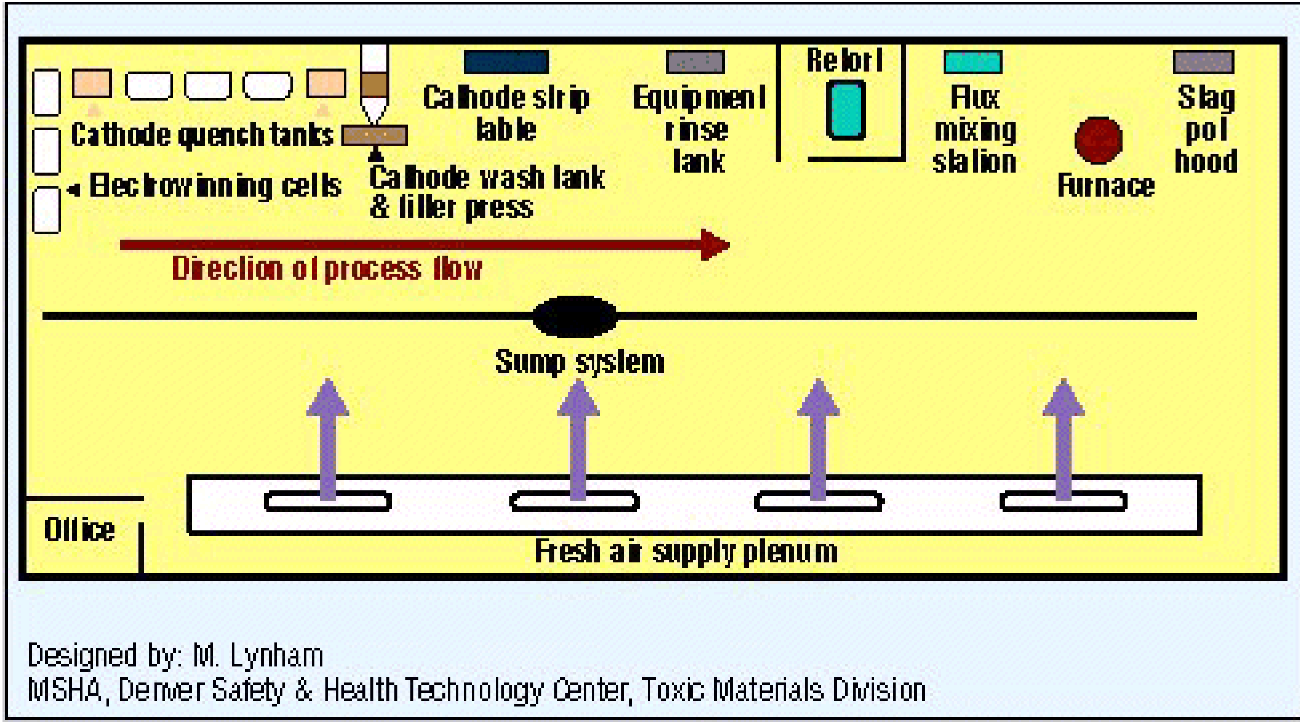
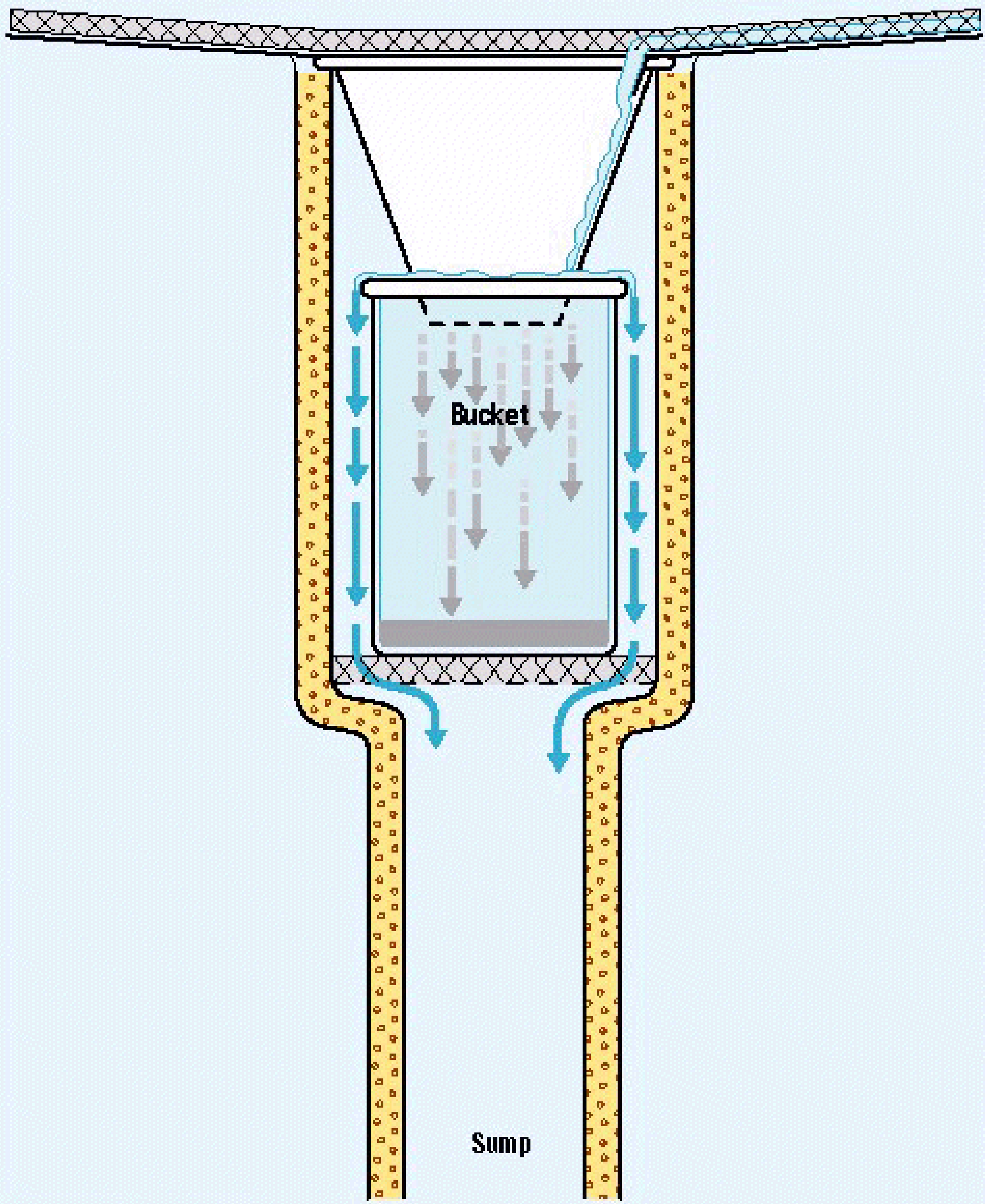


Figure 5.—Refinery building

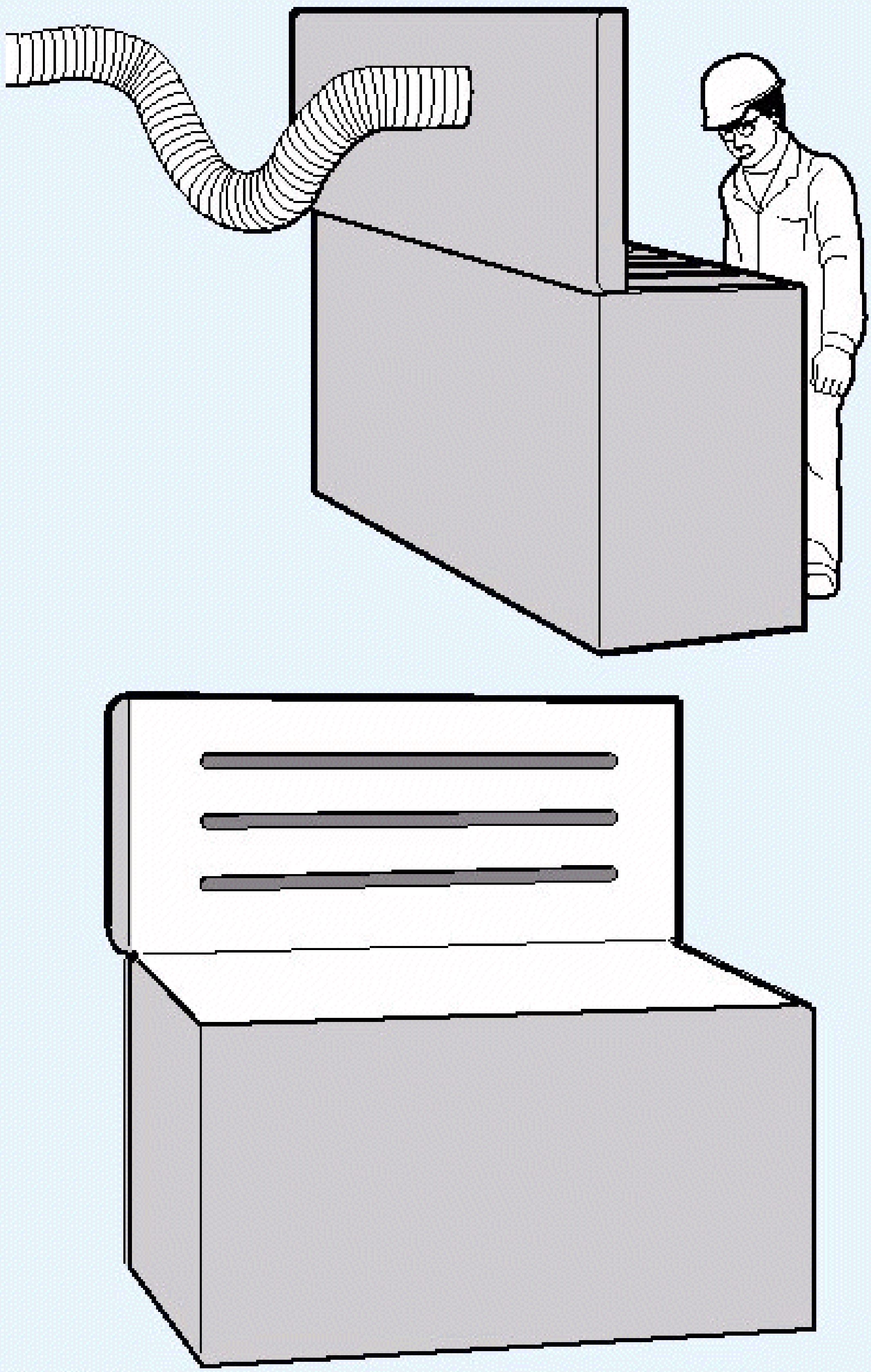
Graphic Image Number 6:
Gravity Mercury Trap



Designed by: M. Lynham
MSHA, Denver Safety & Health Technology Center, Toxic Materials Division
Illustration by R. Duran and F. Bigio

Figure 6.—Gravity mercury trap

Graphic Image Number 7: Electrowinning Tank With Lid Plenum



Designed by: M. Lynham
MSHA, Denver Safety & Health Technology Center, Toxic Materials Division
Illustration by R. Duran and F. Bigio

Figure 7.—Electrowinning tank with lid plenum

Graphic Image Number 8: Down Draft Exhaust Hood

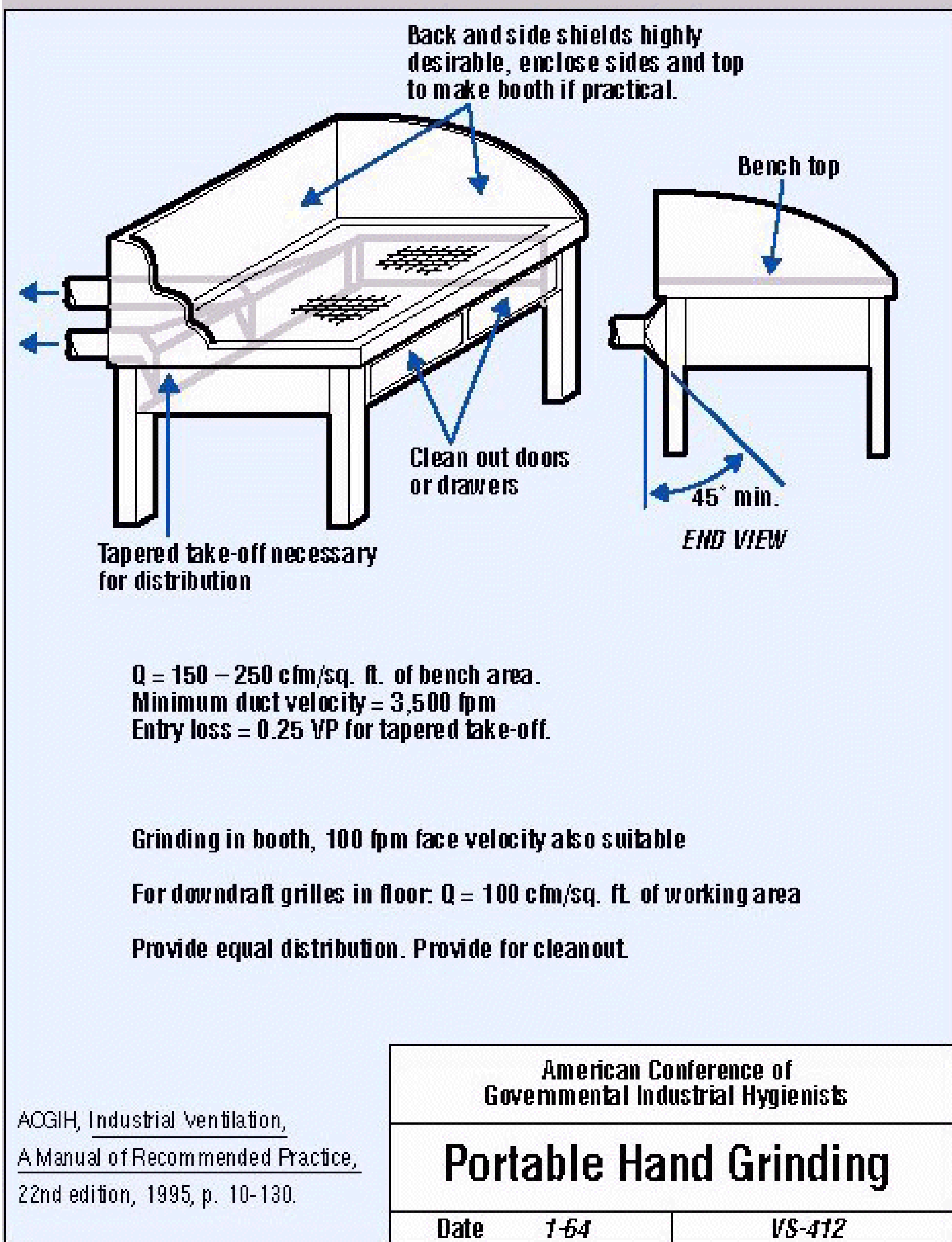
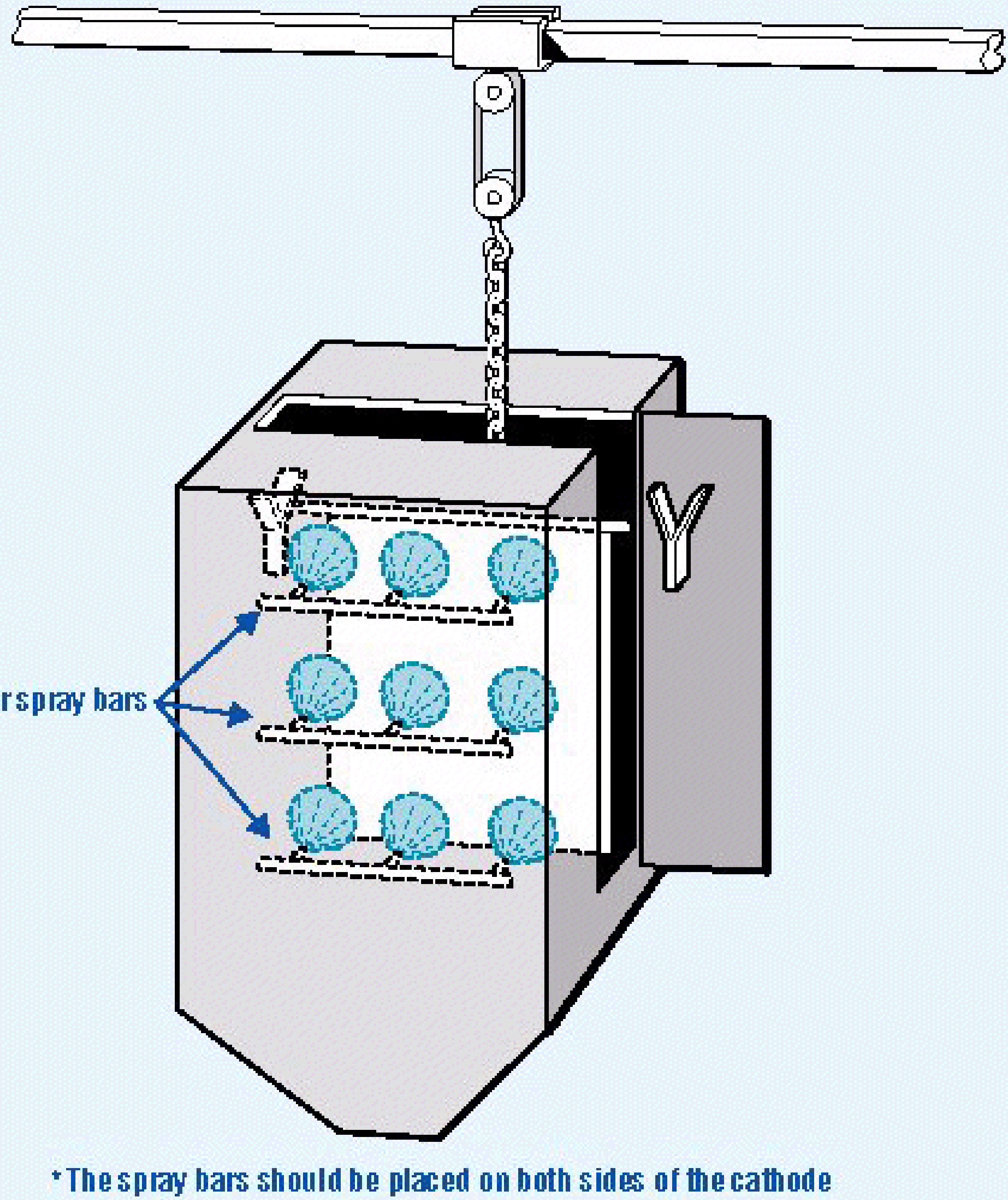


Figure 8.—Downdraft exhaust hood

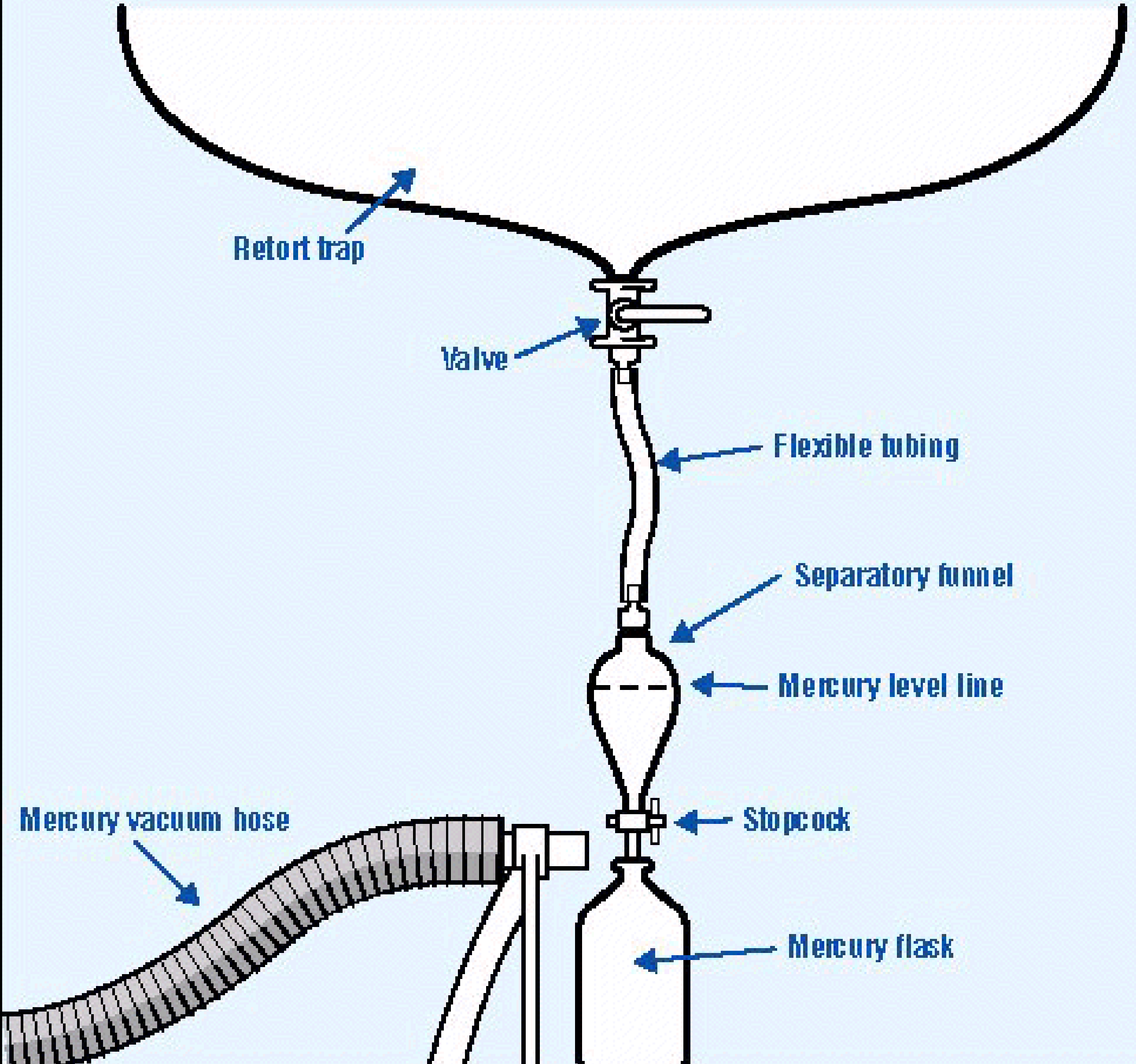
Graphic Image Number 9: Cathode Wash Tank



Designed by: Denver Mineral Engineers, Inc., Littleton, Colo., and
M. Lynham, MSHA, Denver Safety & Health Technology Center, Toxic Materials Division
Illustration by R. Duran and F. Bigio

Figure 9.—Cathode wash tank

Graphic Figure 10: Mercury Trap Transfer Apparatus



Designed by: M. Lynham, MSHA, Denver Safety & Health Technology Center, Toxic Materials Division
Illustration by R. Duran and F. Bigio

Graphic Image Number 11: Flux Mixing Table

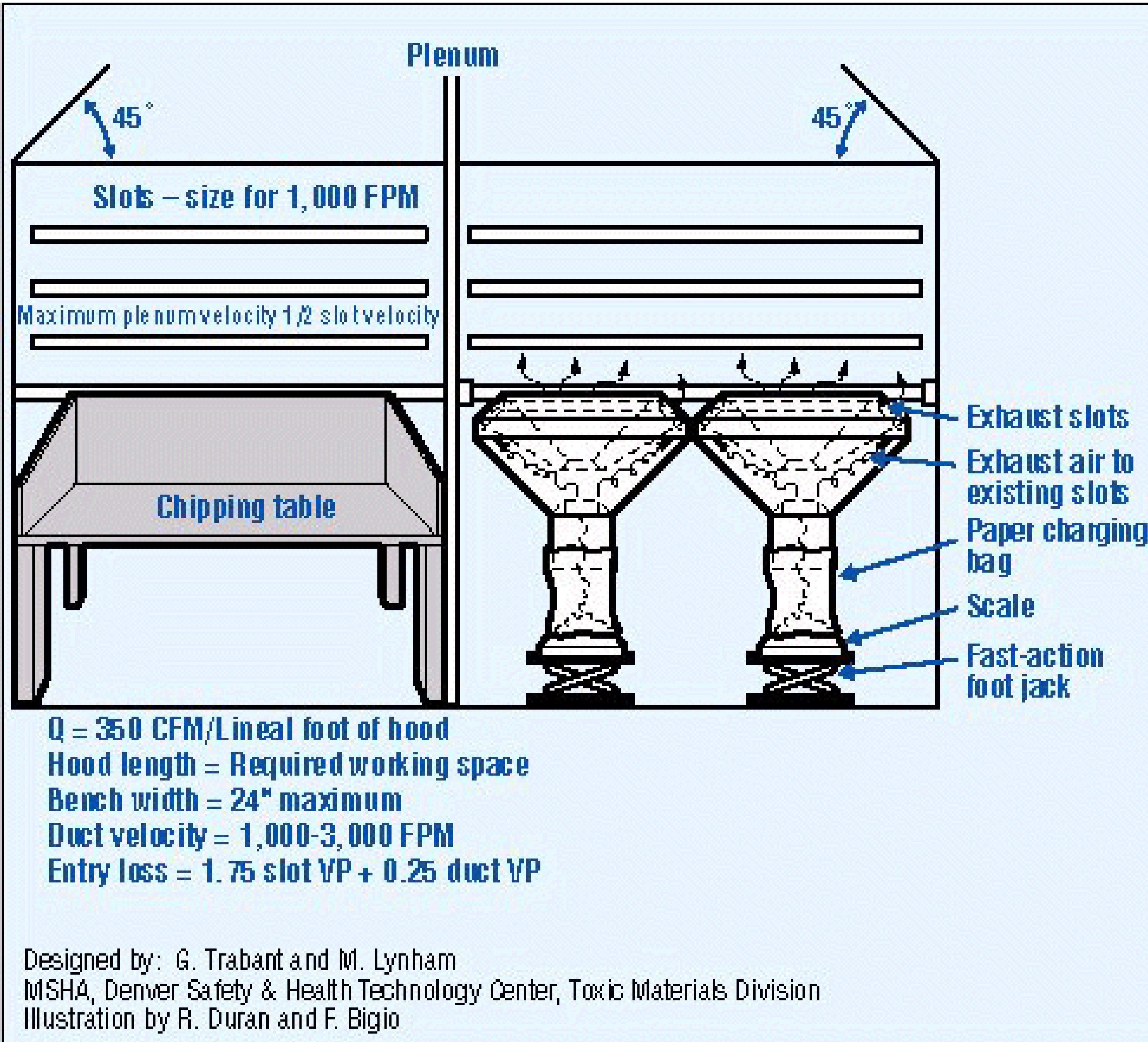
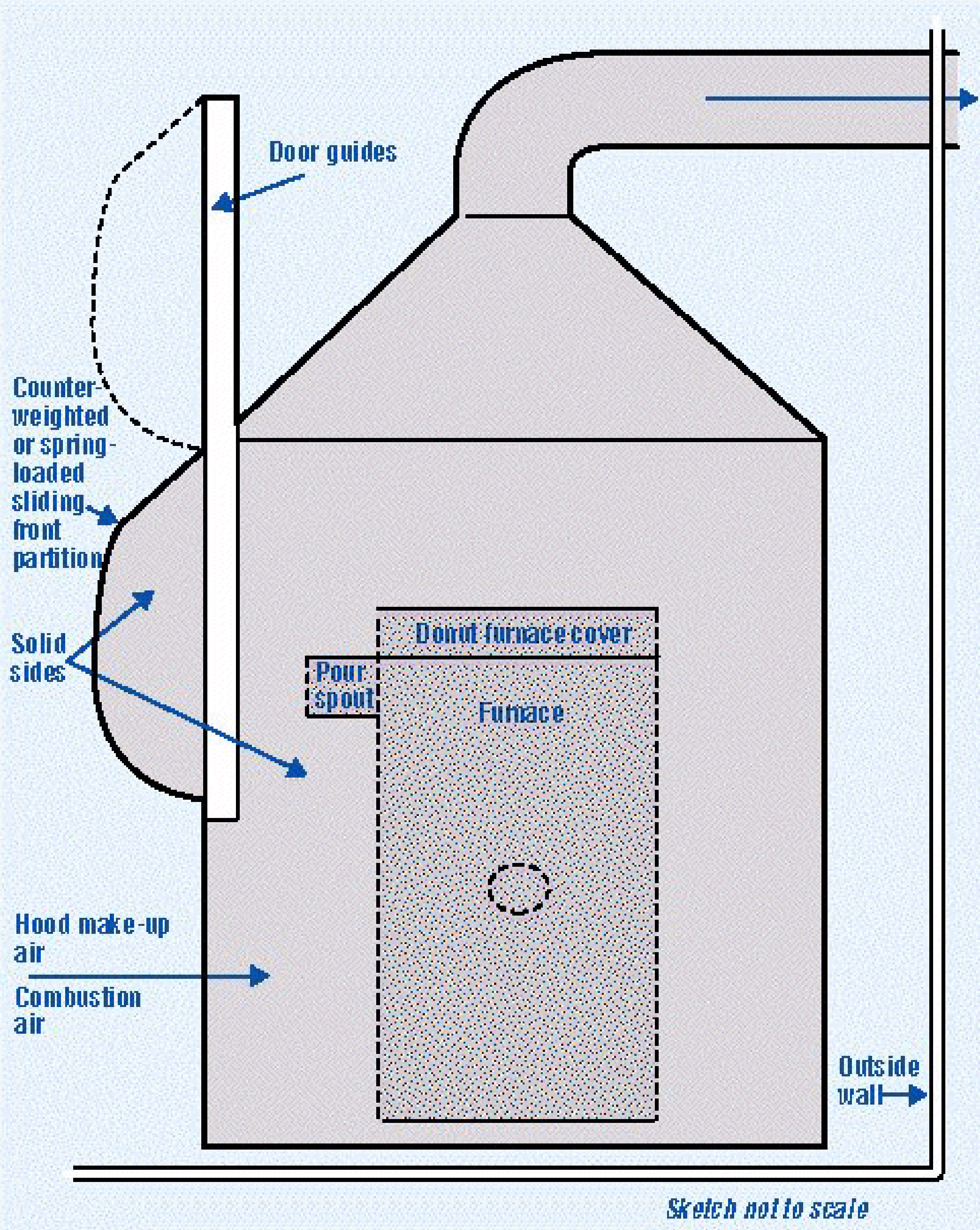


Figure 11.—Flux mixing table

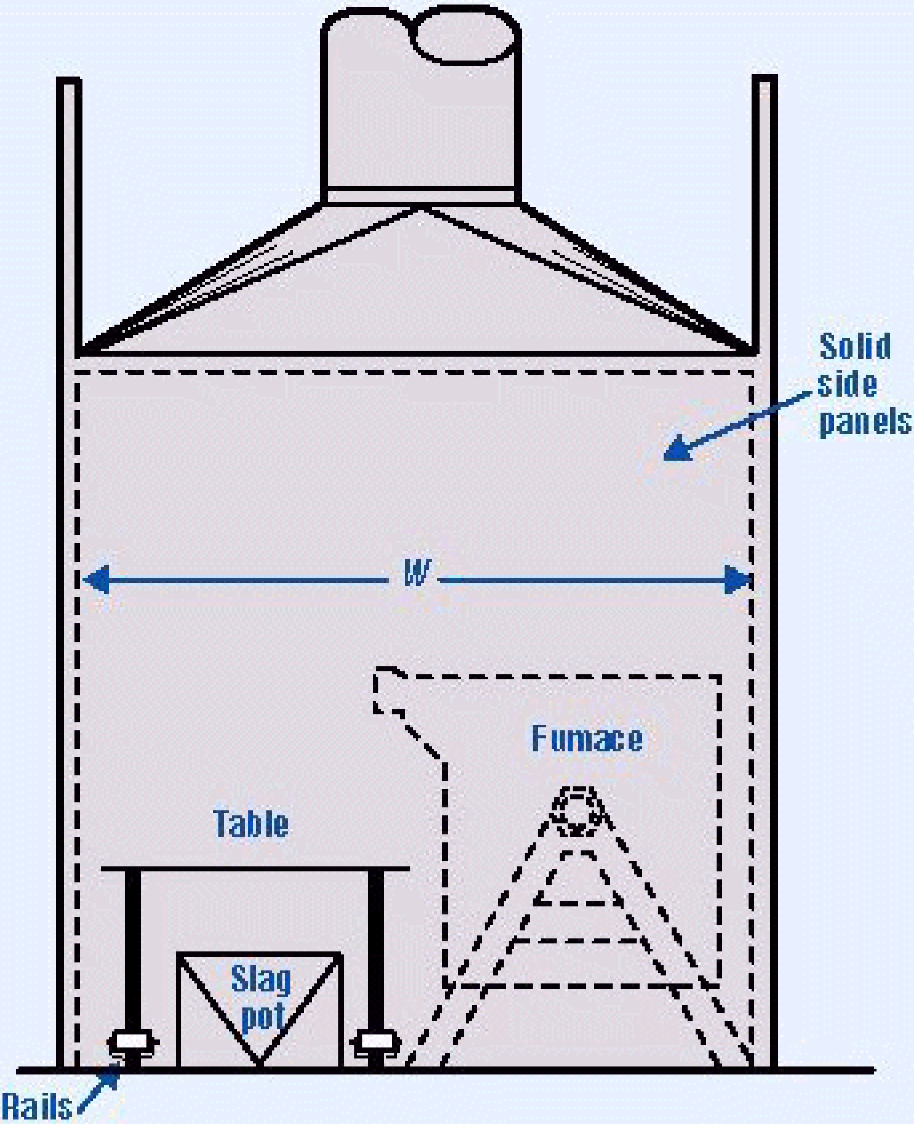
Graphic Image Number 12: Gas Furnace Exhaust Hood



Designed by G. Trabant and M. Lynham,
MSHA, Denver Safety & Health Technology Center, Toxic Materials Division

Figure 12.—Gas furnace exhaust hood

Graphic Image Number 12a:
Electric Furnace Exhaust Hood



Q = 200 LW: but not less than
200 SCFM/Sq. ft. of all openings
with doors open*
Entry loss = 0.25 VP
Duct velocity = 1,000-3,500 FPM**

* Correct for temperature and combustion products.

** For horizontal runs, transport velocity is necessary

ACGIH, Industrial Ventilation, A Manual of Recommended Practice, 20th edition, 1990

Figure 12A—Electric furnace exhaust hood

Graphic Image Number 13: Method For Detecting Low Levels Of Mercury Vapor In The Soil

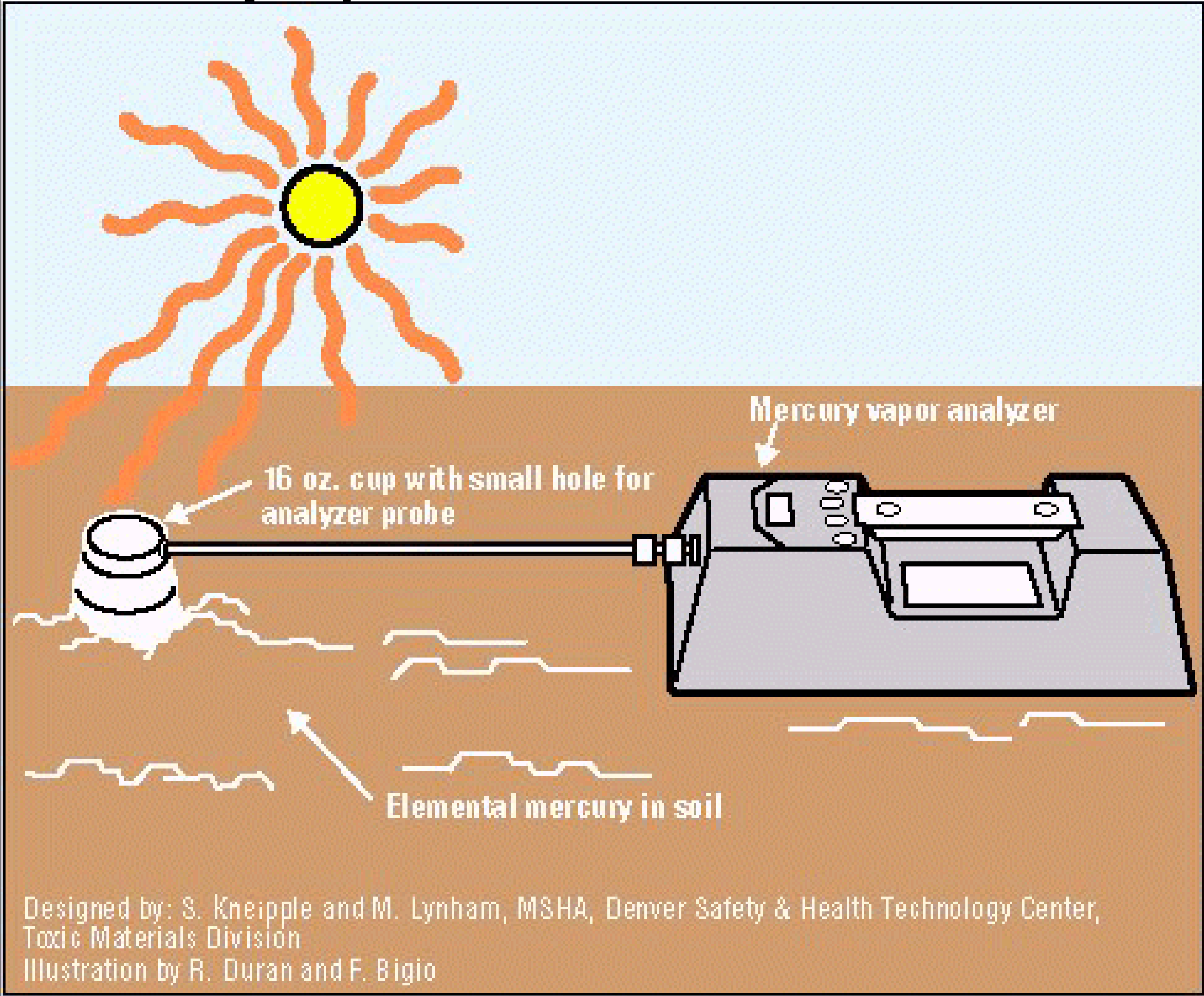


Figure 13.—Method for detecting low levels of mercury vapor in the soil