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CONTROLLING THE USE OF HAZARDOUS MATERIALS IN RESEARCH AND DEVELOPMENT LABORATORIES

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Summary

The author describes a systematic approach for controlling the use of hazardous materials in a large industrial research and development complex. The basic concepts, although fundamental, require the pooling of several technical disciplines. Although, a system may be in place and is functioning effectively, new governmental restraints are constantly occurring, hence, the program is continually expanding.

Introduction

The use of hazardous materials is inherent in the daily activities of a research and development laboratory. The control of these hazardous materials is extremely complex, for control must extend from the origin to the dispoal of such substances. Because of its wide scope and technical nature, control requires the expertise of industrial hygienists, health physicists, physicians, safety professionals, toxicologists, fire protection engineers, ventilation engineers, environmental engineers and a host of other technical specialists. Pooling the efforts of experts in these critical disciplines is the predominant responsibility of one individual who has been assigned by management to recommend policies and procedures to protect employees, the external environment, and the facility itself.

For a manager of occupational safety and health dealing with hundreds of scientists, engineers, and technicians (who are using thousands of toxic, flammable, or other hazardous materials), the task becomes seemingly insurmountable. Nevertheless, it is possible to shape an effective program for controlling hazardous materials.

This article is intended to describe an integrated program that is presently functioning and continually expanding. The subject matter here specifically concerns hazardous materials; it will not cover the physical hazards of ionizing and non-ionizing radiation, noise, heat stress, etc.; nor will it cover site facilities such as gas services, automatic sprinklers, evacuation systems, egress components, and other standard controls. Rather, the aim is to present a basic concept with discussion that covers affirmative action to making that concept work.

The basic concept

The parameters of a strong overall program embrace four major areas:

- Restrictive procurement of hazardous materials
- Pertinent data concerning hazardous materials
- Appropriate facilities and procedures
- Proper disposal of hazardous materials

Safety for personnel and property, that is, does not depend on meticulous laboratory procedures alone. Both restrictions on obtaining dangerous materials and restrictions on disposing of the materials must support careful laboratory procedures. Such restrictions, in turn, must derive from reliable information about the properties of hazardous materials.

Monitoring at the procurement stage

Governmental agencies such as (but not limited to) the Occupational Safety and Health Administration, the Environmental Protection Agency, the Energy Research and Development Administration, and State Agencies have placed specific restrictions on a variety of hazardous materials. In addition to these restrictions, some departmental-imposed restrictions to monitor requests for certain materials have been established jointly by the Purchasing and Safety Operations for the large program described here. See Table 1 for the continually growing list of materials.

Before an individual can purchase or otherwise procure any of the materials listed in Table 1, specific approvals must be obtained from the Manager-Occupational Safety and Health or, in the case of aquatic pollutants, from the Environmental Control Specialist.

Determining how a material is to be used

Once a materials request that indicates the use of a restricted substance is submitted, the applicant must review the proposed usage of that substance with the Manager-Occupational Safety and Health. During the review, the Manager-Occupational Safety and Health must consider many facets of the proposed usage in order to recommend to the applicant appropriate procedures to follow and additional safety features that must be observed. Hence, the following are typical questions that must be answered:

- What are the hazards associated with the material?
- Is there a less hazardous material that can be used?

- Will it be used in conjunction with other materials?
- What amounts will be used?
- Where will it be used?
- How many employees will be potentially exposed?
- What kinds of facilities are available?
- How can emissions be monitoried?
- What type of medical surveillance should be employed?
- What are the qualifications of the persons involved?
- Who will be responsible in carrying out the recommendations of the Manager-Occupational Safety and Health?
- What are the Occupational Safety and Health Administration, Environmental Protection Agency, and Insurance Underwriter requirements?

TABLE 1

Typical restricted materials list

All radioactive materials
Asbestos
Nickel carbonyl
Mercury and mercury compounds
Polychlorinated biphenyls
Liquid hydrogen
Strong oxidizing and reducing agents
Controlled carcinogens
Vinyl chloride monomer
Beryllium and beryllium compounds
Large volumes of flammable liquids
Banned insecticides
Explosives
Controlled drugs

Prescribing the facilities needed and procedures to follow

Because of the nature of research and development activities, the amounts of hazardous materials used may vary from microgram to megagram quantities. However, the amounts used are for the most part in the kilogram range. Generally, all laboratory bays are equipped with fume hoods, which exhaust hazardous emissions from the laboratory and from the breathing zone of the experimentalist. These hoods (if properly designed) are considered to be adequate to control the thousands of chemicals that are unrestricted. They are, however, not considered to be adequate for the control of restricted materials.

The extra controls needed for the restricted materials, such as the standards established by OSHA for the carcinogenic materials, may be extremely stringent. The OSHA requirements include such features as high-velocity fume hoods, restricted entry and exit procedures, total containment through the use of glove boxes, special air-monitoring procedures, decontamination procedures, personal hygiene procedures, special recordkeeping, medical surveillance, negative air pressure, posting and labeling, and other requirements.

Most of the previously mentioned controls apply in part when the experimentalist uses radioactive materials. Depending upon the radionuclides in use, there will be other considerations for shielding, as well as stringent controls for waste disposal.

Large-scale laboratory projects that use flammable liquids or gases require such features as additional room ventilation, damage-limiting construction, explosion proof electrical fixtures, liquid containment, special drainage, extra hazard automatic sprinkler protection, grounding and bonding during liquid transfer, and isolated locations.

High-pressure chemical reactions and other extra-hazardous reactions must be conducted in specially constructed cells employing the features mentioned for flammable liquids. In addition, the reaction must be controlled outside of the cell by way of an exterior operating panel.

Experiments involving highly toxic materials are largely controlled by high-volume, local exhaust ventilation equipped with appropriate scrubbers. These experiments require industrial hygiene monitoring techniques. Fortunately, in a research and development complex virtually every conceivable analytical instrument is available along with the expert information of analytical chemists.

Providing information on hazardous materials

One of the most difficult problems in a research and development environment is to maintain a complete library of data on the hazards of all materials used. Although the program described here cannot claim total information, current references and files are continually expanding. The titles that follow are some of the most used references and therefore constitute a basic bibliography.

N.I. Sax, *Dangerous Properties of Industrial Materials*, Reinhold Book Corporation, New York.
F.A. Patty et al., *Industrial Hygiene and Toxicology*, John Wiley & Sons, New York.
M.N. Gleason et al., *Clinical Toxicology of Commercial Products*, The Williams and Wilkins Co., Baltimore.
The Merck Index.
Hazardous Materials — National Fire Protection Association (NFPA).
Hazardous Chemical Reactions — NFPA.
Registry of Toxic Effects of Chemical Substances — Occupational Safety and Health Administration.
Hygienic Guide Series — American Industrial Hygiene Association.

Material Safety Data Sheets — General Electric Corporate Research and Development.
Manufacturing Chemists Association Data Sheets.

In addition to these references and many others, the research and development library has access to "Toxline" (a computerized data acquisition service located near Washington, DC)*. This service provides access to ∿300,000 citations on the toxic properties of chemical substances.

Since one of the purposes of research and development is to develop new materials, we should also be cognizant of the hazards associated with newly synthesized chemicals. To that end, all new chemicals that show any possibility of usage are screened for toxic properties by a firm located in Michigan**. If the new chemical shows promise of becoming a product, then chronic toxicity studies are conducted. Flammable and explosive properties of new chemicals are determined on site.

Assuring proper disposition of waste

The proper disposal of chemical waste is necessary to ensure the maintenance of a clean and safe environment, as well as to preserve equipment. Such disposal requires the proper identification of wastes and their disposition through the correct channels. The purpose of the procedures described below is to institute an organized means by which the laboratory worker can and must dispose of the waste chemicals generated.

The laboratory drain systems are not to be used for disposal of any solvents, acids or chemicals, with very few exceptions. Any material that is foreign to water and that enters the drains has the potential for causing severe environmental problems, no matter how small the amount of such material. Organic chemicals in general impose a load on treatment facilities and/or oxygen demand in the receiving waters. Some organics act as foaming agents and cause operating difficulties; many toxins, such as heavy metals, can cause severe disruption to aquatic life.

Waste solids

The materials that may be disposed of the wastepaper baskets in laboratories are limited to those, such as paper, sand, and clay, that can be safely mixed and handled by the cleaning personnel for final disposition at the town landfill. Therefore materials such as broken glass and scrap metals are not to be placed in wastepaper baskets; instead, they are to be put into separate, labeled containers or special pails made available by the Safety Office.

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* Toxicology Information Services, National Library of Medicine, 8600 Rockville Pike, Bethesda, Maryland 20014 (U.S.A.).

**International Research and Development Corporation, Mattawan, Michigan (U.S.A.).

Waste solvents (less than drum quantities)

Waste solvents for those laboratories generating more than one gallon per day to be poured into special two-gallon waste solvent safety containers that are provided in the laboratories. However, large amounts of polymers in solution should *not* be placed in the waste solvent safety cans, for polymers precipitated out of solution, can destroy a costly container.

Instead, these solutions are sent to the Waste Chemical Disposal Station in disposable containers (Fig. 1). The two-gallon containers are picked up, emptied, and replaced on a regular schedule by the Waste Chemical Coordinator. Laboratories generating less than one gallon per day quantities are provided with one-gallon waste solvent cans that are to be returned to the Waste Chemical Station by the laboratory people. Those using the waste solvent collection service must restrict its use to solvents that are compatible, that is, to those

Fig. 1. Waste Chemical Disposal Station.

that can be mixed safely with other solvents discarded from other laboratories at the site. Waste solvents accumulated by the internal collection service are combined in 55-gallon drums for pickup by a licensed disposal firm*. However, if there is reason to suspect incompatibility, the waste should be segregated. Because the process of combining is done manually, there is a genuine urgency in the compatibility feature.

Mercury

All apparatus and waste containing mercury or mercury residues (broken thermometers, manometers, barometers, compounds, etc.) are to be transported to the Mercury Disposition Center (Fig. 2). This facility is designed specifically for the handling of all equipment containing mercury and waste materials contaminated with mercury and its compounds. It is important to realize that the measure of mercury pollution of the environment includes mercury compounds as well as metallic mercury. Therefore, all compounds of mercury must be treated and disposed of through the Disposition Center. Obviously, mercury and its compounds should *never* be disposed of in the laboratory sink and drain system.

Pilot plant waste

Special arrangements must be made for disposal of large scale laboratory waste. It must again be stressed that the laboratory drains must not be used for disposal of chemicals. A letter should be addressed to the Environmental Control Specialist, before starting an operation for which waste disposal service is needed. Information on identification, hazard category, packaging and estimated rate of waste production is needed for each waste item. Once the operation is approved, waste disposal service will be provided, but only if each container is properly labeled.

Waste acids and bases

Waste acids and bases in small amounts are to be brought in a proper, labeled container to the Waste Chemical Collection Station for neutralization. Since small amounts of acids or bases can greatly affect the pH of the effluent, it is imperative that none is dumped into the sinks. What an individual may feel to be an insignificant amount of acid will have an additive effect when combined with what others at the time may feel to be an insignificant amount of acid. Any person or group of persons planning to generate a large amount of waste acids or bases that could nevertheless be handled by the Waste Chemical Collection Station must notify the Environmental Control Specialist before such generation. This notification should include the quantity and identity of the waste material. Provisions are then made to handle the waste.

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*Chemtrol Pollution Services Incorporated, P.O. Box 200, Model City, New York 14107 (U.S.A.)

Fig. 2. Mercury Disposition Centre.

Other chemicals

Other chemicals designated for disposal, including contaminated glassware, must be properly packaged in nonreturnable containers to prevent the possibility of breakage or the chemical attack of the container; and they must be labeled. They must then be sent to the Waste Chemical Collection Station. There the packages are repacked in 55-gallon drums according to category. Clearly, it is imperative that each container be labeled properly in order to comply with shipping requirements, as well as to maintain site safety.

Radioactive waste

All radioactive waste must be returned to the Safety Office and inventoried by the Radiation Safety Officer (Fig. 3).

Fig. 3. Monitoring of Radioactive Waste Container.

Labeling procedure

Labels are supplied at the Waste Chemical Collection Station. It is essential that the labels be used and filled out completely. Each label must include the employee's name, telephone extension and the chemical name of the waste. In addition, the pertinent one of the following chemical groups must be indicated:

Group A

(1) Inorganic acids, (e.g., hydrochloric or sulfuric acid).

(2) Elements and inorganic salts that do not liberate gaseous products when acidified (e.g., sodium chloride, barium sulfate).

Group B

(1) Inorganic alkaline chemicals (e.g., sodium hydroxide, ammonium hydroxide).
(2) Organic bases (e.g., triethanolamine, pyridine).
(3) Elements and inorganic salts that liberate gaseous products when acidified (e.g., potassium cyanide, sodium sulfide).

Group C

(1) Solid organic compounds (excluding organic acids and bases, e.g., pentachlorophenol, glucose).

Group D

(1) Organic liquids, including organic acids but excluding organic bases (e.g., acetone, xylene).

Group E

(1) Inorganic oxidizing agents (e.g., potassium nitrate, sodium peroxide).

Group W

(1) Water-reactive or shock-sensitive materials.

Group O

(1) Organic oxidizing agents.

Containers too small for the label should be placed in polyethylene bags and then labeled. Quantities of small containers containing the same chemical may be grouped in a single polyethylene bag and labeled. In labeling solution or mixtures of chemicals, the predominant constituents with their approximate percentages must be listed. The same is true for reaction mixtures for which either no product was formed or which the product is unknown.

Conclusion

Controlling the use of hazardous materials in a large research and development complex is an extremely difficult problem. Nevertheless the program described here is in place and functioning effectively. It is administered by the Manager-Occupational Safety and Health with the support of the Safety Specialist, an Environmental Control Specialist, the laboratory scientists, and numerous technical experts. The program operates successfully by coordinating technical knowledge concerning hazardous materials with their procurement, then handling in the laboratory, and their disposal.

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