Lab Manager Magazine Article: "Managing Chemical Life Cycles" - by Richard Flaherty, Director of Clean Harbors' CleanPack® Laboratory Chemical Packing Services

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Labs generally do a good job of managing their chemical inventories. However, oversight of laboratory chemicals tends to be less controlled than that of waste chemicals. Materials at this end of the process are just as volatile and can, in fact, be more of a hazard because they are no longer in their original containers, may be mixed with other, potentially reactive agents, or simply may have decomposed due to age and become less stable.

Virtually all labs have established procedures, but they may be outdated or the staff may be uninformed or poorly trained. We occasionally encounter unexpected mixtures that, at best, present storage and disposal challenges and, at worst, are dangerous for lab personnel as well as the environment. Such encounters point to the fact that all labs must periodically review their policies, develop procedures, and conduct training for managing hazardous waste inventories.

Working for a company that removes hazardous waste from labs enables me and my staff to witness the full spectrum of chemical management practices. Although chemical storage practices continue to improve, we still see a number of safety and/or regulatory violations, including:

- *Storage of expired chemicals*
- *Incompatible and reactive chemicals stored alphabetically*
- *Oxidizing chemicals mixed with organic lab waste*
- *Open containers kept in satellite storage areas between pours*
- *Improper waste storage combinations*
- *Poor record keeping*
- *Unlabeled or poorly labeled secondary containers*
- *Containers labeled with chemical notations rather than chemical names*

We've seen sophisticated programs under the guidance of chemical hygiene managers. Corporate and industrial labs are easier to control, since they tend to conduct repetitive processes that use defined sets of chemicals. Research and, particularly, academic labs are less stringent than other labs due to the number of researchers, the broader range of chemicals used, and the temporary nature of student researchers. Occasionally, we see labs that have grown quickly and outpaced their chemical management procedures.

Managing the chemical life cycle

The chemical life cycle spans three stages. The first is chemical inventory, which relates to the procurement, storage, and management of chemicals before they are used; the second is the use of chemicals in research or processes; and the third is post-use, which is when the chemicals or new compounds move to waste storage and removal.

Effective chemical life cycle management is centered on expiration dates, which must be noted when chemicals arrive at the lab and tracked until they are removed. Chemical inventory management should be relatively easy since materials arrive in approved, labeled containers supported by paperwork. Nevertheless, a few factors challenge effective management.

One factor is that, in order to save money, many labs purchase chemicals in bulk. It is better to buy smaller quantities and turn inventory over more frequently, because old chemicals are potentially dangerous. An example of a chemical with a short shelf life is peroxide formers, such as diethyl ether, which can form explosive peroxides and subsequently become unstable.

These and other chemicals require close tracking to avoid exceeding their expiration dates. Saving a percentage of the cost reflects a false economy if the materials remain unused and the lab has to pay a company thousands of dollars to remotely open the container and then stabilize and dispose of the chemical. Generally, the best practice is to have a centralized purchasing and

inventory process that purchases appropriate quantities for the organization, manages the inventory, and dispenses chemicals as necessary.

Chemical inventory storage is also an issue. Chemicals are occasionally stored alphabetically. Commingling incompatible but alphabetically sequential chemicals, such as acetone and benzoyl peroxide, can lead to explosive chemical reactions. Compatible chemicals should be stored together within secondary containers or trays to sequester spills.

<< Laboratory lecture bottle once contained hydrogen fluoride. When stored over two years, hydrogen fluoride reacts with the iron in the bottle and begins to form hydrogen gas. The hydrogen gas builds up over time to the point where the bottle can rupture.

For the next two stages, once chemicals are removed from their original containers for use or waste storage, all labs should adhere to Title 29 of the Code of Federal Regulations, Section 1910.1450, Occupational Exposure to Hazardous Chemicals in Laboratories, when labeling containers. This extends to smaller dispensing containers, such as isopropyl alcohol spray bottles, cleaning chemicals, and other materials that may or may not be part of the research or production process.

A chemical hygiene officer should be designated, as required under the Code of Federal Regulations, Title 29, Section 1450. He or she should be actively involved in the development of procedures, proper labeling of containers, communications, and training of lab personnel related to the proper management of chemicals. The chemical hygiene officer is ultimately responsible for ensuring that all regulations are met and that a safe management protocol is followed. The protocol must cover the full life cycle.

Waste management

Waste chemicals pose additional challenges in that they may no longer be in their original containers; their use in processes or research may cause the formation of new compounds; and they are often mixed with the same chemical from a different batch (based on expiration date) of other compatible chemicals. Yet, some chemicals that would seem to be compatible are not. It is necessary to do a full evaluation of the byproduct of any mixture. For instance, not all oxidizers are compatible, and copper solutions mixed with sodium azide can form copper azide—an explosive.

Chemical waste oversight requires close management, well-established safe management protocols, effective communication, and frequent inspections. All accumulation containers must have accurate labels and logs. We often find containers that are labeled with chemical formulas rather than names. Not everyone will understand the chemical formulas, and first responders to an emergency must be able to quickly assess the hazard. Chemical names should always be used. The percentages of the different constituents and the accumulation start dates should also be noted on the labels.

Also, containers should list the earliest expiration date from among all the chemicals in the mix. If that changes because a chemical from an older lot is added to the mix as the container is filled, then the expiration date should be updated. This could move up the removal date and require expedited handling. Any container that is not properly labeled with its contents logged will require testing before removal, adding complexity and cost. All containers must be properly sealed between pours. We often see open containers with funnels left in them, which allows the chemicals to vent off.

Containers in the satellite accumulation area (SAA) must have only compatible chemicals in them to be secure, have secondary containers nearby in case of a spill, and be clearly labeled. Once full, containers must be moved to the main storage area (MSA) and may be combined with other compatible waste. Generally, organizations have 90 days to remove chemicals from the MSA, unless, once again, the expiration date predates the projected disposal date. See the Code of Federal Regulations, Title 40, Section 262.34, for more information.

A note here about lost inventory. We often find, especially in academic labs, caches of old chemicals that have been stashed in a corner or closet and forgotten. Perhaps a researcher left or moved on to another project and did not dispose of the chemicals; therefore, these abandoned chemicals have fallen off the map. Any number of bad things can happen, such as picric acid coming in contact with metal shelving and forming metal picrate, a highly unstable explosive. These lost chemicals need to be located, identified, and removed. This is certainly something that chemical hygiene officers should be on the lookout for and discuss with staff, and perhaps they can even organize “amnesty days” to encourage the discovery and removal of these waste chemicals.

If containers are properly labeled and contain compatible materials, the removal company will know what it is dealing with and be able to efficiently (and cost effectively) remove the chemicals for recycling or incineration. However, if the containers are not properly labeled, include incompatible materials, or are unlabeled and unknown, the service provider will be required to test and/or stabilize the chemicals before removal, adding significant cost and complexity.

Taking control with a database

The most efficient way to manage chemical inventories, waste storage, and waste removal is to rely on a digital tracking system. This is especially true when it comes to managing a central chemical storage area and inventories at multiple labs.

At a minimum, the system should track all the key dates. It should note and update locations as they change. More sophisticated uses tie into purchasing systems, assign cost center allocations, and allow multiple authorized users to enable lab personnel to easily and quickly report chemical movements. Templates to make management and Environmental Health & Safety (EH&S) program reporting more efficient also should be included.

The most sophisticated databases include chemical profiling, are flexible, feature online distribution and Web reporting, and have direct links to waste removal companies in order to facilitate automated requests for removal pickup.

<< An example of poor packaging of laboratory chemicals for disposal. Poor packaging can cause breakage. If the materials were not properly categorized and segregated, materials can potentially react.

Many labs develop spreadsheet applications to manage their inventories. This is certainly a step in the right direction but stops well short of comprehensive life cycle management. Spreadsheets require researchers' time to develop, and they are often quirky and only make sense to the designer. They often track inventory only from receipt through use and do not extend to waste management. Many lack the ability to easily sort and search against expiration dates and other criteria. Spreadsheets are also generally stand-alone applications and do not have built-in reporting.

Moving to an in-house system built on a generic database can address some of these issues but still requires time and expertise to develop the application and generally falls short on reporting and integration with other systems.

Chemical management software systems should provide comprehensive chemical inventory, hazardous waste, and compliance management support. New developments include online portals that handle in-house management of the entire chemical life cycle and extend to waste disposal and reporting.

These systems list thousands of chemical profiles that can be selected to make building the database easier, quicker, and more accurate—and the inventory safer. They are generally flexible enough to enable chemists to create new profiles or edit existing ones. These systems maintain accurate inventory details by generating a location code that includes the container number, shipping name, drum size, shipping volume, waste codes, daysin- location, and description. Profiled containers also include the profile number, profile status, and expiration date.

Ideally, chemical management databases can also be integrated with hazardous waste removal companies over the Internet to report full containers and containers that are ready for packing and pickup. With an integrated, accurate inventory management system, it is more cost effective for the removal company to generate Materials Safety Data Sheets (MSDSs) and packing lists for laboratory chemical packaging. An integrated management system also facilitates reporting back to the chemical hygiene officer in order to have a complete, auditable life cycle management report for each chemical that is used by the lab.

Effective lab chemical management is a day-in, day-out affair. It requires constant attention supported by well-articulated, well-communicated procedures. Normal operating procedures should be examined and made safe. Any new process or chemical that enters the lab should be evaluated to ensure safe handling, storage, and removal. Comprehensive databases are helpful in identifying unexpected chemical compound reactions, either in use or in storage. A well-managed chemical life cycle program can

significantly increase employee and environmental safety, as well as reduce materials and removal costs.