Chemical Waste

Avoiding unexpected reactions

By Emmett C. Sullivan, Mark A. O'Riley and Sanjay Shiwprasad

MANY CHEMICAL SUBSTANCES are used in scientific research and teaching activities throughout colleges and universities across the country. Consider for example the undergraduate general chemistry laboratory sessions where students perform some elemental manipulations under the watchful eye of a professor or teaching assistant. Students are instructed to wear appropriate PPE, such as a lab coat and safety glasses, and to not wear shorts or open-toed shoes (National Research Council, 1995). Each lab session typically consists of assigned reading material about the specific laboratory procedure, instructions from the instructor and, hopefully, a successful outcome.

Likewise, in the scientific research realm, many more different chemical substances are used and the researchers themselves are performing the same actions, just in greater detail than in the undergraduate lab sessions. While most college and university environmental safety and health departments and institutional committees conduct training and offer guidance, the individual users are ultimately responsible for their safety and well-being when handling various chemical substances.

Colleges and universities are typically not viewed as industrial facilities, yet they face many of the same regulatory concerns, such as hazardous waste, air quality and storm water, as industrial facilities. While most colleges and universities attempt to reduce, reuse and recycle as much chemical waste as possible, some ultimately ends up being discarded as waste.

A subset of chemical waste is defined as hazardous waste per EPA (2008) rules. EPA, along with state regulatory agencies such as the Texas Commission on Environmental Quality (TCEQ), regulates hazardous waste from cradle to grave. According to EPA, hazardous waste can be thought of as waste that exhibits a characteristic, defined as ignitable, corrosive, reactive and toxic, or that is listed in the EPA rules in one of four groups: K-listed, F-listed, P-listed and U-listed.

The waste generator is responsible for classifying its chemical waste as either hazardous or nonhazardous, and following the appropriate rules. This is a sizeable undertaking for most colleges and universities and consumes many resources. Also, there is no long-term investment in waste disposal costs for colleges and universities other than a demonstration of regulatory compliance.

The University of Houston (UH) is located just south of downtown Houston, TX. The campus covers approximately 550 acres and includes more than 100 buildings. Current enrollment is more than 35,000 students with approximately 5,000 faculty and staff (UH, 2009c). The campus features more than 700 laboratories, with more planned for the future. UH plans to double sponsored scientific research on campus and grow the student population to 45,000 in the coming years (UH, 2009a).

One critical function of the Environmental Health and Risk Management Department (EHRM) is to manage the university's chemical waste in accordance with applicable EPA and TCEQ regulations. UH faces regulatory and economic pressure to minimize the amount of hazardous waste generated on

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Avoiding the potential consequences of improper hazardous waste disposal requires a comprehensive plan and education of chemical handlers.

Abstract: *Universities are typically not viewed as industrial facilities, yet they face many of the same regulatory concerns, such as hazardous waste, air quality and storm water, as industrial facilities. University of Houston has implemented several measures to reduce the amount of chemical waste generated and shipped off campus for disposal.*

campus. As a large-quantity generator, UH must develop a pollution prevention (P2) plan and report yearly on progress to TCEQ (2003). This article focuses on EHRM's efforts to minimize chemical waste generated on campus in a safe manner.

Waste Minimization Activities

EHRM has undertaken a range of initiatives to minimize the amount of hazardous waste shipped off campus for disposal. When possible, staff try to eliminate the initial generation of waste at the source, such as by adding a silver recovery unit in a photographic darkroom, and eliminating the generation of silver-contaminated wastewater (Bialowas, Sullivan & Schneller, 2006).

The department also created a chemical exchange program (CHEM-SWAP) that allows university users to swap reusable chemicals across the campus. EHRM has also prepared recommendations for the university's purchasing group in an effort to prevent the introduction of likely future hazardous-waste-generating products, such as mercury thermometers, and to promote the use of greener products.

In recent years, EHRM has reduced the amount of hazardous waste generated on campus that is shipped off-site for disposal. Figure 1 shows the amount of hazardous waste generated on the main campus and reported to TCEQ per calendar year.

The challenge is to continue to reduce the amount of waste shipped off campus for disposal, especially as the university embarks on its major growth campaign. The level of sponsored research had grown to more than $86 million in FY07 (UH, 2009c), with the goal to double that level in the future.

General Waste Handling Procedures

EHRM manages the daily chemical, biological and radioactive waste programs for the university. Individual hazardous waste generators across the campus are treated as satellite accumulation areas per EPA and TCEQ rules. Briefly, this means that waste

Figure 1

Hazardous Waste Generation at UH, 2003-08

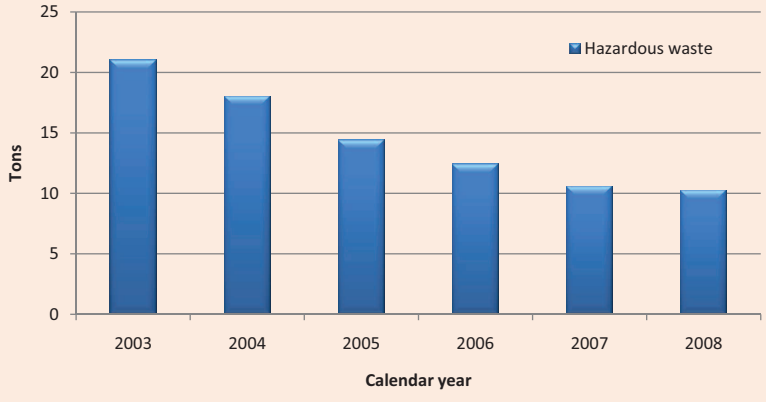

Photo 1: Comparison of a lab over-pack drum (left) versus a bulked drum of compatible waste (right).

generators cannot accumulate more than 55 gallons of characteristic hazardous waste that include ignitable, corrosive, reactive and toxic substances. For listed waste, no more than 55 gallons of F-listed (spent solvents from nonspecific sources), K-listed (spent solvents from specific sources) or U-listed (individual off-spec compounds) can be stored. P-listed waste (individual off-spec compounds that are considered acutely hazardous) is restricted to no more than 1 quart at the accumulation area.

In addition, waste containers must be labeled as hazardous waste and the area must be secured when no one is present (EPA, 2004). Each person involved in generating and removing hazardous waste from a specific satellite area is directed to take a hazardous waste procedures training class, which is available on the EHRM (2009) website. EHRM maintains a database of those who have completed the course.

The online training class covers the basic EPA hazardous waste rules, satellite accumulation area requirements and how to use the university's online waste pickup request system. The importance of labeling containers and storing waste materials in compatible containers is stressed as well.

After completing the course, individuals are expected to be aware of their responsibility to manage waste safely in their respective laboratory or work area. This sense of responsibility is considered to be crucial in the efforts to safely handle waste.

EHRM generally becomes involved in the waste handling process after a waste-pickup request is received. This is an important step and it represents the first opportunity to identify potential problems. Staff regularly encounter partially labeled or mislabeled waste, as well as waste stored in incompatible containers. Therefore, waste personnel must be vigilant when conducting waste pickups, as this is the first opportunity to avoid an unexpected reaction.

As noted, the online waste procedures training course covers key requirements for those involved in chemical waste handling activities. However, the college/university environment differs from a traditional industrial setting. For example, a researcher's funding level can differ dramatically each year, causing him/her to buy ahead or purchase additional stock chemicals when funding is available, regardless of immediate need. Researchers often leave behind legacy wastes, which are unused or unopened chemicals with an outdated shelf life.

In some cases, EHRM staff may decide to not remove a waste from the satellite area. For example, if a waste container has deteriorated over time and presents a potential explosive hazard such as picric acid, EHRM may opt to have a qualified vendor remove the waste directly from the area.

Legacy wastes also can be a chronic problem for colleges and universities as these waste containers can be old and have faded labels. To combat this problem, EHRM has an aggressive laboratory audit team that stresses the importance of keeping accurate chemical inventories and the need to regularly dispose of outdated and unusable chemical compounds.

Hazardous Waste Facility Operations

In FY08 (Sept. 1, 2007, to Aug. 31, 2008), EHRM staff performed 334 chemical waste pickups (EHRM, 2008). The amount of waste can vary widely as can the size of the container, although historically most waste containers are 4 L bottles. It appears that the generators on campus reuse original purchased stock bottles as hazardous waste containers by simply adding a hazardous waste label. The 4 L bottle is the container most commonly purchased on campus.

Photo 2: EHRM staff modified a fume hood at the hazardous waste facility, which allowed for more bulking with a higher comfort level for EHRM waste personnel.

Throughout the year, a steady stream of chemical waste arrives during the university's regular business hours. Upon delivery to the waste facility, containers are examined, dated and segregated by hazard category. During this process, potential CHEM-SWAP items are placed in a separate location and all unknowns are placed in a central location.

The waste facility is operated in accordance with TCEQ rules for a less-than-90-day storage facility. This means that hazardous waste must be shipped off site within 90 days of its arrival. UH currently ships out waste on a monthly schedule using an outside vendor. Although this is a higher frequency than necessary, it has been advantageous in terms of limiting the amount of chemical waste stored in the facility at any one time. In addition, the more frequent shipments allow EHRM personnel to respond to any concerns from the transporter or receiving facility that may arise from a particular waste shipment.

In general, waste shipments from the UH facility tend to be either a laboratory over-pack (lab pack) or a bulk shipment of compatible waste (Photo 1). One of the more successful waste minimization projects implemented in the facility has been the increased bulking of compatible chemical waste. This consists of safely bulking compatible liquid chemical wastes by combining the contents of individual containers into a single larger container such as a 55-gallon drum.

The increase in the amount of bulking has significantly reduced the quantity of lab pack waste. A 55-gallon lab pack waste drum typically contains 14 to 16 individual containers (bottles) packed in absorbent packing material. Historically, this was a convenient way for laboratories to dispose of multiple containers of various waste chemicals at one time. However, the entire drum is considered hazardous waste even though a significant percentage of its contents may be packing material. By bulking the contents of the individual containers together in a single drum, the total quantity of lab pack waste can be reduced.

While bulking is an attractive waste minimization technique, the potential exists for an unexpected reaction ("the big bang") during this process. In some cases, for example, if a container shows signs of crystallization, severe corrosion or deformity, it would be safer not to bulk an individual container but rather to ship it out in a lab pack. Therefore, EHRM personnel must be vigilant in handling chemical waste and take steps to avoid an unexpected reaction. The goal is simple: Zero surprises during bulking activities.

Avoiding the Big Bang

After the initial assessment of the waste container, a preliminary decision is made on the planned shipment for disposal. The first decision for potential bulk chemical wastes is whether the individual container can be safely opened. EHRM personnel examine the container for signs of crystal formation or bulging. Some waste picked up on campus may be shock-sensitive or explosive. Depending on the specific compound, some additional research is conducted via the generator, Internet or the university's waste disposal vendor. Periodically, personnel may decide to isolate a specific container and bring in a specially trained and equipped high-hazard team to handle the waste.

Generally, EHRM staff bulks halogenated solvent waste containers into a 55-gallon drum and bulks nonhalogenated solvent waste containers into a separate 55-gallon drum. Many university laboratory waste streams are cyclical as new research projects are funded and laboratories are set up. Therefore, EHRM staff tends to pick up the same "labeled" waste multiple times, which can lead to a sense of complacency in handling the waste. This is where the experience and best practices of the waste handling team play a role in avoiding problems. For example, EHRM personnel use test buckets to identify potential reactions on a small scale rather than having a reaction in a larger drum.

EHRM also modified the fume hood in the waste facility so that solvent bulking can be performed in the fume hood (Photo 2). The original fume hood

Table 1

Summary of Potential Actions by Waste Handling Personnel

Action	Benefits
Careful physical observation of the container	Identify potential hazards such as leaks, formation of crystals
pH measurement	Categorize the waste, avoid unexpected reactions
Use of commercially available test strips	May identify the waste, learn about the characteristics
Use test containers for bulking	Avoid large-scale unexpected reactions
Conduct additional research on waste	May be able to identify it or learn more about the characteristics of the waste
Modification of containment equipment to facilitate bulking	Increased safety for waste handling personnel
Purchase of additional detection equipment	Depending upon capability quick identification of unknowns
Use outside vendor expertise for removal	Elimination of hazard for waste-handling personnel

Depending on the hazard involved, EHRM personnel may decide to isolate a specific container and bring in a specially trained and equipped high-hazard team to handle the waste.

had a cabinet as its base. The cabinet was removed so that a 55-gallon drum can be rolled under the fume hood. A hole was drilled through the countertop so that materials can pass directly into the drum beneath the fume hood. The benefit of this modification is that the level of exhaust is much stronger than the local flexible duct that was formerly used. This change has allowed for more bulking with a much higher comfort level for EHRM waste personnel.

Unknown and partially labeled wastes pose a special challenge. Again, after an initial decision is made to open the container, several steps may be taken to identify potential hazards. A pH measurement can determine whether the waste is acidic or basic, and what level of PPE is appropriate.

An over-the-counter test strip is another potential tool. Available from various sources, these strips can yield information about multiple properties of the waste. The strips EHRM uses are color-coded and identify the presence of oxidizers, fluoride, organic solvents, iodine, bromine, chlorine and pH (NPS, 2009). Staff also can use a balance to estimate density, which can help identify an unknown waste.

On several occasions, EHRM has worked with faculty and scientific staff to use gas chromatographs on campus to identify unknown wastes. Similarly, chemical waste managers who do not work in an educational environment should consider what resources may be available in their respective facilities that could be utilized in handling unknown chemical wastes.

In addition, a new generation of detectors is coming on the market as part of Homeland Security initiatives designed to identify potential chemical and explosive hazards (DHS, 2009). For example, First Defender is a handheld device that uses Raman Spectroscopy to identify unknowns (Ahura Scientific, 2009). In one demonstration, the instrument was placed next to a bottle of mosquito spray and it quickly identified the contents as insect repellant. In all cases, the more that can be learned about unknown waste the more it benefits all involved in handling and disposal.

Table 1 (p. 57) presents a summary of actions and potential benefits that EHRM waste handling personnel have found to be helpful in avoiding unexpected reactions.

Conclusion

UH generates substantial quantities of chemical waste on a yearly basis, much of it defined as hazardous per the EPA and TCEQ rules. EHRM is responsible for collecting this waste and preparing it for ultimate disposal at an approved facility. The group accomplishes its mission by picking up waste at many satellite accumulation areas around the campus and bringing it to a central storage facility where it is prepared for final disposal off site.

During this process, EHRM personnel strive to avoid any unexpected reactions. EHRM personnel believe that all waste generators should receive a basic level of training, particularly about how to label and store hazardous waste. This training can help avoid problems such as storing acidic waste in metal containers that can corrode over time and pose further hazards as a result.

One of EHRM's more successful waste minimization techniques has been the increased bulking of compatible chemical wastes into a single container versus sending out lab pack drums with several individual containers and packing material. However, this practice increases the risk of an unexpected reaction, so steps must be taken to avoid these reactions.

Modifications to a fume hood, and the use of test buckets, portable pH monitors and multipurpose test strips have been helpful practices as well. The Internet offers many sources concerning chemical compatibility and chemical identification. In EHRM's experience, the more information that can be learned about a waste, the better the chances of avoiding an unexpected reaction while handling it. ■

References

Ahura Scientific. (2009). Chemical and explosives identification. Wilmington, MA: Author. Retrieved Jan. 7, 2009, from http://www.ahurascientific.com/chemical-explosives-id/index.php.

Bialowas, Y.D., Sullivan, E.C. & Schneller, R.D. (2006). Designing a low-cost pollution prevention plan to pay off at the University of Houston. *Journal of the Air and Waste Management Association, 56*(9), 1320-1324.

Department of Homeland Security (DHS). (2009). Science and technology. Washington, DC: Author. Retrieved Feb. 13, 2009, from http://www.dhs.gov/xres.

Environmental Health and Risk Management Department (EHRM). (2008). Annual report fiscal year 2008. Houston, TX: University of Houston, Author. Retrieved Feb. 13, 2009, from http://www.uh.edu/plantops/reports/EHRM_2008_Annual_Report.pdf.

EHRM. (2009). Online training: Hazardous waste procedures. Houston, TX: University of Houston, Author. Retrieved Feb. 13, 2009, http://www.uh.edu/plantops/ehrm/ehrm_safety_training_online.html#HazardousWaste.

EPA. (2004). Frequent questions about satellite accumulation areas. Washington, DC: Author. Retrieved Feb. 13, 2009, from http://www.epa.gov/epawaste/hazard/generation/labwaste/memo-saa.htm.

EPA. (2008). Standards applicable to generators of hazardous waste [40 CFR Parts 260-265]. Washington, DC: Author. Retrieved Feb. 13, 2009, from http://www.access.gpo.gov/nara/cfr/waisidx_08/40cfrv25_08.html.

National Research Council. (1995). *Prudent practices in the laboratory.* Washington, DC: National Academy Press.

NPS Corp. (2009). Spilfyter chemical classifier strip. Green Bay, WI: Author. Retrieved Feb. 13, 2009, http://www.npscorp.com/spilfyter/570010.

Texas Commission on Environmental Quality (TCEQ). (2003). Pollution prevention: Source reduction and waste minimization [Chapter 335 Subchapter Q]. Austin, TX: Author. Retrieved Feb. 13, 2009, from http://www.tceq.state.tx.us/assets/public/legal/rules/rules/pdflib/335q.pdf.

TCEQ. (2006). Standards applicable to generators of hazardous waste [Chapter 335 Subchapter C]. Austin, TX: Author. Retrieved Feb. 13, 2009, from http://www.tceq.state.tx.us/assets/public/legal/rules/rules/pdflib/335c.pdf.

University of Houston (UH). (2009a). Campus master plan. Houston, TX: Author. Retrieved Feb. 12, 2009, from http://www.uh.edu/about/initiatives/master-plan/index.php.

UH. (2009b). Facts and figures. Houston, TX: Author. Retrieved Feb. 12, 2009, from http://www.uh.edu/about/uh-glance/facts-figures/index.php#research.

UH. (2009c). UH at a glance. Houston, TX: Author. Retrieved Feb. 12, 2009, from http://www.uh.edu/about/uh-glance/index.php.