Session No. 704

Minimizing Chemical Waste without the Big Bang

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Introduction

The University of Houston (UH) is located just south of downtown Houston, Texas. The campus covers approximately 550 acres and includes over 100 buildings. Current enrollment is over 35,000 students with approximately 5,000 faculty and staff (UH at a Glance, 2009). There are over 700 laboratories on campus presently with more planned in the coming years. The University has plans to double sponsored scientific research on campus and to grow the student population up to ~45,000 in the coming years (Campus Master Plan, 2009).

Many different chemical substances are used in scientific research and teaching activities throughout the campus. In addition, many solvents are used in the maintenance and support areas of the University. While efforts are made to reduce, reuse and recycle as much as possible, many chemical substances ultimately are discarded as regulated hazardous waste per the Environmental Protection Agency (EPA) and the Texas Commission on Environmental Quality (TCEQ) rules (EPA, 2008). The TCEQ is the state agency which implements EPA rules in Texas (TCEQ, 2006). Currently the University is classified as a large quantity generator and generates over 10 tons of hazardous waste per year.

The University faces regulatory and economic pressure to minimize the amount of hazardous waste generated on campus. As a large quantity generator, the University is required to develop a pollution prevention (P2) plan and report yearly on progress to the TCEQ (TCEQ, 2003). One of the critical functions of the Environmental Health and Risk Management Department (EHRM) is to manage the University's chemical waste in accordance with the applicable EPA and TCEQ rules. This is a sizeable undertaking for the EHRM staff and ties up many resources. In addition, chemical waste disposal currently costs the University thousands of dollars per year. There is no long term investment in waste disposal costs for the University other than a demonstration of regulatory compliance.

Waste Minimization Activities

Colleges and universities are typically not considered as industrial facilities, yet many face the same regulatory concerns, such as hazardous waste, air quality, and storm water as industrial facilities. The EHRM has undertaken a range of initiatives to minimize the amount of hazardous waste shipped off campus for disposal. When possible we try to eliminate the initial generation of the waste at the source, such as by adding a silver recovery unit in a photographic darkroom,

and eliminating the generation of silver contaminated waste water (Bialowas et al, 2006). We also created a chemical exchange (CHEM-SWAP) program which allows University users to swap reusable chemicals across the campus. The EHRM has also prepared recommendations for the University's Purchasing Department in an effort to stop the introduction of likely future hazardous waste generating products, such as mercury thermometers, and, to promote the use of greener products.

The EHRM has been successful over the past several years in reducing the amount of hazardous waste generated on campus that is shipped off-site for disposal. The graph below shows the amount of hazardous waste generated on the main campus and reported to the TCEQ per calendar year.

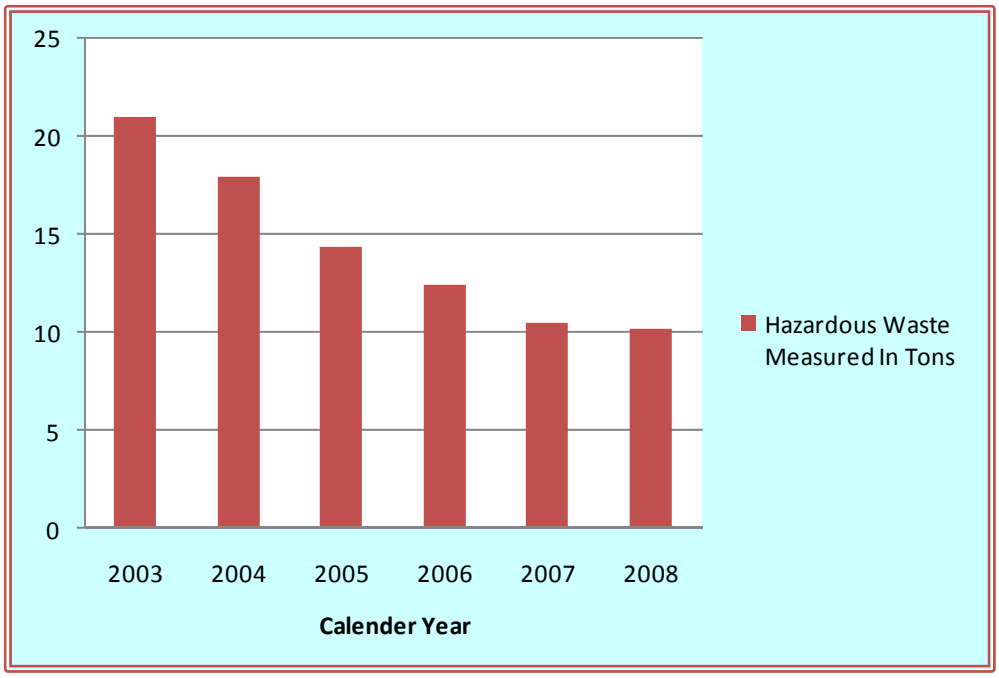

Exhibit 1. Graph showing hazardous waste generation for calendar years 2003 through 2008 at the University of Houston.

The challenge facing the EHRM is to continue to reduce the amount of waste shipped off campus for disposal, as the University undertakes a major growth campaign in the coming years. The level of sponsored research has grown to over 86 million dollars in FY 2007 (Facts and Figures, 2009). Again, the current goal is to double the level of funded research in the coming years.

General Waste Handling Procedures

The 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 the EPA and TCEQ rules. Briefly, this means that waste generators cannot accumulate more than 55 gallons of hazardous waste or one quart of an extremely hazardous waste (p-listed) at their location. Also, waste containers must be labeled as hazardous waste and the area secured when no one is present (EPA, 2004). Each individual involved in the generation and removal of hazardous waste from a specific satellite area is directed to take a Hazardous Waste Procedures Training Class. The EHRM now has this class available on its web site and maintains a database of the individuals who successfully completed the course (Online Training, 2009).

The training class covers the basics of the EPA Hazardous Waste Rules, the satellite accumulation area requirements and how to use our on-line waste pick up request system. The importance of labeling containers and storing waste materials in compatible containers is stressed in the presentation. Upon completion of the course, the EHRM expects the individual to be aware of his or her responsibility in managing waste safely in their respective laboratory or work area. We consider this sense of responsibility crucial in our efforts to safely handle waste.

The EHRM generally becomes involved in the waste handling process after a waste pick-up request is received in our office. This is an important step for EHRM personnel and it is our first opportunity to identify potential problems with the waste. We regularly encounter partially labeled or mislabeled wastes, as well as waste stored in incompatible containers. Therefore, it is important for our waste personnel to be vigilant when conducting waste pick-ups, as this is our first opportunity to avoid an unexpected reaction.

There may be occasions when the EHRM will decide not to 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, we may opt to have a qualified vendor remove the waste directly from the area. Likewise legacy wastes, from past researchers and instructors, can be a chronic problem for most colleges and universities. Frequently these waste containers can be decades old and have faded labels. The EHRM combats this problem by having an aggressive laboratory audit team that stresses the importance of keeping accurate chemical inventories and regularly disposing of outdated and unusable chemical compounds.

Hazardous Waste Facility Operations

In FY08, the EHRM performed 334 chemical waste pick ups (Annual Report, 2008). The amount of waste can vary widely as well as the size of the container, although historically most of our waste containers are 4 liter bottles. There is a steady stream of chemical waste arriving during the University's regular business hours throughout the year.

Upon delivery to our 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 the unknowns are placed in a central location. The waste facility is operated in accordance with the 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. We currently ship out waste on a monthly schedule using an outside vendor. Although this frequency is more than necessary, we have found it to be 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 the EHRM

to respond to any concerns from our transporter or receiving facility that may arise from a particular waste shipment.

In general, the waste shipments from our facility tend to either be a laboratory over pack or a bulk shipment of compatible waste. One of the more successful waste minimization projects implemented in our waste facility has been the increased bulking of compatible chemical waste. This project 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 EHRM has increased the amount of bulking over the past several years. This has lead to a significant reduction in the quantity of our laboratory over pack (lab pack) waste. A 55 gallon lab pack waste drum typically contains 14 – 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, although a significant percentage may be the packing material. Therefore by bulking the contents of these individual containers together in a single drum, a reduction in the total quantity of lab pack waste can be readily achieved.

While bulking has become an attractive waste minimization technique at the University, there is a potential for an unexpected reaction (i.e. the big bang) during the bulking process. For example, there may be cases where it would be safer not to open an individual container but rather ship it out as a lab over pack. We face the same challenges as other institutions and facilities in handling waste containers that may be mislabelled or labelled as unknown. Many of our laboratory generated waste streams contain mixtures of multiple compounds, which may or may be not be identified. Therefore EHRM personnel must be ever vigilante in handling chemical waste and take steps to avoid an unexpected reaction. Our goal is very simple; we strive for zero surprises during bulking activities.

Exhibit 2. Comparison of a lab over-pack drum (left) versus a bulked drum of compatible waste (right).

Avoiding the Big Bang

After the initial assessment of the chemical waste container is made, 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 of the waste we pick up on campus may be shock-sensitive or explosive. Depending on the specific compound, we will conduct additional research via the generator, web, or our waste disposal vendor. There are numerous resources available on the web and the EHRM has several posted on our web site. Periodically, a decision may be made to isolate a specific container and have a specially trained and equipped high-hazard team brought in to handle the waste.

Generally the EHRM bulks halogenated solvent waste containers into a 55 gallon drum and bulks non-halogenated solvent waste containers into a separate 55 gallon drum. Many laboratory waste streams tend to be cyclical at the University as new research projects are funded and laboratories are set up. Therefore the EHRM tends to pick up the same "labeled" waste multiple times and this can lead to a sense of complacency in handling the waste. This is where the experience and best practices of your waste handling team can 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.

Another step we have taken is to modify our fume hood in the waste facility to allow for solvent bulking to be done in the fume hood (see photograph below). The original fume hood had a cabinet as the base of the fume hood and we removed the cabinet in order to allow a 55 gallon drum to be rolled under the fume hood. A hole was drilled through the counter top to allow for passage of materials into the drum directly 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 modification has allowed us to increase the amount of bulking with a much higher comfort level for the EHRM waste personnel.

Exhibit 3. A picture of the modified fume hood in the UH hazardous waste facility.

Unknown and partially labeled wastes pose a special challenge to EHRM personnel. Again, after an initial decision is made to open the container, there are several steps that may be taken to identify potential hazards with waste. A pH measurement can be taken if a probe is available, and it can very useful in making a preliminary identification of the waste. Another potential tool is the use of an over the counter test strip. These can be purchased from a variety of

sources and can yield information about multiple properties of the waste (NPS, 2009). The availability of a balance to estimate density can also aid in the identification of an unknown waste.

The EHRM has benefited at times through the cooperation of our faculty and scientific staff. We have been able to use gas chromatographs on campus on several occasions to identify unknown wastes. While many readers involved in chemical waste management do not work in an educational environment, there may be resources available in their respective facilities that could be utilized in handling unknown chemical wastes. There is also a new generation of detectors that are coming on the market as part of the Homeland Security initiatives that are designed to identify unlabelled or unknown chemical compounds (DHS, 2009). The more that can be learned about unknown waste benefits all involved in the handling and disposal.

The following table is a summary of the actions and potential benefits that EHRM waste handling personnel have found to be helpful in avoiding unexpected reactions.

Action	Benefits
• Careful physical observation of the container	• Identify potential hazards such 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

Table 1. A summary of potential actions that can be taken by waste handling personnel to avoid unexpected reactions.

Conclusions

The University of Houston generates substantial quantities of chemical waste on a yearly basis. Much of this waste is defined as hazardous per the EPA and TCEQ rules and must be managed in accordance with the applicable regulations. The EHRM has the responsibility of

collecting this waste and preparing it for ultimate offsite disposal at an approved facility. The EHRM accomplishes its mission by picking up waste at many satellite accumulation areas around the campus and bringing it to a central storage facility in preparation for final disposal offsite. The University faces economic and regulatory pressure to minimize the generation of hazardous waste.

During this process EHRM personnel strive to avoid the unexpected reaction (i.e. the big bang) when handlings hundreds of containers of various sizes throughout the year. It has been one of our observations that all waste generators should have a basic level of training, particularly in the labeling and storage of hazardous waste. This can help avoid problems such as storing acidic waste in metal containers that can corrode overtime, and create problems for EHRM personnel. We have been able to present a training class on our web site, which is virtually available to all members of the UH community.

One of our more successful waste minimization techniques has been the increased bulking of compatible chemical wastes into a single container versus sending out laboratory over pack drums with several individual containers and packing material. However, with increased level of bulking, the risk of an unexpected reaction increases and steps must be taken to avoid these reactions. We have found that modifying our traditional fume hood has increased the safety of our bulking procedures as well as the comfort level of the EHRM personnel. The use of test buckets has also aided our efforts to improve safety by identifying potential reactions on a small scale versus a larger scale.

There are many commercially available probes and test strips that are available to help characterize waste. The EHRM has found portable pH monitors and multipurpose test strips to be particularly useful in identifying waste properties. On a similar note, we have been able at times to utilize some of the scientific equipment and expertise on campus to help identify or characterize a waste. Another consideration may be the purchase of additional detection equipment instruments which is being driven by the Homeland Security initiatives. The web also has numerous informational sources concerning chemical compatibility and chemical identification. It has been our experience that the more information that can be learned about a waste, the chances of an unexpected reaction in handling of that waste decrease.

The University is expected to experience dramatic growth in the coming 10 years. There are plans to increase student enrollment, add more buildings, and increase the level of funded research. This will no doubt lead to greater pressure on the EHRM to minimize the generation of hazardous chemical waste on campus. We will continue our efforts to handle the expected increase in waste in a safe manner and avoid unexpected reactions.

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