EMERGING TECHNOLOGIES: Hazard Assessments Find SAME OLD PROBLEMS

By LAURA L. HODSON and ROBERT E. UHORCHAK

Emerging technologies may present unique hazards beyond common chemical, biological and/or physical safety hazards. One would expect that state-of-the-art technologies would be designed to minimize potential hazards. This expectation was tested through hazard assessments of seven emerging technologies. The assessments were not performed as OSHA inspections, but rather as total or holistic hazard evaluations. The facilities involved were located in North Carolina, New York, Pennsylvania, Iowa and Arizona.

THE TECHNOLOGIES

The emerging technologies evaluated:

- treatment of medical waste by steam autoclave, microwave, pyrolysis and mechanical/chemical methods;
- biomass reactor;
- mobile coal gas desulfurization lab;
- a semiconductor research and development lab.

Hazard evaluations focused on chemical, physical and safety hazards, since biological hazards were unique to the medical waste treatment facilities and have been reported elsewhere (Owen, et al 1; Leese, et al 8).

Each facility had written safety and contingency plans. All were concerned with providing a safe, healthy work environment. The number of employees at each site ranged from two to 30.

Medical Waste Treatment Facilities

Four of the seven technologies evaluated involve processing of medical waste. The Medical Waste Tracking Act of 1988 defines medical waste as "any solid waste which is generated in the diagnosis, treatment or immunization of human beings or animals, in research pertaining thereto, or in the production or testing of biologicals." Treatment is defined as "any method, technique or process designed to change the biological character or composition of any regulated waste so as to reduce or eliminate its potential for causing disease."

Traditionally, incineration has been a primary method of treating and destroying medical waste. Due to environmental air pollution concerns, however, several new treatment technologies have been developed as viable alternatives. The treatment technologies evaluated were: steam autoclave, microwave, pyrolysis and mechanical/chemical treatments.

Steam autoclave treatment combines moisture, heat and pressure to inactivate infectious agents. The process has long been used in hospitals to sterilize medical instruments, and its validation as a sterilization technique for medical equipment and supplies is well documented. However, using a large steam autoclave that can treat nominally 3,000 lbs. of medical waste per cycle at 160°C and 80 to 85 psi is unique. After treatment, the waste is suitable for disposal in a municipal landfill.

Microwave treatment uses non-ionizing radiation to heat water and medical waste in order to produce the steam/thermal inactivation of infectious agents. Waste is fed by continual batch mode into a grinding chamber where it is mechanically shredded/destroyed to render it unrecognizable. The shredded waste is then treated with steam as it slowly moves through a transport auger under a series of microwave units. Internal temperature of the microwave system is maintained at 95°C and can treat between 220 and 900 lbs./hr. Treated waste is suitable for disposal in a municipal landfill.

Pyrolysis brings about a chemical reaction by the action of heat (usually at very high temperatures) and in the absence of oxygen. Pyrolysis units pyrolyze waste at a controlled temperature of nominally 500°C. This reduces most medical waste to gases, leaving only a small amount of dust and solid debris; metals and ceramics are not reduced in size, but are sanitized by the high temperature in the treatment unit. Treatment capacity of the unit evaluated was 40 lbs./hr. Acidic waste gases are neutralized and the solution disposed of via the sanitary sewer; solids are suitable for disposal in a municipal landfill.

Mechanical/chemical treatment technology involves a continuous-feed process that combines waste shredding with a chemical treatment (12 to 16 percent sodium hypochlorite solution), at a capacity of 2,000 lbs./hr. Treatment solution is recycled in the process, and treated waste is suitable for disposal in a municipal landfill.

Biomass Reactor

The biomass reactor pyrolyzes wood chips and uses the off-gases to power gas and diesel engines that drive an electric generator. This technology may be used to produce electricity in areas without access to petroleum products. The prototype studied pyrolyzes approximately 2,000 lbs. of wood products per hour to power a 1 MW generator. Small amounts of wood tar byproduct are also produced, along with larger amounts of activated carbon.

(Left): Electrical safety was universally inadequate. Access to electrical control panels was often obstructed by clutter, and circuit breakers were unlabeled and often had no protective blanks. In many cases, required ground fault circuit interrupters were not in place.

(Top): The assessment found that the facilities often did not have the same degree of concern about materials stored outside as for those stored inside. For example, in this parking lot, no barriers were in place to protect the drums from vehicle traffic.

(Above): At one facility, unlabeled liquids were found in used drink bottles around machine shop and mechanical support areas. These presumed flammable liquids were not stored in a flammables cabinet nor was secondary spill containment in place.

Coal Gas Desulfurization

The mobile coal gas desulfurization unit consists of an 8x12x50-ft. trailer with an 8x12x30-ft. laboratory area and an 8x12x20-ft. office area. The trailer is designed to be located onsite at a coal-powered electrical generation facility. A portion of exhaust gases from the burning of coal in the power plant is routed to the desulfurization unit located in the laboratory area; sulfur is removed from the waste stream by use of a novel catalytic method.

Semiconductor Laboratory

The semiconductor laboratory was 100x100x12-ft. with high efficiency particle arresting (HEPA)-filtered incoming air for product protection. Ventilated work chambers contained a customized semiconductor material growth apparatus that used flammable and highly toxic gases as raw materials. Novel semiconductor chips were "grown" by control of gases used and substrate materials. Excess gases were oxidized in a controlled manner and resultant oxides trapped on HEPA filters.

HAZARD ASSESSMENT PROCEDURES

Evaluation of complex situations requires a logical strategy designed to focus on work situations with the greatest potential to produce adverse health effects (Hawkins). Since the authors did not reside near the locations studied, a three-phase assessment strategy was devised.

Phase 1 entailed gathering as much information as possible about the facility and its processes prior to the site visit. Data gathered included the number of employees and their jobs; chemicals and other materials used; potential reactions; training provided; and required personal protective equipment (PPE).

This information provided a picture of what to expect before the site visit; ensured that researchers would have correct PPE for those visits; and allowed pre-planning of sampling and assessment activities. In an effort to not "alarm" employees, the researchers decided to wear only PPE required at each facility, despite knowing that the hazard assessment might reveal that those requirements were not adequate.

Phase 2 was the initial site visit, which began with an introductory meeting during which the purpose of the visit—to identify oversights and help provide a safe, healthy workplace—was explained. Since this was not a "compliance-oriented" activity, workers were encouraged to talk with the assessors and identify concerns.

The walkthrough inspection was performed using an OSHA safety self-inspection checklist (www.osha-slc.gov/SLTC/smallbusiness/chklist.html). The assessors also talked with supervisors, reviewed written plans and observed each facility's safety procedures (Laing 155, 379). Emission points were sampled utilizing evacuated cylinders, colorimetric indicator tubes and filters/sorbent tubes using NIOSH methods where applicable (NIOSH 94-113). Area noise and indoor air quality surveys (temperature, relative humidity, carbon dioxide and carbon monoxide) were performed, as was physical hazard monitoring (e.g., microwave and radiation surveys).

Phase 2 results were used to determine collection points and sampling procedures for Phase 3, which included personal chemical and physical exposure measurements.

In most cases, a return site visit was scheduled after Phase 2 results were obtained; this allowed the researchers to select chemical-specific sampling media. At two medical waste treatment facilities, a combination assessment was performed during which both area and personnel sampling were completed; this was possible because the researchers had previously identified chemical species expected from assessments at the other two medical waste facilities.

One note: Although the purpose was not to enforce regulations, deviations from OSHA's general industry standards (29 CFR 1910) were noted in the hazard assessment reports prepared for each facility.

ASSESSMENT FINDINGS

Administrative Controls

All facilities had addressed safety and industrial hygiene concerns through written plans; in most cases, these plans were being implemented. However, some areas of concern were noted. For example, at one site, the written plan prohibited food and drink in the processing area, yet both a water fountain and a drink machine were found in that area. Another site had a written respiratory protection program, yet no training records were available for employees using respirators.

Generally, initial processes remained unchanged with respect to the use of materials; substitution of less-hazardous materials was rare. Most changes involved efforts to optimize material flow and modify equipment to perform in ways not originally intended. Often, MSDS were either dated (yet still applicable) or unavailable.

Personal Protective Equipment

Although initial selection of PPE was good, enforcement of its use was fair to poor. One site had a comprehensive written respiratory protection program, yet uncleaned, unbagged and unlabeled respirators were stored haphazardly in cabinets. Another site had a written requirement for face shields, which workers wore in the "up" (nonprotective) position.

Facilities

At the time of construction, facilities met relevant fire, electrical and mechanical codes and were designed to handle the original process. Over time, however, operating staff had made changes to facilitate processes; these changes often created safety problems due to the staff's unfamiliarity with relevant codes.

Common problems involved electrical safety, hazardous materials storage and fire protection. In several cases, emergency egress doors were unlabeled or locked, and basic egress maps and directional signage were not in place. Toe boards—to protect people and material from falling objects—were often missing as well.

In some cases, facilities were not using available tools to detect hazards. For example, the microwave facility had microwave survey detectors to monitor for leaks, but these devices were found to be out of calibration and without batteries. One microwave unit was leaking because bolts were loose. Had the facility been following its written procedures, this problem would have been corrected before this hazard assessment was conducted.

Slip and fall hazards—including wet floors, loose planks, hoses and electrical wiring strewn across walkways—were present at all sites as well.

Inspection of the facilities' exteriors found that most lacked secondary containment, as well as proper signage and barriers to protect materials from being struck by vehicles. Fire truck access and hydrant hookup were neglected as well; these areas were obscured, with signage in poor condition or missing.

Ergonomics

Each facility had work activities that required manual materials handling. For example, at medical waste treatment facilities, workers had to lift, turn and dump boxes and bags that weighed 15 to 70 lbs. At both the biomass reactor and coal gas desulfurization facilities, employees had to assume awkward positions for brief periods of time. It appeared that automation had not been considered in the design of these processes.

Noise Exposure

High noise levels (>85 dBA) were associated with mechanical grinders and shredders at medical waste treatment facilities, as well as with the biomass reactor conveyor/feeder and generator. These exposures were addressed via active use of PPE rather than engineering controls to reduce noise levels. Hearing conservation programs were in place, ear plugs were available and compliance was consistent.

Chemical Safety

A wide variety of chemicals were sampled, including total organic compounds, formaldehyde, ketones and other aldehydes, metals, chlorine, ammonia, and total and respirable dust. Air sampling found concentrations of high-hazard items to be well below established limits (due to good engineering controls).

However, ordinary hazards/potentials—such as the potential for asphyxiation from release of nitrogen in a confined area—were often overlooked. For example, at one facility, an employee was observed "holding his breath" while pouring ammonia in a boiler room. (This employee changed his work practice the next day to include use of a respirator while pouring ammonia.)

Unlabeled liquids were found in used drink bottles around machine shop and mechanical support areas. These presumed flammable liquids were not stored in a flammables cabinet nor was secondary spill containment in place.

In a facility that used propane forklift trucks, the concentration of carbon monoxide (CO) was nearly 150 ppm (OSHA's permissible exposure limit is 50 ppm). Normally, the facility's loading dock doors were open, but due to extreme weather, the doors had been closed.

Electrical Safety

Electrical safety was universally inadequate. Access to electrical control panels was often obstructed by clutter, and circuit breakers were unlabeled and often had no protective blanks. In many cases, required ground fault circuit interrupters were not in place. Extension cords were damaged, improperly taped and used as permanent wiring. In one facility, an extension cord ran through a broken window of one building to another building.

CONCLUSION

Despite documented safety plans, several areas of improvement were noted. Although each site had planned for safety, facility modifications, poor work practices and inadequate policy enforcement often negated those plans.

From an administrative perspective, non-compliance with existing written plans was common. Written respiratory protection programs were frequently violated. For example, employees often stored respirators without cleaning them or putting them in storage bags. One site had no written record of training (although employees claimed they had been trained).

The assessment also found that the facilities did not have the same degree of concern about materials stored outside as for those stored inside. Some facilities had secondary containment, while others stored 55-gal. drums within easy access of vehicles. None had formally considered hazards from adjacent properties. For example, at one site, a boulder was blocking the nearest fire hydrant; at another, an adjacent property had an uncontained fuel oil tank that could leak fuel onto the site.

Assessment conclusions were well-received by site management, and the authors were told that identified hazards would be abated. Due to the scope of work, however, this has not been verified. In the case of the most-imminent danger (high CO levels), dock doors were opened immediately and management purchased a CO detector. The facility was also considering a CO scrubber for the fork truck.

Common Problems at Emerging Technologies

ADMINISTRATIVE
- Non-implementation of written plans.
- Failure to enforce policies/procedures.
- Lack of safety design within processes.
- Outdated or missing MSDS.

PERSONAL PROTECTIVE EQUIPMENT
- Incorrect use/no use.
- Incorrect storage.

FACILITIES
- Unlabeled or blocked emergency doors.
- Improperly stored materials inside and/or outside facilities.
- Outdated safety equipment.
- Slip/trip hazards.

ELECTRICAL SAFETY
- Incorrect use of electrical cords.
- Cluttered areas around circuit breaker panels.
- Unlabeled circuits in panels.
- Missing blanks in panels.
- Lack of ground fault circuit interrupters.

CHEMICAL SAFETY
- Unlabeled bottles.
- Flammables not stored in flammables cabinet.
- Lack of secondary containment.

RECOMMENDATIONS

Hazard assessments at any facility should include inspections from a holistic perspective. This big-picture review should encompass standard OSHA-type concerns as well as fire, environmental and transportation factors. Administrative and engineering controls and rules enforcement should also be reviewed, and workers interviewed and observed to assess compliance with procedures. Materials used should be reviewed, and the list of chemicals used compared to MSDS available. MSDS should be reviewed to ensure that correct PPE is being used.

To conduct an effective survey within a limited timeframe, it is best to review written plans *before* arriving onsite; use prepared checklists to ensure that no items are overlooked; bring appropriate PPE and survey instruments/tools; and expect the unexpected. A camera is also useful, since resulting images can clearly depict the hazards observed and facilitate preparation of an accurate final report. In retrospect, the researchers should have spent less time reviewing written plans and more time observing workers.

After reflecting on the big picture, the researchers noted that several facilities faced the same exposure and safety issues. Despite the diversity of these technologies, certain problems were common. Overall, management and staff were attempting to operate safely, yet were unaware of relevant regulations and codes. All of the facilities assessed would be well-served to have a knowledgeable safety/industrial hygiene expert conduct an independent review on a regular basis. ■

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Laura L. Hodson, *CIH, is a research industrial hygienist with Research Triangle Institute (RTI), located in Research Triangle Park, NC. She holds a B.S. from Wright State University and an M.S.P.H. from the University of North Carolina, Chapel Hill. She is a member of ASSE's North Carolina Chapter.*

Robert E. Uhorchak, *CSP, ALCM, ARM, is director of risk management at RTI and is the Institute's radiation and chemical safety officer. He holds an M.S. in Chemistry Education from St. John's University; and an M.S. in Industrial Management from Clarkson University.*

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