Transforming Medical Waste Disposal Practices to Protect Public Health:

Worker Health and Safety and the Implementation of Large-Scale, Off-Site Steam Autoclaves

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Transforming Medical Waste Disposal Practices to Protect Public Health:

Worker Health and Safety and the Implementation of Large-Scale, Off-Site Steam Autoclaves

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EXECUTIVE SUMMARY

Regulatory and public recognition that burning medical waste in incinerators produced major sources of dioxins and other hazardous emissions led to significant changes in medical waste disposal practices. In 1997, there were approximately 2,400 hospital/medical infectious waste incinerators operating in the United States, whereas in 2004, 110 such incinerators remained. However, alternative approaches to improve medical waste disposal practices have primarily been directed towards ensuring treatment efficacy and reducing the environmental impacts of disposal technology. The potential worker health and safety concerns common to the implementation of all medical waste treatment technologies, i.e., the handling and transport of infectious sharps and other hazardous materials, have received limited scrutiny.

In December 2002, representatives of the Center for Environmental Health, the American Nurses Association, and Greenaction brought the issue of potential health impacts of the medical waste disposal work process to the attention of the California Department of Health Services Occupational Health Branch (CDHS/OHB). As part of Health Care Without Harm, these organizations advocate for medical waste management practices that minimize the impact on the health of workers, communities, and the environment. Specifically, these organizations were concerned about the potential occupational health hazards of large-scale, off-site steam autoclaves that have been implemented to treat medical waste in lieu of incinerators that were shut down due to improved environmental regulations.

Primary prevention of occupational injury and illness involves ensuring that the implementation of alternative technologies to address environmental concerns also protects the health of workers. However, there was limited information about what hazards workers at steam autoclave or other treatment facilities actually encountered in practice, and how, or if, workers' exposures were controlled. Although the potential for worker hazards was not unique to steam autoclave technology, off-site steam autoclaves were of particular importance. An estimated 90 percent of California hospitals manage essentially all of their regulated medical waste off-site, and nine of 12 off-site medical waste treatment facilities in California utilize steam sterilization technology. In response to this concern, CDHS investigated the potential occupational hazards associated with a large-scale, off-site steam autoclave to make recommendations to prevent illness and injury.

METHODS

To investigate the potential occupational hazards associated with large-scale, off-site steam autoclaves, CDHS/OHB researchers: (1) observed the medical waste treatment process at one off-site steam autoclave facility; (2) interviewed employer representatives; (3) interviewed Drivers and Medical-Waste-Treatment Plant Workers; (4) reviewed employer written records; and (5) conducted key informant interviews. To evaluate the potential occupational hazards we assessed the presence of: (1) worker exposure to chemical, biological, and/or physical hazards and ergonomic stressors; (2) one or more potential routes of exposure, i.e., skin, air, eye, ingestion; (3) measures to limit workers' exposures; and (4) worker training and hazard communication about their exposures.

RESULTS

The steam autoclave employed an average of 70 male workers as Drivers (54.3 percent), Plant Workers (31.4 percent), and Managers/Supervisors (14.3 percent). Workers ranged in age from 23 to 61 years (average 39 years) and spoke English and/or Spanish. Plant Workers worked one of three eight-to-ten hour shifts, six days a week, and additional overtime as required. Drivers worked up to 15 hours a day, with up to 12 hours of driving. No union represented the Plant Workers. At the time of the CDHS/OHB investigation the Drivers were represented by the Brotherhood of Teamsters and Auto Truck Drivers, Local No. 70; subsequently, the Drivers decertified their union.

- The steps in the off-site steam autoclave work process were: (1) segregate and collect the medical waste stream; (2) load trucks and transport waste to an off-site steam autoclave; (3) unload tubs of waste from the truck; (4) scan, weigh, and monitor tubs for radiation; (5) dump waste from tubs into autoclave bin; (6) autoclave waste; (7) compact treated waste; (8) wash tubs; (9) maintain autoclave, boiler, and conveyor systems; and (10) bury treated waste at a landfill.
- During the period April to December 2002, the injury rate was 62 injuries per 100 full-time workers. In 2003, the injury rate was 46 per 100 full-time workers. The majority (59.4 percent) of the documented injuries were musculoskeletal injuries, followed by acute traumatic injuries (21.9 percent), needlesticks (12.5 percent), and eye injuries (6.2 percent). Virtually all of the workers' musculoskeletal injuries were related to routine, repetitive tasks, i.e., lifting, pulling, pushing, or otherwise moving tubs of waste.
- Many ergonomic hazards had been reduced or eliminated by the design of the work process. However, many risk factors for injury were still present, including: (1) extensive, repetitive manual handling of heavy waste containers; (2) picking up tubs of waste stored at generators in inaccessible areas or locations that required unassisted moving of the tubs on stairs; (3) transporting very heavy tubs, reportedly resulting from the disposal of large volumes of liquids in single tubs; and (4) the practice of stacking two or three tubs on top of each other, which also posed considerable safety hazards, as the height of the tubs made the load precarious and obscured the workers' field of vision.

- The work process involved manual handling of open tubs of infectious waste, and workers had the potential for direct contact with untreated waste during routine and maintenance activities.
- The worker protection afforded by waste packaging was integrated into the design of the work process in two ways: (1) waste was generally contained by packaging prior to autoclaving; and (2) the efficacy of steam autoclave treatment did not rely on shredding or other "unpackaging" of infectious waste.
- Post-treatment compaction of treated waste resulted in breaking sharps containers and the discharge of treated needles and syringes from their packaging. Treated sharps waste is a safety hazard and a biological hazard because sterility is not maintained in the ambient environment. The disposal of uncontained sharps led to a worker's injury at one landfill; several members of the public were also injured when they came into contact with sharps at this landfill.
- Housekeeping was generally good on the day of the investigation, and clean work clothes, gloves, safety glasses, face shields, showers, lockers, and hand washing stations were readily accessible and freely available to workers. Weaknesses of these measures were: (1) wearing short sleeve shirts left workers' arms exposed; (2) eye protection was not required and/or consistently used by all workers who handled waste; (3) there was no written policy about the use of gloves at the autoclave control panel; (4) the timing and frequency of cleaning floors and surfaces were not specified (i.e., every shift, daily, weekly, etc.) and documented; and (5) contaminated poles and shovels were placed haphazardly at the dumping station.
- Chemicals that are strong respiratory and eye irritants, and respiratory sensitizers, were used routinely for cleaning. Health protective cleaning work practices were present, but had not been fully incorporated into purchasing and operating procedures. Maintenance workers were especially at risk for exposure to hazardous chemicals.
- Workers were exposed to carbon monoxide levels of concern from an operating propane powered forklift.
- Workers were exposed to noise at or above the California Division of Occupational Safety and Health (Cal/OSHA) action level while engaged in routine tasks and as a result of equipment failure; however, workers were not enrolled in a hearing conservation program.
- Drivers encountered considerable traffic hazards while picking up and transporting waste although, notably, no vehicular accidents had been reported.
- Approximately 0.24 percent of the medical waste containers sent for steam autoclave treatment contained radioactive, chemical, or other waste that was unsuitable for a steam autoclave treatment. Off-site medical waste treatment service providers are required to notify CDHS when radioactivity above specified levels is detected in waste. There was no other established mechanism, and no requirement to systematically compile, evaluate, and report data regarding the discrepant waste stream.
- Results of the employer's air sampling at the facility demonstrated that on the days that sampling was conducted chemicals that might be volatilized in the steam autoclave were all below detectable levels. However, air sampling may have been limited in its ability to fully characterize workers' exposures.

- Mercury was detected in 12 of 13 wastewater samples collected at the facility over 28 months; four of the 13 samples were approximately three to seven times greater than the local discharge limit of 0.01 mg/L. Mercury was measured in accumulated solids at concentrations above hazardous waste levels.
- Twelve of 14 wastewater samples collected at the facility in 2003 were determined to be out of compliance with local discharge limits for Total Toxic Organics; an estimated 90 percent of the waste stream discharges were isopropyl alcohol and acetone. Other chemicals detected in wastewater leaving the facility were trichloroethylene, xylene, 1,4-dichlorobenzene, and bis(2-ethylhexyl)-1 phthalate (DEHP).
- The concentration and commingling of large volumes of waste at the off-site treatment facility made it virtually impossible to trace back the source(s) of chemically hazardous substances detected in water discharged to the sanitary sewer and landfill.
- Drivers relied on the generators to properly screen the waste for radiation before pick-up, but some hospitals either were not screening their waste, did not have a radiation detector, or did not have a detector that was working properly.
- Workers' maximum measured exposures to ionizing radiation were approximately 300 mrem/year (three millisievert). However, the dosimetry data may not be representative of workers' cumulative exposures to radiation. There should be no work-related exposure to radiation for individuals transporting and treating medical waste.
- Drivers often encountered waste that was not properly packaged for transport.
- Workers had received initial and ongoing health and safety training in their primary language, and Material Safety Data Sheets were readily available. A critical weakness of the employer's overall safety efforts was the lack of a Health and Safety Committee.
- Workers' health was monitored through pre-placement and periodic physical examinations at which time workers were offered Hepatitis B vaccinations and received relevant laboratory and other tests. The most notable deficiency of the Medical Monitoring Program was that it did not fully incorporate the expectation that workers would encounter considerable ergonomic hazards.

CONCLUSIONS

Workers had a very high rate of injury.

Workers at this facility were injured at a rate 3.4 and 5.8 times higher than the rate of injury among California waste treatment and disposal workers, and health care workers, respectively. The hazardous exposures that resulted in these injuries may be present in other off-site medical waste treatment facilities.

Injuries resulted from ergonomic stressors, sharps, and safety hazards.

Almost three-quarters (72 percent) of the injuries were caused by exposure to ergonomic stressors and sharps hazards. Acute traumatic injuries accounted for more than one in five documented injuries. The documented injuries likely understate the health risks for these workers because many barriers to acute illness recognition and chronic disease reporting exist.

Workers encountered a variety of hazardous exposures.

Workers' primary exposures were to ergonomic stressors, infectious agents, and safety hazards, as well as to chemicals used for cleaning and maintenance activities, carbon monoxide from operating forklifts, and noise, heat, odor, and ionizing radiation.

Generators sent waste unsuitable for a steam autoclave to the facility for treatment.

Waste segregation errors made by generators were identified in approximately 0.24 percent of the medical waste containers received for steam autoclave treatment, equal to about five containers of discrepant waste every day. Due to the superficial nature of the detection system for all but radiation-related segregation errors, the 0.24 percent error rate underestimates the true amount of discrepant waste that arrived at this steam autoclave. Because vast quantities of infectious waste are produced by the health care industry, an estimated 100 million pounds annually in California alone, a "small" segregation error rate can have a large cumulative downstream impact.

The failure of waste generators to properly segregate medical waste can lead to occupational and environmental exposures to hazardous chemicals and ionizing radiation.

Chemical hazards such as mercury made their way into the autoclave and left the facility in wastewater. The subsequent installation of a wastewater treatment system did bring the sanitary sewer discharge into regulatory compliance, and will prevent the discharge of some chemically hazardous materials into the sanitary sewer; however, the system does not control worker exposure to these chemicals prior to their release into the water, it does not prevent airborne emissions, nor does it prevent the diversion of contaminated wastewater (via water bound to the treated waste) to the landfill.

Autoclaves operating in small, enclosed spaces, having poor dilution and local exhaust ventilation, and involving work practices which permit workers to stand close to the autoclave when the doors are opened after the treatment process, have an increased potential for workers to be exposed to airborne mercury if it is present in the waste stream. Workers who have contact with accumulated solids from work processes have the potential for skin exposure to mercury.

Radioactive medical waste was transported to the autoclave facility due to improper disposal of materials used in diagnostic and therapeutic treatments. As a result of these practices, the Drivers incurred intermittent, unrecognized, and largely unmeasured exposures to ionizing radiation.

The primary occupational hazards documented at the steam autoclave facility were related to the design of the work process, not to the steam autoclave technology.

The occupational health impacts of the steam autoclave were related to work processes upstream, on-site, and downstream of the autoclave. Workers' most significant exposures were a predictable consequence of a work process design that involved extensive manual handling of untreated waste. Some design features of the medical waste treatment work processes (such as compaction of treated sharps waste) that may be advantageous from an environmental perspective, or required by regulation, may introduce occupational hazards into the overall waste disposal process.

The employer had implemented many measures to prevent hazardous worker exposures.

Many ergonomic hazards associated with handling waste had been designed out of the work process through the use of conveyors, a tipper that mechanically dumped waste into the autoclave bin, and handcarts. The autoclave was fully automated. Waste packaging, hygiene and housekeeping procedures, and the availability and use of personal protective equipment reduced workers' exposures to bloodborne pathogens. Workers received training and were part of a Medical Monitoring Program. Steps were taken to identify and remove materials unsuitable for autoclaving from the waste stream.

The major weakness of the exposure control measures was that they disproportionately relied on controlling exposure after the hazard was created, rather than on eliminating the hazard from the work process.

Although it is reportedly feasible to design a fully-automated steam autoclave facility, the facility in this investigation had been retrofitted, rather than designed for, steam autoclave treatment capabilities. Engineering controls were used to eliminate many, but not all ergonomic hazards, with control of the remaining hazards reliant on job rotation and training. These secondary measures were an inadequate match for the heavy physical demands of the job.

Workers' direct contact with infectious materials had not been eliminated from the work process, and these exposures were controlled by "end-of-pipe" measures, i.e., housekeeping, hygiene, and personal protective equipment. The number of needlestick injuries at the facility demonstrates that these measures were not fully protective.

The steam autoclave employer had implemented few incentives or other primary prevention measures to eliminate hazardous chemical and radioactive materials from entering the autoclave waste stream prior to pick-up. Secondary methods to detect, evaluate, and correct waste segregation errors at the waste treatment facility were inadequate.

Feedback mechanisms necessary to identify, evaluate, and prevent occupational hazards were inadequate, fragmented, or absent.

An industrial hygiene and ergonomic assessment of the steam autoclave work process was not required nor performed as part of the permitting process when the facility began operations. There was no Health and Safety Committee, or other strong, ongoing, and reliable mechanism for workers to communicate freely about hazards without fear of retaliation. Detection of radioactive materials in waste occurred after the materials had been transported, and the system did not have the capacity to provide accurate information to workers about the health risks of their exposures to ionizing radiation. Worker injury rates were not calculated, evaluated, or reported to impacted workers. There was no comprehensive electronic tracking and reporting system for waste segregation errors or environmental emissions at the treatment facility.

LIMITATIONS

Limitations of this investigation include: (1) we observed only one steam autoclave at one point in time; (2) we did not take independent measurements of potential physical, biological, or chemical hazards; (3) we did not thoroughly assess safety hazards and maintenance activities; and (4) worker participation in the investigation was low.

RECOMMENDATIONS FOR PREVENTION

Primary prevention of the occupational hazards of the off-site medical waste treatment work process involves undertaking activities to: (1) generate less medical waste; and (2) incorporate the prevention of work-related hazards into the design of medical waste treatment technologies and associated work processes. Education, feedback, and incentive mechanisms are needed to support the goal of primary prevention. The report describes each of these measures, followed by CDHS/OHB's recommendations for specific activities that medical waste treatment service providers, facilities that generate medical waste, and agencies that regulate aspects of the medical waste stream, can do to realize these goals.

Generate less medical waste.

- Eliminate the use of needles or sharp components wherever feasible;
- Decontaminate infectious laboratory waste (i.e., cultures and stocks) within the laboratory where the waste is generated; and
- Participate in, monitor, and evaluate pollution prevention activities.

Incorporate the prevention of work-related hazards into the design of all medical waste treatment technologies and associated work processes.

- Anticipate and prevent technology and work process design features that pose a risk to worker health and safety;
- Segregate and package medical waste properly; and
- Build interdisciplinary partnerships between frontline workers, and infection control, industrial hygiene, engineering, regulatory, environmental health, and other relevant disciplines to create comprehensive, lasting solutions.

Adopt education, feedback, and incentive mechanisms, to support primary prevention.

- Educate decision-makers and end-users as to worker health and safety consequences of product purchasing, use, and waste disposal practices;
- Scrutinize medical waste disposal technologies and work processes to ensure that hazards are not transferred across populations, and over time, but rather, are eliminated;
- Adopt industry-wide regulatory, economic, and other incentives, to foster public reporting and evaluation of occupational and environmental health data related to the medical waste stream; and

- Adopt industry-wide regulatory, economic, and other incentives, to overcome the substantial barriers to primary prevention including the: (1) lack of a prevention-based regulation for ergonomic hazards in the workplace; (2) limited number of interdisciplinary mechanisms for collaboration; (3) limitations of the current regulatory review process with respect to occupational and environmental health, i.e., current regulatory approval mechanisms of waste treatment technologies are focused almost exclusively on the efficacy of technology to treat waste; and (4) absence of comprehensive, uniform national standards governing medical waste management.

What Can Off-Site Medical Waste Treatment Service Providers Do to Protect Worker Health and Safety?

- Identify and prevent hazardous worker exposures;
- Implement monitoring and feedback mechanisms about the occupational health impacts of medical waste disposal; and
- Provide pollution prevention education and incentives to waste generators.

What Can Facilities that Generate Medical Waste Do to Protect the Health and Safety of Medical Waste Treatment Workers?

- Reduce the danger and quantity of medical waste;
- Segregate and package medical waste properly;
- Explicitly integrate measurable worker health and safety criteria into decision-making about the use and selection of off-site medical waste treatment providers;
- Train employees about the occupational and environmental health impacts of medical waste disposal practices; and
- Serve as a model for best practices by implementing recommendations to ensure worker health and safety in the health care industry.

What Can Agencies that Regulate Aspects of the Medical Waste Stream Do to Protect the Health and Safety of Medical Waste Treatment Workers?

- Build partnerships between labor and public health programs; and
- Explicitly encourage the development of public health-protective waste treatment technologies and work processes.

INTRODUCTION

At the core of justice in the global work life, is the right of working people to benefit from industrial transformations (Ashford 2004).

TRANSFORMING MEDICAL WASTE DISPOSAL PRACTICES

Health care practices are being transformed by increasing demands that health care institutions take responsibility for practices that degrade ecosystems and damage the health of humans and other species (Schettler 2001). The transformation of medical waste[1] disposal practices is illustrative of this trend. Data compiled under the 1987 California Air Toxics 'Hot Spots' Information and Assessment Act (Assembly Bill 2588) led to the recognition that burning medical waste in incinerators produced major sources of dioxin and other hazardous emissions, and posed a significant health risk to surrounding communities. California and federal regulations to reduce emissions of dioxins from medical waste incinerators (Cal/EPA 1990; U.S. EPA 1997), coupled with on-going public opposition to pollution from incinerators, led to significant changes in medical waste disposal practices. In 1997, the U.S. Environmental Protection Agency (U.S. EPA) estimated there were approximately 2,400 hospital/medical infectious waste incinerators operating in the United States, combusting approximately 16.9 million pounds of waste annually (U.S. EPA 1997). In 2004, 110 such incinerators remained (U.S. EPA 2004a). There are currently no commercial off-site medical waste incinerators operating in California.

Alternative approaches to improve medical waste disposal practices have been primarily directed towards ensuring treatment efficacy and reducing the environmental impacts of disposal technology. Regulations and laws that govern medical waste disposal in California[2] also explicitly and implicitly provide for some worker health and safety protections, for example, through the California Division of Occupational Safety and Health (Cal/OSHA) Bloodborne Pathogen Standard,[3] and waste segregation and packaging requirements. However, the potential worker health and safety concerns common to the implementation of all medical waste treatment

1 The definition of medical waste in California is found in The Medical Waste Management Act (California Health and Safety Code Sections 117600 – 118360). Waste must satisfy three criteria in order to be classified as medical waste: (1) the material must actually be a waste product; (2) the waste must be either biohazardous or sharps waste; and (3) the waste must be produced as a result of a specified action in the delivery of health care.

2 California Health and Safety Code Sections 117600–118360.

3 California Code of Regulations, Title 8, Section 5193. Bloodborne Pathogens.

technologies, i.e., handling and transporting infectious, sharps, and other hazardous materials, have received limited scrutiny.

A 1990 survey of Washington state residential, commercial, and landfill/transfer waste industry workers found that of 438 respondents, only 26 percent were trained specifically to deal with safety hazards associated with medical waste, and that in the previous year workers had experienced cuts and scratches on the job (50 percent), direct contact with waste blood on clothing or shoes (22 percent), skin exposure to blood (8 percent), face or eye exposure to blood (3 percent), and work-related needlestick injuries (6 percent) (Turnberg 1990). In 1996, the National Institute for Occupational Safety and Health (NIOSH) estimated there were more than 10,000 medical waste treatment workers in the United States, processing 500,000 tons of waste prior to its ultimate disposal (NIOSH 1996a). There is a general lack of data about these workers, as medical waste handlers and treatment workers are not included in "health care worker" statistics and hazard information (NIOSH 1996a).

NIOSH investigated the worker hazards at three medical waste treatment facilities utilizing either off-site (i.e., not located at the facility where the waste is generated) steam autoclave, off-site microwave, or on-site pyrolysis technology for waste decontamination (NIOSH 1996a). NIOSH found there was extensive manual handling of wastes resulting in frequent blood splashes at two facilities; all of the facilities had worker safety hazards. Exposure to medical waste at an off-site treatment facility resulted in at least one case of occupationally-acquired *Mycobacterium tuberculosis* (Washington State Department of Health 1998; Johnson 2000). A NIOSH follow-up investigation identified several factors present at the Washington medical waste treatment facility that could contribute to employee exposure to pathogens potentially present in medical waste, including equipment deficiencies and operating failures, insufficient employee training, and respiratory protective equipment inadequacies (Weber 1998; Johnson 2000). A recent study found workers at an infectious waste incineration plant had elevated serum levels of dioxin compared to controls, and serum dioxin levels of the workers declined when occupational exposure to dioxin ended (Kumagai 2005).

WORKER HEALTH AND SAFETY AND THE IMPLEMENTATION OF LARGE-SCALE, OFF-SITE STEAM AUTOCLAVES

Steam autoclaves, which utilize steam under pressure to disinfect medical waste, are an alternative to incineration.[4] When proper precautions are taken to exclude hazardous substances, such as mercury and radioactive materials, steam autoclaves produce minimal emissions (Emmanuel 2001, p. 25). This health benefit of steam autoclaves over technologies that rely on burning infectious waste accrues to all community members, including medical waste stream workers.

4 Disposal by incineration is currently required for certain parts of the regulated medical waste stream (California Health and Safety Code, Sections 117600–118360).

In December 2002, representatives of the Center for Environmental Health,[5] the American Nurses Association,[6] and Greenaction[7] brought the issue of potential health impacts of the medical waste disposal work process to the attention of the California Department of Health Services Occupational Health Branch (CDHS/OHB). Specifically, these organizations were concerned about the potential occupational health hazards of large-scale steam autoclaves that have been implemented to treat medical waste in lieu of incinerators that were shut down because of improved environmental regulations. As part of Health Care Without Harm,[8] these organizations advocate for medical waste management practices that minimize the impact on the health of workers, communities, and the environment. Medical waste disposal worker representatives contacted by CDHS/OHB, including the Brotherhood of Teamsters and Auto Truck Drivers, Local No. 70, and the International Brotherhood of Teamsters, also shared this concern.

CDHS/OHB is mandated to investigate the effects of the workplace on public health, and to make recommendations to prevent occupational illness and injury.[9] Primary prevention of occupational injury and illness involves ensuring that the implementation of alternative technologies to address environmental concerns also protects the health of workers. However, there was limited information about what hazards workers at steam autoclave or other medical waste treatment facilities actually encountered in practice, and how, or if, workers' exposures were controlled. Although the potential hazards were not unique to steam autoclave technology, off-site steam autoclaves were of particular importance because these facilities comprise an increasingly large segment of the industry in California. In 2003, an estimated 90 percent of California hospitals managed essentially all their regulated medical waste off-site (Bay Area Dioxins Project 2003). As of May 2005, nine of the 12 off-site medical waste treatment facilities in the state employ steam sterilization technology (CDHS 2005a). Therefore, CDHS undertook an investigation to assess the potential occupational hazards associated with a large-scale, off-site steam autoclave to make recommendations to prevent illness and injury.

5 Mamta Khanna, Program Manager, Health Care Without Harm, Center For Environmental Health. The Center for Environmental Health is a non-profit organization that seeks to protect the public from environmental and consumer health hazards. http://www.cehca.org/

6 Susan Q. Wilburn, Senior Specialist, Occupational Health and Safety, American Nurses Association. The American Nurses Association is a full-service professional organization representing the nation's 2.7 million Registered Nurses through its 54 constituent state associations. http://www.nursingworld.org

7 Susan Chiang, Community Health Advocate, Greenaction. Greenaction is a non-profit organization whose mission is to mobilize community power to win victories that change government and corporate policies and practices to protect health and to promote environmental justice. http://www.greenaction.org/org/background.html

8 Health Care Without Harm is an international coalition of hospitals and health care systems, medical professionals, community groups, health-affected constituencies, labor unions, environmental and environmental health organizations, and religious groups who share the mission of transforming the health care industry worldwide, without compromising patient safety or care, so that it is ecologically sustainable and no longer a source of harm to public health and the environment. http://www.noharm.org/aboutUs/missionGoals

9 California Health and Safety Code, Sections 105175–105180.

METHODS

A. DATA COLLECTION

To investigate the potential occupational hazards associated with large-scale, off-site steam autoclaves, CDHS/OHB researchers:

Observed the medical waste treatment process

On June 18, 2003, CDHS researchers[1] conducted an investigation at one off-site steam autoclave medical waste treatment facility in Alameda County, California. The facility was selected for the following reasons: (1) the employer owned four of the eight off-site steam autoclave facilities permitted in California at the time of this investigation; (2) the facility was the alternative treatment facility for part of the waste stream previously treated at an incinerator that had closed; and (3) the facility was conveniently located to CDHS/OHB offices. On the day of the on-site investigation, we observed the work processes and worker exposure control measures beginning with pick-up at the facilities of health care providers that generate medical waste, through the entire autoclave process, up until loading treated waste into a truck for delivery to the landfill for final disposal. All observations were made in the presence of employer and worker representatives.[2] On April 21, 2005, CDHS researchers[3] observed the delivery and disposal of treated medical waste at the landfill. CDHS researchers also visited another landfill on August 27, 2004;[4] the landfill had been used to dispose of treated medical waste in the past.

1 The June 18, 2003, on-site investigation was conducted by the following CDHS/OHB staff: Patrice Sutton, M.P.H., Research Scientist; Julia Quint, Ph.D., Chief, Hazard Evaluation System and Information Service; Elizabeth Katz, M.P.H., C.I.H., Industrial Hygienist, Hazard Evaluation System and Information Service; and Robert Harrison, M.D., M.P.H., Chief, Occupational Health Surveillance and Evaluation Program. Jorge Emmanuel, Ph.D., PE, CHMM., E&ER Group, Rodeo, California, also participated in the investigation as a Technical Consultant to CDHS.

2 The Drivers were represented by Jim Brown, Business Agent, Brotherhood of Teamsters and Auto Truck Drivers, Local No. 70. The medical-waste-treatment Plant Workers were not unionized and were represented by a co-worker selected by the employer.

3 The April 21, 2005, landfill observation was conducted by the following CDHS/OHB staff: Patrice Sutton, M.P.H., Research Scientist; Elizabeth Katz, M.P.H., C.I.H., Industrial Hygienist; Jennifer Flattery, M.P.H., Research Scientist; and Charles LaRoche, M.D., M.P.H., Occupational Medicine Fellow.

4 The August 27, 2004, landfill observation was conducted by the following CDHS/OHB staff: Patrice Sutton, M.P.H., Research Scientist; and Julia Quint, Ph.D., Chief, Hazard Evaluation System and Information Service. Jorge Emmanuel, Ph.D., PE, CHMM, E&ER Group, Rodeo, California, also participated in the investigation as a Technical Consultant to CDHS.

Interviewed employer representatives

Ten employer representatives were present during some or all of the on-site visit. Employer representatives were asked about the medical waste treatment work process, job tasks, exposure control measures, and the employer's health and safety program. Employer representatives included individuals responsible for worker health and safety, environmental compliance, and the day-to-day operations of the plant. Follow-up information was collected from employer representatives by phone, e-mail, and through meetings.

Interviewed Drivers and Medical-Waste-Treatment Plant Workers

Drivers: At the time of this investigation, the Drivers were represented by the Brotherhood of Teamsters and Auto Truck Drivers, Local No. 70. Patrice Sutton of CDHS/OHB attended an off-site meeting of the union. During this meeting, Ms. Sutton described the scope and purpose of the CDHS/OHB investigation, answered questions, and sought information from the perspective of the employees about their work, any potentially hazardous exposures, and any health problems they may have experienced. We also attempted to interview a convenience sample of Drivers by phone.

Medical-Waste-Treatment Plant Workers: The employer provided CDHS/OHB researchers with a roster of names, home phone numbers, and addresses of all employees at the facility. We attempted to contact all of the Plant Workers three or more times at their homes to ask them to participate in a voluntary, confidential interview. Informed consent was obtained from workers who agreed to be interviewed, and interviews were conducted by phone or in person in their homes. Interviews were conducted in English or Spanish using a structured questionnaire including multiple choice and open-ended questions. Questions were designed to elicit the perception of the workers as to health, safety, training, policies and procedures, availability and use of personal protective equipment, working conditions (shifts, safety climate), etc. Employees' names, job titles, or shifts were not recorded in the interviews.

Reviewed employer's written records

We reviewed the employer's written health and safety materials including the: Injury and Illness Prevention Program; Hazard Communication Program; Bloodborne Pathogen Exposure Control Plan; methodology for, and results of, physical and chemical agent exposure monitoring and ergonomic evaluation; Material Safety Data Sheets for all products used at the facility; ventilation and autoclave-related maintenance records; description of job tasks; OSHA Logs and Summaries of Occupational Injuries and Illnesses and Supplementary Record; Employer's Reports of Occupational Injury and Illness; medical monitoring pre-placement and periodic forms, and completed medical records; waste acceptance protocol; and documentation of worker training and training materials. Because the waste stream can impact workers' exposures, we also compiled employer-generated data on the quantity and type of waste received at the facility, and on the results of sampling wastewater for chemical hazards.

Conducted key informant interviews

Initially, CDHS/OHB researchers asked representatives of the non-governmental organizations that initiated the investigation, the autoclave employer, and state regulatory agencies to recommend other individuals who had knowledge pertinent to medical waste disposal practices. These contacts were in turn asked to recommend others whose experience was relevant to medical waste disposal practices. We conducted interviews with at least 35 individuals by phone, or in meetings with representatives of industry, labor, state and local regulatory and public health agencies, worker/environmental health advocates, technical experts, medical waste generators, and landfill operators.

B. EVALUATION CRITERIA

To evaluate the potential occupational hazards associated with large-scale, off-site steam autoclaves CDHS/OHB researchers:

- Assessed the presence and magnitude of worker exposure to chemical, biological, and/or physical hazards and ergonomic stressors.
- Assessed the presence of one or more potential routes of worker exposure, i.e., skin, air, eye, and ingestion.
- Assessed the presence, use, and efficacy of measures to limit workers' exposures, i.e., engineering and administrative control measures and personal protective equipment.
- Assessed the presence of worker training and hazard communication about their exposures.

RESULTS

A. STEAM AUTOCLAVE WORKFORCE

Between April 2002 and May 2004, the steam autoclave facility employed an average of 70 male workers at any one time who ranged in age from 23 to 61 years (mean and median age = 39 years) and were employed as: Drivers (N=38; 54.3 percent), Plant Workers (N=22; 31.4 percent), and Managers/Supervisors (N=10; 14.3 percent). Workers spoke English and/or Spanish. Plant employees worked one of three eight-to-ten-hour shifts, six days a week, and additional overtime as required. No union represented the Plant Workers. Drivers worked up to 15 hours a day, with up to 12 hours of driving. Drivers received a $100 bonus every pay period if the following criteria were met: no vehicle accidents, no injuries, no damage to company equipment, and no sick calls. At the time of the CDHS/OHB investigation, the Drivers were represented by the Brotherhood of Teamsters and Auto Truck Drivers, Local 70; subsequently the Drivers decertified their union. CDHS researchers interviewed 20 percent (7/35) of the Drivers and 43 percent (6/14) of the Plant Workers, for an overall response rate of 27 percent.[1]

B. OFF-SITE STEAM AUTOCLAVE WORK PROCESS

The steps in the off-site steam autoclave work process were: (1) segregate and collect the medical waste stream; (2) load trucks and transport the waste to an off-site steam autoclave; (3) unload the tubs of waste from trucks; (4) scan, weigh, and monitor tubs for radiation; (5) dump waste from tubs into the autoclave bin; (6) autoclave waste; (7) compact treated waste; (8) wash tubs; (9) maintain autoclave, boiler, and conveyor systems; and (10) bury treated waste at a landfill.

1 Drivers were interviewed primarily in mid-2003 and Plant Workers in the first quarter of 2004. As of July 1, 2003, there were 35 Drivers on the roster provided by the employer; as of January 26, 2004, there were 15 Plant Workers (down from 21 in July 2003). We did not attempt to interview one Plant Worker who lived with a supervisor.

Figure 1. Environmental Services worker collects waste from hospital ward

Figure 2. Radiation detector at hospital exit

Figure 3. Environmental Services worker transporting waste to central storage area

1. Segregate and Collect the Medical Waste Stream

The off-site steam autoclave work process begins at the facilities that generate medical waste. We observed the waste disposal process at one San Francisco Bay Area 207-bed hospital. At this hospital, Environmental Services (EVS) workers were trained to monitor the sharps containers in the course of cleaning the rooms and change the containers when they were three-quarters full. The EVS workers placed the filled sharps containers in a locked cabinet on each ward. An EVS worker then collected the sharps and other medical waste from each ward (Figure 1), transported the waste through a hospital exit equipped with a radiation detection monitor (Figure 2), and placed the containers in a locked, central storage area outside the main hospital (Figure 3).

The tubs filled with medical waste were picked up by outside service providers for off-site treatment and/or disposal. EVS staff reported that when the radiation monitor at the exit alarms (as it does every two to three weeks), the waste is returned to Nuclear Medicine to decay; the origin of the radioactivity is not traced back to identify and correct the source of the problem. EVS workers were reportedly trained on what to do if the radiation alarm sounds, not on the hazards of exposure to radiation. Needlestick injuries were cited as the chief medical waste concern among EVS staff.

2. Transport Medical Waste to the Off-Site Steam Autoclave

CDHS/OHB researchers observed one Driver pick up medical waste over a period of approximately five hours from a total of nine health care facilities in San Francisco, including four hospitals, three medical/dental clinics, one clinical laboratory, and one ambulance service. The Driver transported various types of medical waste that were destined for either steam autoclave or incineration treatment.[2] Customers' fees were based on a service contract, not on the number of tubs of waste generated.

Figure 4. Driver transporting tubs containing waste

In general, the Driver loaded the tubs of waste onto a handcart by pushing the handcart under one tub and lifting a second tub, if present, on top of the first. The Driver then walked the handcart loaded with tubs back to the truck, rolled the handcart with tubs onto the lift gate at the rear of the truck, placed and scanned a bar code on each waste container, mechanically moved the lift gate to the level of the truck bed, and deposited the tubs into the back of the truck (Figure 4). Drivers delivered clean, empty tubs to the storage area.

TABLE 1. CONDITIONS OF MEDICAL WASTE TRANSPORT ENCOUNTERED BY DRIVER

(N=9 Health Care Facilities)

Condition	Number of Facilities
Waste not placed in tubs/overflowing from tubs/not packaged properly/tubs not tightly covered	4
Removing tubs from storage area involved stairs, steps, steep gradients, and/or tight spaces	3
Vehicular traffic, crossing streets in the middle, Driver's visibility obstructed, or crossing path of busy garage entry/exit	3
Storage area with poor ventilation	2
Storage area in busy clinic reception area	1
Tub difficult to lift due to its weight	1

2 Disposal by incineration is required by law for the following types of medical waste: (1) empty containers of chemotherapy waste, including sharps, syringes, intravenous (IV) tubing/bags/bottles, vials, and other discarded contaminated items generated in the preparation and administration of cytotoxic/antineoplastic drugs; (2) animal and human pathology waste, exclusive of preservative agents; and (3) hazardous pharmaceuticals, as defined under California's hazardous waste regulations.

Figure 5. Driver waits for Laboratory Worker to package waste for transport

Figure 6. Driver climbing stairs with tubs containing waste

Figure 7. Driver crosses traffic

Medical waste was improperly packaged for transport at four of the nine health care facilities observed (Table 1). At three facilities, red bags were not placed in or were overflowing from the tubs. The Driver declined to pick up the red bags from two of these facilities; at the third, the Driver waited for a laboratory worker to load the waste into the tubs for transport (Figure 5).

At one facility, the medical waste storage area was not accessible to the handcart, and the Driver hand-carried two tubs at a time up and down many flights of stairs over a circuitous route to move between the storage area and his truck (Figure 6). Other conditions included moving the tubs of infectious waste across streets with heavy traffic (Figure 7) and through a crowded patient area in a clinic, poor ventilation in the facility storage area, and at one facility, a tub that was very difficult to lift due to its weight. After picking up the tubs of medical waste at health care facilities, the Driver transported the waste by truck to the off-site steam autoclave (Figure 8).

FIGURE 8. DIAGRAM OF AUTOCLAVE FACILITY

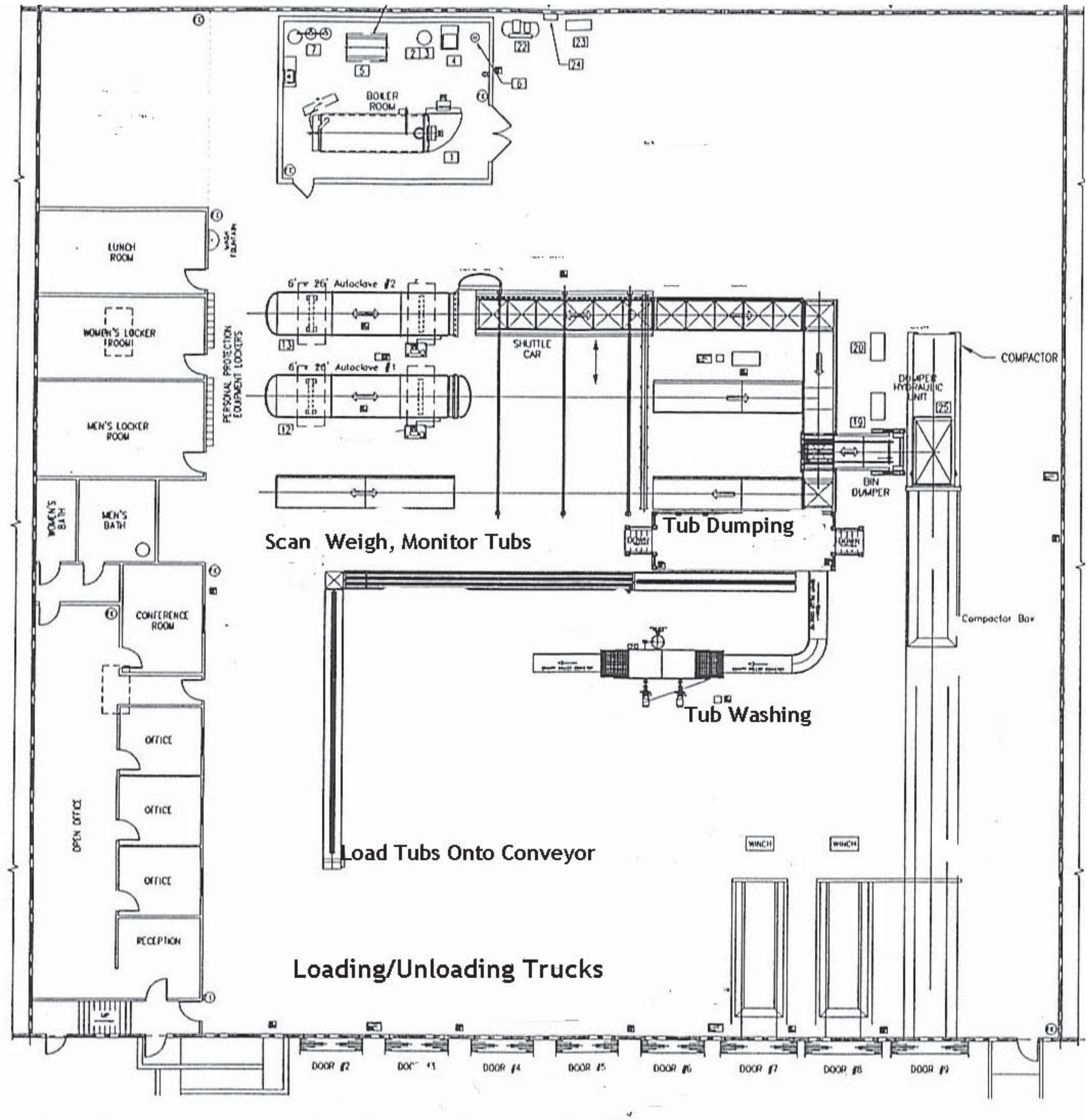


Figure 9. Loading docks

Figure 10. Unloading waste-filled tubs from truck

Figure 11. Unloading waste-filled tubs from truck

3. Unload the Tubs of Waste from Trucks at the Off-site Steam Autoclave

The 22,350 square foot steam autoclave facility was located adjacent to a municipal solid waste transfer station in a neighborhood densely populated with light industries. A diagram of the autoclave facility indicating the location of each task is presented in Figure 8.

The facility began steam autoclave treatment operations in June 2002 and had been in full operation for nine months at the time of the CDHS/OHB investigation. The facility's offices related to medical waste transport were located in a separate building across a large, busy street.

Drivers backed up their trucks to one of eight loading docks at the autoclave facility (Figure 9). Plant Workers unloaded the medical waste from the trucks using standard handcarts. The handcarts were loaded with two to three tubs stacked on top of each other (Figures 10 and 11). Workers deposited the tubs on the plant floor approximately 10 to 45 feet from the truck.

4. Scan, Weigh, and Monitor Tubs for Radiation

Workers manually lifted the tubs from the floor and placed the containers onto a conveyor system (Figure 12). The conveyor moved the tubs mechanically to the scanning station. Next, a worker at the scanning station took the lid off every tub, visually observed the top contents of the tub, scanned the bar code for billing information, and noted the weight of the tub (Figure 13).

A radiation detection system with two fixed monitors placed on each side of the conveyor system scanned every tub (Figure 14).[3]

The detection equipment was set to alarm at three times background level of radiation (i.e., 30 micro rems (micro R) per hour). The worker removed any tubs from the conveyor that: (1) contained chemotherapeutic, pathology, or other waste not suitable for an autoclave that was visible at the top of the tub; and/or (2) set off the radiation detector alarm (Figures 15 and 16). The worker replaced the lids on all the tubs. Tubs that were identified as non-conforming or "discrepant" waste were manually moved to a separate area of the plant for further handling (Figure 17). All other tubs continued to move up the conveyor to the elevated container dumping station.

There was a separate area where chemotherapeutic and pathology waste was weighed, scanned, re-loaded into a truck, and driven approximately 650 miles to Salt Lake City, Utah, for incineration.[4]

3 Thermo Electron LFM-2 System with two, two-inch Sodium Iodide (NaI) scintillation detectors (similar to most landfill monitors) and a Ludlum Model 177 meter with a one-inch NaI detector (Model 44-2). There were also two portable meters available for scanning waste: a Ludlum Model 3 meter with a one-inch NaI detector (Model 44-2) and a Bicron Micro Analyst meter with an internal one-inch NaI detector. The radiation detectors were calibrated annually.

4 The Drivers pick up waste destined for both off-site autoclaving and incineration. The tubs for autoclaving remain at the facility for treatment; pathology and chemotherapeutic waste is shipped to Utah for incineration.

Figure 12. Lifting tubs of waste onto conveyor

Figure 13. Scanning waste tubs

Figure 14. Radiation scanner

Figure 15. Discrepant waste identified

Figure 16. Discrepant waste removed from conveyor

Figure 17. Radioactive waste storage area

Figure 18. Worker dumping waste from tubs

Figure 19. Waste tipped into autoclave bin

Figure 20. Tipper and autoclave tracks

5. Dump Waste from Tubs into Autoclave Bin

When the tubs on the conveyor reached the elevated platform, two workers pulled the lids off the tubs and tossed the lids over one side of the conveyor into a cart. Next, the workers manually emptied the waste from the tubs into a "container dumper," a mechanized unit of larger containers. The workers filled the container dumper with waste by either manually lifting or pulling the tub onto the dumper, or by picking up a tub and emptying the waste from the tub into the dumper (Figure 18). Sometimes workers bypassed the dumper and picked up and emptied tubs directly into the autoclave bin. Workers used a long pole to manually release waste that stuck to the bottom of the container dumper, and a shovel to pick up waste from the platform floor. Workers activated the container dumper at a control panel, causing it to lift up and tip over. The waste fell into the autoclave bins stationed below the dumper (Figure 19).

The autoclave bins were moved mechanically on tracks by a worker operating the system from a control panel. After six autoclave bins were filled in this manner, the worker at the control panel pushed buttons on the automated system to move the "train" of autoclave bins along the track into the autoclave (Figure 20).

6. Autoclave Waste

The facility operated two large autoclaves (six feet in diameter by 26 feet long), each capable of treating about 2,000 pounds of waste per cycle (Figure 21). Each stainless steel vessel had a quick-opening, breech-lock door, which uses a locking ring that rotates to engage a number of lugs around the door. The process was computer controlled.

Figure 21. Autoclaves

After the bins were moved inside an autoclave, the worker used the control panel to close the door remotely. The computer controller initiated a pre-vacuum phase wherein air was removed from inside the vessel for three minutes. Evacuated air was mixed with steam before being sent to a blowdown tank. The pre-vacuum phase was followed by the treatment phase, which began by introducing steam into the vessel and raising the temperature and pressure inside to 292°F and 59 psi (44 psig). Waste was exposed to steam at this temperature and pressure for 30 minutes.[5]

At the end of the treatment phase, steam was released into a spray condenser. The condensate flowed into the drain while any remaining vapors from the condenser went to the blowdown tank and a carbon bed filter before being released to the air above the roof. Condensate inside the autoclave was partially removed through a valve. Just before the door was opened, a post-treatment vacuum was applied for about a minute.

An audible tone signaled the operator to open the door. The operator first had to move a locking pin by the door and engage some levers. The worker then walked to the control panel and pushed the Unload button. As the chamber door opened, large amounts of condensate flowed out into the drains directly under the door. The bins automatically rolled out into another conveying system for removal into the compactor area.

5 Temperature and pressure charts from 5/12/03 to 6/11/03 showed fairly consistent temperatures of 295°F and 59-62 psi for both autoclaves. Monthly or bi-weekly monitoring tests with controls were conducted using self-contained biological indicators [B. subtilis ATCC #9372] and color-changing indicator strips. All test results from 6/4/02 until 8/6/02, and from 12/17/02 until 11/05/03 were negative.

Figure 22. Compactor box

7. Compact Treated Medical Waste

The autoclave bins were lifted up and tilted so that treated waste fell into the compactor. The compactor used a hydraulic system to compress the treated waste into a roll-off container that had a 20,000-pound limit (Figure 22). It was reported that it takes about five to seven trains, or 30 to 42 autoclave bins filled with waste, to fill the compactor. Compacting the waste caused the sharps containers and red bags to break open. The process of changing the filled compactor box reportedly involved using a forklift to push and pull the box for about 15 minutes. Finally, the full compactor-receiving box was pulled onto a roll-off truck and driven to the landfill (Task 10).

Figure 23. Tub washer conveyer

Figure 24. Tubs entering washer

Figure 25. Worker monitoring tub washer

8. Wash Tubs

After the waste was dumped from the tubs into the autoclave bins (Task 5), the empty tubs were placed upside down onto a declining conveyor that gravity fed the containers into the tub washer (Figures 23 to 25). The tub washer was a fully automated system that cleaned the containers by pressure spraying them with a 0.04 percent solution of quaternary ammonium compounds and hot water.[6] A worker manually removed the empty tubs from the conveyor and stacked them to air dry. Subsequently, the clean tubs were moved back into the trucks and delivered to waste generators.

9. Maintain Autoclave, Boiler, and Conveyor System

CDHS/OHB researchers did not observe any maintenance activities. Daily and weekly checklists guided maintenance workers through the routine tasks to be performed on the equipment and to meet permit requirements, i.e., tub washer temperature checks, radiation detection equipment source checks, etc.

6 Tubs were sprayed from nozzles at 50 psi with a solution of hot water (190°F) and 0.04 percent quaternary ammonium compounds for 15 seconds, followed by 170°F rinse for 15 seconds.

Figure 26. Worker unloads treated waste at landfill

10. Bury Treated Medical Waste at Landfill

CDHS researchers observed the disposal of the treated medical waste at one landfill. After medical waste is treated, it is no longer considered medical waste; it is now considered solid waste. Compacted waste from the steam autoclave facility had been hauled to this landfill three times a day, five days a week, for approximately two years. Each bin of waste unloaded weighed an average of seven tons; two bins were frequently delivered in each truckload. The landfill was not open to the public.

Figure 27. Dumping treated medical waste at landfill

At the landfill, the Driver of the truck from the steam autoclave facility backed up to an area dedicated exclusively to treated medical waste, manually opened the back door to the compactor box, and cleaned off the waste adhering to the door with a metal hoe (Figure 26).

Next, the Driver mechanically tipped the box and the waste fell from the box by gravity onto the dirt (Figure 27).

Figure 28. Bulldozing treated medical waste at landfill

Figure 29. Compacting treated medical waste at landfill

After the waste was dumped, Heavy Equipment Operators at the landfill drove a bulldozer and a compactor repeatedly over the treated waste (Figures 28 to 30). Finally, the treated waste was covered with dirt. The Heavy Equipment Operators at the landfill were seated in enclosed cabs. The sharps that adhered to the tracks on the bulldozer were reportedly scraped off with metal stakes on a daily basis.

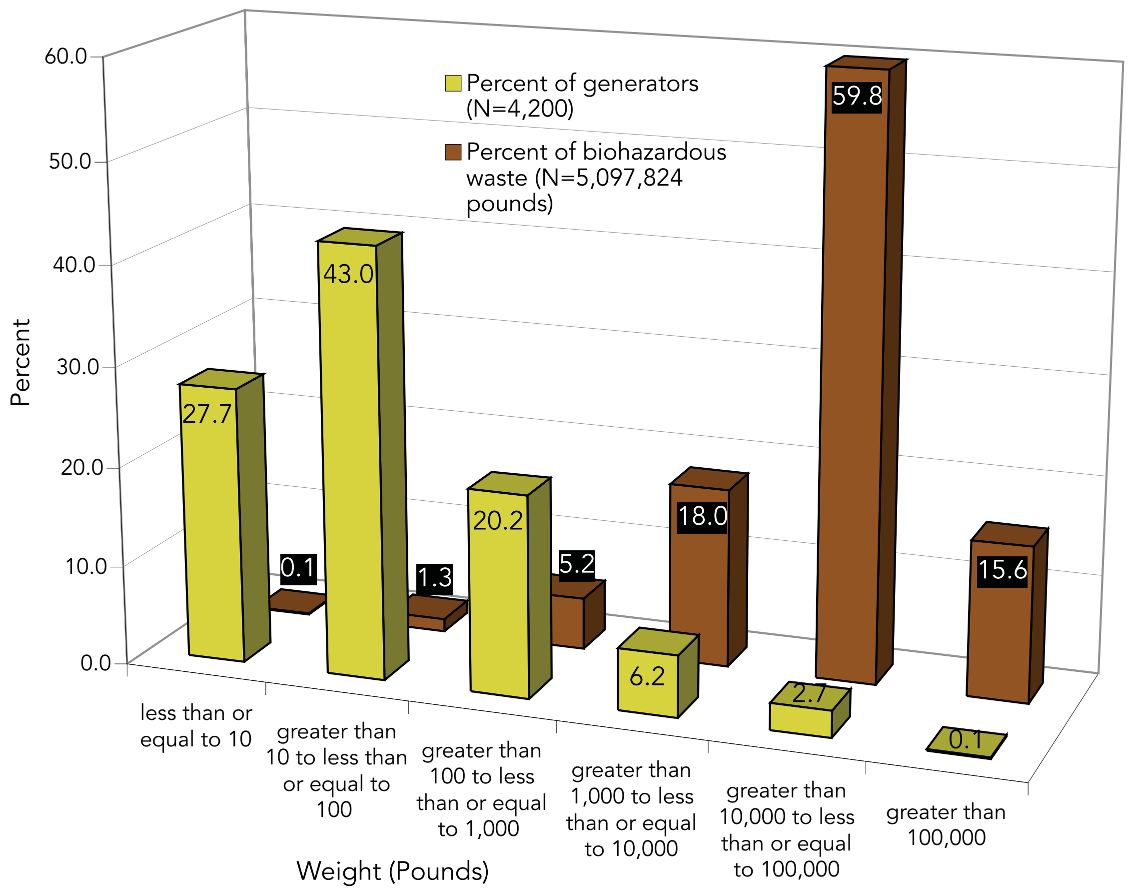
Figure 30. Treated medical waste at landfill

C. WASTE STREAM

1. Volume of Waste Stream

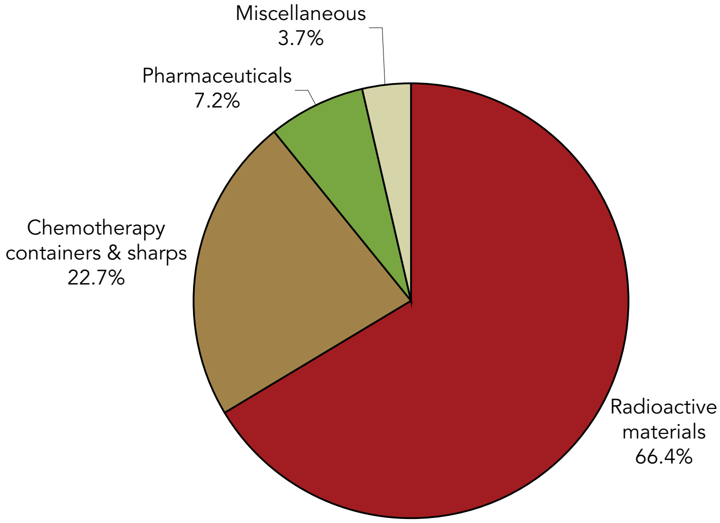
In the three-month period between August and October 2003, the facility observed by CDHS researchers received 5,097,824.3 pounds of biohazardous waste in 155,702 containers from 4,200 generators for steam autoclave treatment. The vast majority of the waste (93 percent by weight, 84 percent by containers) came from nine percent (N=381) of the generators (Figure 31).

Figure 31. Biohazardous Waste by Weight Over 3 Months



Source: Employer Data

Figure 32. Discrepant Waste by Type Over 9 Months (N=1,114 Containers Identified)



Source: Employer Data

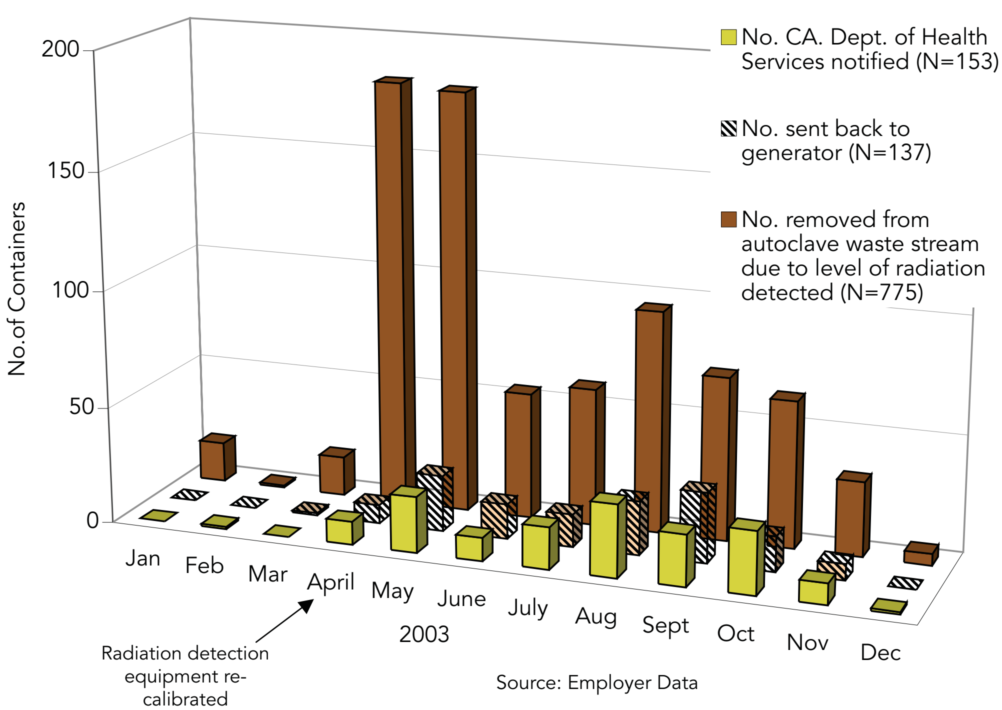
2. Discrepant Waste Stream

In the nine-month period between April and December 2003, 1,114 waste containers were identified by Plant Workers with waste not permitted for steam autoclave disposal (Figure 32). Two-thirds (66.4 percent) of the containers with discrepant waste contained radioactive materials, more than one in five (22.7 percent) contained chemotherapy containers and sharps, 7.2 percent contained pharmaceuticals, and the remaining 3.7 percent contained pathology containers, incineration cartons, and other miscellaneous materials not permitted for steam autoclave treatment.

In the one-year period between January to December 2003, 28 generators were charged a service fee for improper packaging, with two customers charged a fee twice. During this same period, 775 containers were removed from the waste stream due to the level of radiation detected in the container (Figure 33); of the 775 containers, 516 (66.6 percent) had radiation levels at or above 90 micro R per hour[7] and 56 (7.2 percent) had radiation detected at or above 1,000 micro R per hour.

Very few containers (N=35) were identified in the first quarter of 2003,

Figure 33. Medical Waste Containers with Radioactive Materials by Month (N=775 Containers Identified)



Source: Employer Data

7 90 micro R per hour is equal to three times background levels of radiation.

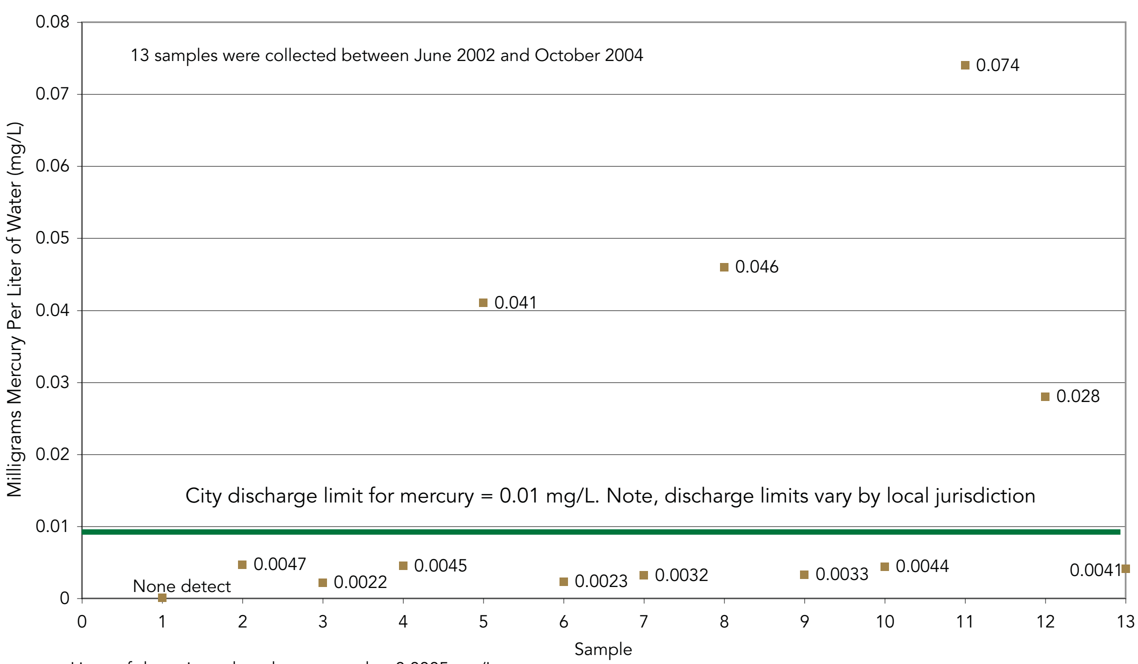
prior to re-calibrating the radiation detection monitor. The majority (82.3 percent) of the 775 containers were set aside for up to 27 days at the autoclave facility to allow the radioactivity time to continue to decay. These containers were subsequently autoclaved. The remaining 137 containers were removed from the waste stream and sent back to the generator. The CDHS requires off-site waste treatment providers to notify CDHS when radioactivity above specified levels is detected in medical waste (CDHS 2000a). The CDHS Radiologic Health Branch was notified about 153 (19.7 %) of the containers with radioactive materials detected.

3. Wastewater

The steam autoclave facility used an average of 23,000 gallons of water a day. Approximately 15 percent of the incoming water was lost due to "drag-out" and to evaporation in the tub washer unit. Water was discharged from the facility through six floor drains to the city sanitary sewer system after first passing through a wet well, two grinder pumps, two strainers, and a surge tank. Water was also discharged indirectly to the landfill. There was generally a five to eight percent weight gain in the treated waste that went to the landfill for disposal.

In the 28-month period between June 2002 and October 2004, mercury was detected in 12 of 13 wastewater samples collected at the facility; four of 13 samples were approximately three to seven times greater than the local city government discharge limit of 0.01 milligrams mercury per liter water (mg/L) (Figure 34). Mercury was measured in accumulated solids at concentrations above hazardous waste levels.

Figure 34. Mercury Detected in Wastewater (mg/L) Over 28 Months (N=13 Samples)



Limts of detection = less than or equal to 0.0005 mg/L, depending on the sample.

Source: Local Government Testing Results

In 2003, 12 of 14 wastewater samples collected at the facility were determined to be out of compliance with local discharge limits for Total Toxic Organics.[8] The city estimated that 90 percent of the waste stream discharges were isopropyl alcohol and acetone. The acetone levels were in the range of three to five mg/L, with a spike of 63 mg/L. Other chemicals detected in wastewater leaving the autoclave facility were: trichloroethylene, xylene, 1,4-dichlorobenzene, and bis(2-ethylhexyl)-1 phthalate (DEHP), the latter presumably from IV bags containing phthalates. DEHP was measured at levels of 0.5 and 0.6 mg/L.

Subsequent to the 2003 CDHS/OHB on-site investigation, the steam autoclave facility installed a photo ionization detector (PID) to identify the presence of volatile organic chemicals in waste tubs; use of the PID was discontinued early in 2004.[9] In 2004, the steam autoclave facility was required by the city Publicly Owned Treatment Works to install a wastewater treatment system to prevent the discharge of hazardous materials into the sanitary sewer system. The pretreatment system went on line in December 2004 with a multi-stage system to address both metallic and organic pollutants. The system consists of conventional hydroxyl precipitation with plate and frame sludge press, followed by sand filtration polishing, followed by an air stripping tower for volatile organic pollutant removal.

8 Total Toxic Organics is defined as the sum of the masses or concentrations of specific toxic organic compounds found in the discharges at greater than 0.01 mg/L. The local limit for the facility in this investigation was at or above 2.13 mg/L.

9 Approximately two months after the CDHS investigation, a fixed organic monitor, Rae-Guard FGM-1000 Series photo ionization detector, was installed above the scale at the scanning station to detect the presence of certain hydrocarbons in the open medical waste tubs. The detector was alarmed to indicate a level of volatile organic compounds at or above 25 parts per million. The detector did identify a tub containing solvents that was returned to the generator; however, in general, the detector provided little useful data. The photo ionization detector did not identify specific volatile organic compounds, the source of the acetone in the wastewater discharge, nor did it detect all organic compounds of concern (such as formaldehyde and methanol). The detector was also reported to be very difficult to maintain in the steam autoclave workplace environment. A wastewater treatment system was installed at the steam autoclave facility in 2005 at a cost reported to be in excess of $650,000.

D. WORKER EXPOSURES

1. Ergonomic Stressors

CDHS/OHB researchers observed unassisted repetitive manual lifting of the tubs among Drivers and Plant Workers throughout all phases of the work process. This activity was especially prevalent among Plant Workers moving the tubs from the plant floor onto the conveyor, an activity that required workers to manually lift tubs off the top of a stack of two or three and place them approximately one foot above the ground (Figures 35 to 37). Workers also manually lifted tubs to empty the waste into the autoclave bins.

Figure 35. Lifting tubs of waste onto conveyer

In response to CDHS/OHB's investigation, a health and safety consultant retained by the employer conducted a qualitative evaluation of ergonomic risk factors.[10] The evaluation compiled data demonstrating that over a one-year period, Drivers and Plant Workers manually lifted, pushed, pulled, or otherwise handled 592,020 containers weighing 19,808,046 pounds. Workers manually handled each tub multiple times. The evaluation identified 31 different container types in use; 93 percent of the medical waste volume by container count and 95 percent of the volume by weight was transported in four container types holding 20, 37, 44, and 90 gallons of waste, respectively (Figure 38). Workers manually moved tubs weighing from six to 379 pounds. The average weight of the majority of tubs (58.7 percent) was 40 or more pounds; 17 percent of the tubs weighed an average of 87 pounds.

Figure 36. Lifting tubs of waste onto conveyor

The ergonomic evaluation identified job task profiles for the seven plant waste processing tasks: unloading autoclave waste, managing incinerator waste, inspection, scan and weigh station, tipping station, tub washing, loading clean containers, and managing non-conforming waste. Ergonomic risk factors prevalent in all tasks, except for the relatively infrequent task of managing non-conforming waste, were: awkward posture, force (high, low, or medium weight lifting and lowering), repetition (repeating motions greater than two times per minute), and inconsistent coupling[11] (Appendix 3).

Figure 37. Lifting tubs of waste onto conveyor

10 Verliant. Ergonomic Evaluation May 2004.

11 "Coupling" is the quality of the hand-to-container interface, i.e., how good the handles are.

Figure 38. Weight of Medical Waste Tubs Handled by Type Over One Year

Tub Type	Number (%)**	Weight of Each Tub* (Pounds)		
		Range	Mean	Median
20 Gallon 	60,400 (10.2)	6 - 93	19	16
37 Gallon 	142,494 (24.1)	12 - 115	36	33
44 Gallon 	246,900 (41.7)	13 - 141	40	36
90 Gallon 	100,399 (17.0)	28 - 379	87	74
Total	550,193 (93.0)			

* Includes tare weight of tub and weight of medical waste.

** During the one-year period, a total of 592,020 containers were handled in 31 different container types; 93% of the waste volume by container count and 95% of the volume by weight was accounted for by the four container types (i.e., 20, 37, 44, and 90 gallons) shown in the table.

Source: Verliant. Ergonomic Evaluation May 2004

2. Biological Agents

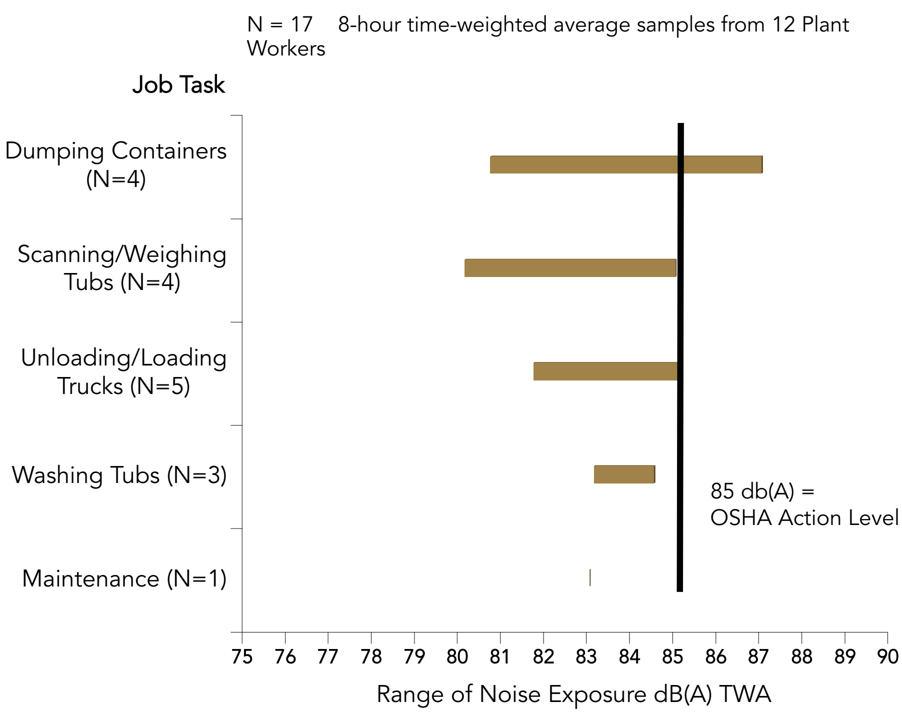
The interior of the truck appeared clean, and the facility appeared to be freshly painted. In general, CDHS researchers observed generally clean walls, floors, and surfaces. In the area where waste was transferred from the tubs into the autoclave bins (Task 5, Figure 19), liquids from untreated medical waste were observed on the exterior side of the autoclave bin and on the floor next to the autoclave bin. The visibly contaminated pole and shovel were stored up against the railing of the platform. Compacting the treated waste breached containment of the waste in red bags and sharps containers, and needles were in and near the floor drains.

3. Physical Agents

On the day of the on-site investigation, a silencer to the pump for the autoclave's carbon bed filter had corroded, and noise levels from the autoclave were at a level that precluded conversation. The employer reported that this problem was repaired shortly thereafter.

Worker exposure to noise was subsequently evaluated at the autoclave facility on four separate days in 2003 by a Certified Industrial Hygienist retained by the employer. A total of 17 personal noise monitoring samples were collected from 12 Plant Workers on different shifts while they were engaged in their routine tasks (Figure 39). Plant Workers' eight-hour, time-weighted average (TWA) exposure to noise ranged from 80.1 decibels measured on the A-scale (dB(A)) to 87 dB(A). Three of 17 personal samples were equal to or greater than the Cal/OSHA action level of 85 dB(A).[12] Workers were exposed to noise at 85 dB(A) TWA or more while they were primarily engaged in dumping containers, scanning tubs, and loading/unloading trucks; workers washing tubs were exposed to noise levels up to 84.5 dB(A) TWA.

Figure 39. Range of Worker Exposure to Noise by Job Task



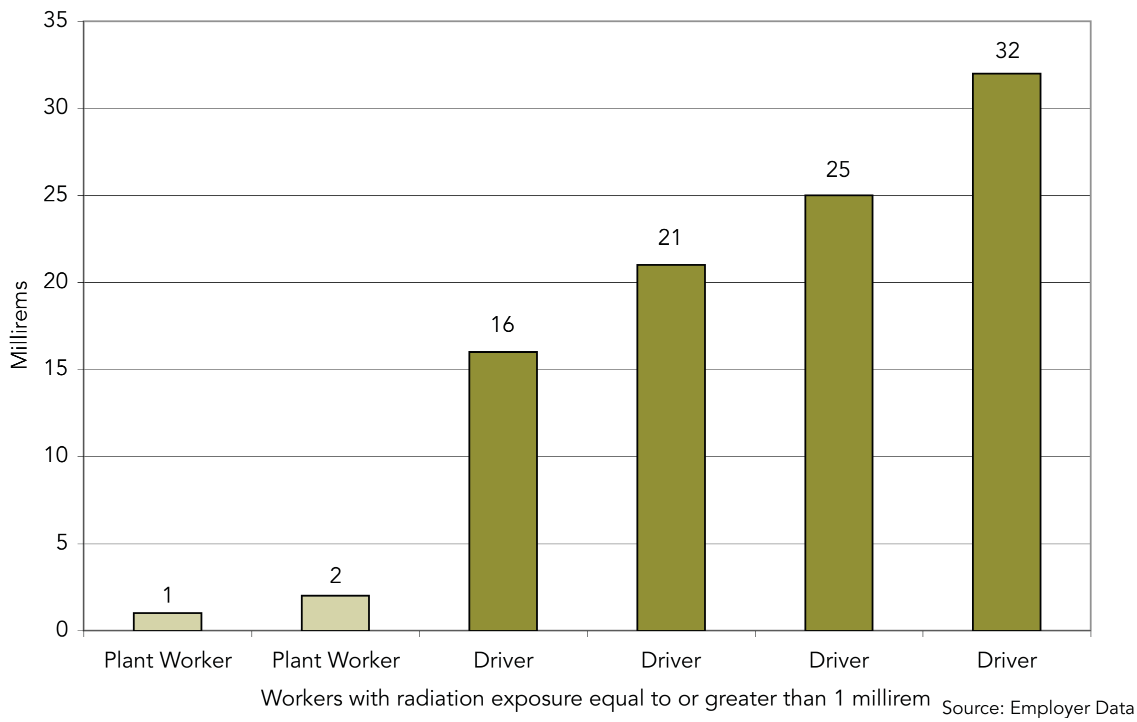
Source: EnvirOSH Services, Inc. Industrial Hygiene Survey

12 California Code of Regulations, Title 8, Section 5097. Hearing Conservation Program.

- **Ionizing Radiation**

  The employer monitored workers' personal exposures to radiation during a three-month period between September and November 2003. Workers were monitored for one to three months. Of 36 workers monitored, 12 returned their badges unused and had no valid measurement, 18 had a one or two-month dose equivalent level below one millirem (mrem), and six had a measured radiation exposure ranging from one to 32 mrem for a two-month period (Figure 40). For five of the six workers with a measured exposure to radiation, all of the exposure was measured in a one-month period. Workers' maximum exposures were approximately 300 mrem/year (three millisievert).[13] By law when biohazardous is mixed with radioactive waste it is no longer considered medical waste (Appendix 1). There should be no work-related exposure to radiation for individuals transporting and treating medical waste.

Figure 40. Worker Two-Month Dose Equivalent Exposure to Radiation (N=6 Workers)



13 The highest monthly radiation exposure level measured was 25 mrem per month which, over a 12-month period, would equal 300 mrem. The total effective dose equivalent to individual members of the public from the licensed operation must not exceed 100 mrem (1 mSv) in a year (Code of Federal Regulations, Title 10, Part 20).

4. Chemical Agents

Potential sources of worker exposure to chemical agents include chemicals brought into the facility in the medical waste stream and chemicals in products utilized in the operations of the work process (Appendix 2). Workers have potential exposure to these chemicals by breathing the workplace air and by having skin or eye contact with chemicals.

In response to the CDHS/OHB investigation, air sampling to evaluate the potential for worker chemical exposure during the waste treatment process was conducted at the autoclave facility on six separate days in 2003 by a Certified Industrial Hygienist contractor retained by the employer. A total of 68 personal air-monitoring samples were collected from 16 Plant Workers over all three shifts while workers performed their routine tasks, including: unloading trucks, scanning, opening lids and weighing tubs, dumping waste into autoclave bins, washing tubs, and loading trucks with waste for incineration and clean tubs (Table 2).

TABLE 2. WORKER CHEMICAL EXPOSURE MONITORING: RESULTS OF PERSONAL AIR SAMPLES* (N=68)

	CHEMICAL MEASURED									
	Total Hydrocarbons (N=13)	Mercury (N=10)	Formaldehyde (N=7)	Ethanol (N=6)	Glutaraldehyde (N=6)	Acetone (N=6)	Acetaldehyde (N=6)	Isopropyl Alcohol (N=6)	Phenol (N=4)	Methanol (N=4)
METHOD	NIOSH 1500	OSHA ID 140	NIOSH 2016	NIOSH 1400	NIOSH 2532	NIOSH 1300	NIOSH 2538	NIOSH 1400	NIOSH 2546	NIOSH 2000
Work Activities Monitored	THE RESULTS OF ALL CHEMICALS MONITORED WERE LESS THAN THE LIMITS OF DETECTION FOR THE METHOD USED									
Unloading/ loading trucks	< 1.2 ppm**	< 0.0057 mg/m³ ***					< 1.9 ppm	< 1.3 ppm	< 0.12 ppm	< 0.37 ppm
Scanning, opening lids, and weighing tubs	< 6.2 ppm	< 0.0065 mg/m³	< 0.028 ppm	< 4.8 ppm	< 0.0099 ppm	< 1.2 ppm	< 1.9 ppm	< 0.64 ppm	< 0.14 ppm	< 0.43 ppm
Dumping medical waste from tubs into autoclave bins	< 2.2 ppm	< 0.0097 mg/m³			< 0.014 ppm	< 1.3 ppm	< 1.9 ppm	< 1.2 ppm	< 0.13 ppm	< 0.41 ppm
Washing empty tubs after medical waste has been dumped out	< 5.0 ppm	< 0.0059 mg/m³	< 0.047 ppm	< 4.2 ppm	< 0.0077 ppm	< 1.1 ppm	< 2.8 ppm	< 1.9 ppm	< 0.13 ppm	< 0.41 ppm

* Personal samples collected over 57 to 425 minutes from a worker's breathing zone level by drawing air at a measured flow rate through NIOSH/OSHA approved sampling media using portable air sampling pumps

** ppm=parts per million

*** mg/m^3=milligrams per cubic meter of air

Source: EnvirOSH Services, Inc. Industrial Hygiene Survey. August 4-7, 2003, and October 6-8, 2003

Each task monitored was evaluated for one or more of the following chemical exposures: total hydrocarbons, mercury, formaldehyde, ethanol, glutaraldehyde, acetone, acetaldehyde, isopropyl alcohol, phenol, and methanol. All personal samples were collected and analyzed by an accredited laboratory according to a NIOSH or OSHA method specific to that chemical. Personal samples were collected over 57 to 425 minutes depending on the chemical. The results of all 68 samples were less than the limits of detection for the sampling method.

In addition to the personal air samples, 71 short-term area samples were collected as workers performed their routine tasks, including scanning, opening lids and weighing tubs, dumping waste into autoclave bins, washing tubs, opening the autoclave door after waste treatment, tipping treated waste into the compactor and changing out the compactor bin with a forklift, and working inside the boiler room (Table 3).

TABLE 3. WORKER CHEMICAL EXPOSURE MONITORING: RESULTS OF SHORT-TERM AREA AIR SAMPLES* (N=71)

	CHEMICAL MEASURED						
	Hydrochloric Acid	Ammonia	Methanol/Isopropyl Alcohol	Chlorine	Carbon Dioxide	Carbon Monoxide	
WORK ACTIVITIES MONITORED	Maximum Result in Parts Per Million (No. of samples)						Total No. Samples
Scanning, opening lids, and weighing tubs	< 1 (2)	0.05 (2)	< 25 methanol/ <50 isopropyl alcohol (2)	< 0.3 (2)			8
Dumping medical waste from tubs into autoclave bins	< 1 (4)	0.25 (3)	< 25 methanol/ <50 isopropyl alcohol (4)	<0.3 (4)	200*** (1)	< 2 (1)	17
Washing empty tubs after medical waste has been dumped out	< 1 (3)	< 0.25 (3)	< 25 methanol/ <50 isopropyl alcohol (3)	< 0.3 (3)			12
Opening autoclave door after waste treatment, closing door, beginning new treatment cycle	< 1 (2)	< 0.25 (2)	< 25 methanol/ <50 isopropyl alcohol (2)	< 0.3 (2)			8
Tipping treated waste into compactor, changing out the compactor bin with forklift	< 1 (3)	< 0.25 (3)	< 25 methanol/ <50 isopropyl alcohol (3)	< 0.3 (3)	400 (2)	175** (4)	18
Working inside boiler room with door closed	< 1 (1)	< 0.25 (1)	< 25 methanol/ <50 isopropyl alcohol (1)	< 0.3 (1)	600 (2)	< 2 (2)	8
Total No. Samples	15	14	15	15	5	7	71

* Grab samples collected over one to eight minutes from a worker's breathing zone level using Draeger direct-reading colorimetric tubes.

** The Cal/OSHA eight-hour, time-weighted average (TWA) exposure limit is 25 parts carbon monoxide per million parts air (25 ppm). The Cal/OSHA Ceiling Limit is 200 ppm (California Code of Regulations, Title 8, Section 5155).

*** Carbon dioxide levels of 200 ppm were reported when changing the compactor bin, in the boiler room, and during container dumping. These three results are too low to be consistent with ambient indoor air levels of carbon dioxide and may indicate an error in the sampling methodology.

Source: EnvirOSH Services, Inc. Industrial Hygiene Survey. August 4-7, 2003, and October 6-8, 2003

Each task monitored was evaluated for one or more of the following chemicals: hydrochloric acid, ammonia, methanol and isopropyl alcohol, chlorine, carbon dioxide, and carbon monoxide. Samples were collected for one to eight minutes from workers' breathing zones using direct-reading colorimetric tubes.

Short-term carbon monoxide levels of concern were measured during the operation of the propane-powered forklift used to change the compactor box. Of four samples, two had no carbon monoxide detected; levels of 30 ppm and 175 ppm were measured in the remaining two samples.[14] Reported carbon dioxide levels consistent with ambient indoor air were measured when tipping waste into compactor (up to 400 ppm) and while working inside the boiler room (up to 600 ppm). Carbon dioxide levels of 200 ppm were reported when changing the compactor bin, in the boiler room, and during container dumping. These three results are too low to be consistent with ambient indoor air levels of carbon dioxide and may indicate an error in the sampling methodology. All other chemicals sampled were below the limits of detection for the sampling method.

A total of 48 chemical products were used in the operations of the facility for the following tasks: floor cleaning (N=7 products), spill cleanup (N=2), deodorizing (N=2), hand washing/disinfection (N=3), tub washing (N=2), autoclave maintenance and operations (N=14), boiler maintenance and operations (N=6), and general use (N=12) (Appendix 2). The key hazards associated with exposure to the chemicals routinely used in large volumes were eye and respiratory irritation, asthma, and neurological effects (Table 4).

14 The Cal/OSHA eight-hour, time-weighted average (TWA) permissible exposure limit is 25 parts carbon monoxide per million parts air (25 ppm). The Cal/OSHA Ceiling Limit is 200 ppm (California Code of Regulations, Title 8, Section 5155). This means that legally, exposures must never exceed this Ceiling Limit for any period.

TABLE 4: KEY HAZARDS OF WORKER EXPOSURE TO CHEMICALS IN PRODUCTS USED AT A STEAM AUTOCLAVE

Task	Chemicals in Products Routinely Used in Large Volumes	Primary Hazards of Worker Exposure to Chemicals in Products Used
Floor Cleaning	Butoxyethanol, sodium hydroxide, bacterial concentrate	Eye and respiratory irritation
Cleaning Spills	Bleach	Eye, respiratory irritation
Handwashing	Alcohol, ethanolamine	Eye, respiratory irritation; asthma
Tub Washing	Quaternary ammonium compounds	Eye, respiratory irritation; asthma
Autoclave	Solvent-based aerosol cleaners	Central nervous system effects, i.e., headache, nausea, dizziness, clumsiness, drowsiness; cancer
Boiler	Sodium metabisulfite and sodium sulfite	Severe eye and respiratory irritation; asthma

Source: Employer Material Safety Data Sheets

E. EXPOSURE CONTROL MEASURES

1. Engineering Control Measures

Many ergonomic hazards had been reduced or eliminated by the following design features: (1) handcarts were used to reduce lifting and hand-carrying tubs; (2) a conveyor belt moved the tubs from the tracking station to the autoclave; (3) a "tipper" mechanically dumped the waste into the autoclave bin; (4) the autoclave bins were mechanically moved in and out of the autoclave; and (5) waste was mechanically transferred from the autoclave bins to the compactor.

Figure 41. Autoclave hoods

Figure 42. Tub washing hood

In the tub washing area the quaternary ammonium compounds were mixed with water, piped into the washer, and the solution was applied to the tubs in an enclosed system.

A heating, ventilation, and air-conditioning (HVAC) system provided two air-changes per hour with no recirculated air. The HVAC system had five exhaust fans: one over each of the two autoclave doors, one over the tub washer, and two over the treated waste compactor system.[15] Each fan was a roof-mounted centrifugal up-blast exhaust fan. There were hoods over each autoclave door (Figure 41) and the tub washer (Figure 42). The canopy hoods had ten feet by four feet openings, and were mounted four feet above the autoclave doors.

As the autoclave chamber door opened, four nozzles in the hood above the door sprayed a deodorizer[16] for about three minutes.

The maintenance procedures specified that the HVAC system be visually inspected and cleaned as needed monthly, inspected and greased quarterly, and inspected by an outside contractor annually.

After the waste was treated in the autoclave, but before the autoclave door was opened, a vacuum was pulled on the autoclave to reduce pressure, remove steam, and collect chemical vapors. The air was subsequently exhausted through a carbon-bed filter before being discharged outside the building. Carbon adsorption

15 The exhaust fan over the tub washer had a capacity of 5,000 cubic feet per minute (cfm). The other four exhaust fans each had a capacity of 10,000 cfm.

16 Ecosorb. According to the Material Safety Data Sheet this product is "non-toxic, non-hazardous, biodegradable, and contains no harmful [volatile organic compounds] VOCs."

systems eventually become saturated. Saturation of the carbon bed was determined by smell; that is, when odor was detected, the carbon bed was replaced.

Safety measures were engineered into the design of the autoclave to protect workers from the danger of working around steam at high temperatures and pressures. The autoclaves at the facility were reportedly designed, built, tested, and certified according to the American Society of Mechanical Engineers (ASME) Pressure Vessel Code.[17] The vessels were rated at 100 psig with a 1.5X safety factor. By design, a high-pressure alarm would sound and send a message to the operator's control screen if the pressure reached 65 psi. The computer controls would then shut off the steam valve. As an added safety measure, two pressure relief valves were set by the autoclave manufacturer to release steam at 100 psig.

The autoclaves at the facility had four redundant safety mechanisms to prevent opening the door while the autoclave is under pressure:[18] (1) a pressure switch that prevents the hydraulic system from opening the door if the pressure is above 1.5 psig; (2) a pressure transmitter on the autoclave that does the same thing; (3) a cylinder connected to the vessel so that steam from inside the vessel pushes on a pin that stops the locking ring from disengaging; and (4) a valve that hinders the flow of oil to the locking ring hydraulic cylinders as long as the pin is engaged. The autoclave is designed to shut off in the event of a power failure.

Some large autoclaves use a "man-inside" safety cable or alarm that can be used by a worker performing maintenance inside the autoclave to keep from being trapped inside. The autoclaves at the facility did not have this feature. Instead, the facility relied on a "lock-out/tag-out" procedure that involves locking the hydraulic pump in the "off" position to prevent the door from closing as long as a worker is inside the autoclave. The facility had lock-out/tag-out procedures for servicing or maintenance of the boilers, tub washer, compactor, shuttle conveyor, bin conveyors, bin tipper, compactor box, air compressor, and tub tippers, in addition to the autoclaves, as well as for the vehicle inspection of the medical waste tractor.[19]

17 ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, American Society of Mechanical Engineers, New York, NY.

18 The ASME Pressure Vessel Code requires at least two mechanisms to prevent accidental opening of quick-opening doors.

19 This is consistent with the Federal OSHA and Cal/OSHA rules on Control of Hazardous Energy: 29 CFR 1910.147 Control of Hazardous Energy and California Code of Regulations, Title 8, Section 3314 (The Control of Hazardous Energy for the Cleaning, Repairing, Servicing, Setting-Up, and Adjusting Operations of Prime Movers, Machinery and Equipment Including Lockout/Tagout). The Cal/OSHA Standard is meant to be equivalent to the Federal Standard but it is not identical. California employers should refer to the Cal/OSHA Standard.

2. Administrative Control Measures

- **Job Rotation**

Plant Workers rotated jobs throughout the shift after two or more hours of working at a task.

- **Hygiene and Housekeeping**

Figure 43. Worker lockers

Figure 44. Worker showers

There was a hand-washing station outside the enclosed break room. According to the Exposure Control Plan dated June 12, 2003, workers were required to wash their hands immediately or as soon as possible after removing gloves or other personal protective equipment. Drivers carried disposable wipes or a hand sanitizer, and a spare uniform or disposable coverall. The facility had a rest room with lockers and showers (Figures 43 and 44), and workers were required to shower after their shifts and leave their uniform and shoes at the facility. Eating, drinking, smoking, and handling of contact lenses were prohibited in all waste handling areas.

The Exposure Control Plan specified that facility floors and work surfaces be cleaned and decontaminated regularly, and vehicle cargo areas be decontaminated whenever the area was visibly soiled with medical waste. No logs or other documentation of cleaning and disinfection of floors and surfaces were maintained. Depending on the surface, decontamination procedures included: use of an U.S. Environmental Protection Agency-registered "hospital disinfectant," a 0.05 percent solution of bleach, a 0.04 percent solution of quaternary ammonium compounds, or exposure to hot water (180°F) for 15 seconds. Use of phenol-based compounds for disinfection was prohibited. The maintenance checklists specified daily washing of the compactor/dumper and conveyor areas and weekly cleaning of dirt and debris from all conveyors. Spill kits were on trucks, and spill procedures were included in the Exposure Control Plan.

- **Waste Packaging**

The Exposure Control Plan specified that Drivers refuse to accept waste that was leaking or otherwise improperly packaged. As previously described, once at the facility, the top contents of the tubs were visually observed when the lids were removed, and the tubs were scanned for radioactive materials and volatile organic hydrocarbons.

- **Medical Monitoring**

  Medical monitoring was contracted out to an off-site clinic and consisted of pre-placement and periodic examinations. For Drivers, this included health history, visual acuity and color vision, optional audiometry, laboratory testing (chem profile, CBC, urinalysis, Hepatitis C Antibody), physical exam covering organ systems (Department of Transportation-based forms), respiratory medical evaluation questionnaire (if needed), Hepatitis B consent form and permanent record, and medical clearance/respirator clearance form. Workers were offered to begin Hepatitis B vaccination free of charge within ten days of initial assignment. For Plant Workers the forms were basically similar. No specific (objective) assessment of physical capacity was performed.

  It was not possible from the provided documentation of medical surveillance to determine if employee records were up-to-date.

  The Exposure Control Plan addressed generic issues pertinent to exposure to infectious materials as it pertains to the Cal/OSHA Bloodborne Pathogen Standard. There was no specific mention of how the employee receives post-exposure counseling about the injury and the risk of acquiring associated infectious diseases.

  There was no Return-To-Work program for injured employees.

Figure 45. Uniform delivery

3. Personal Protective Equipment

All Drivers and Plant Workers wore work boots, gloves made of leather with cotton tops, and long pants and short-sleeved shirts that were delivered to the facility and laundered daily at the employer's expense by an outside uniform service (Figure 45). Plant Workers wore safety glasses. Workers dumping waste into the autoclave bins also wore face shields. The worker washing tubs wore long-cuff black nitrile gloves and rubber boots. There was no respiratory protection program, and no respirators were required or in use.

F. HEALTH AND SAFETY TRAINING AND HAZARD COMMUNICATION

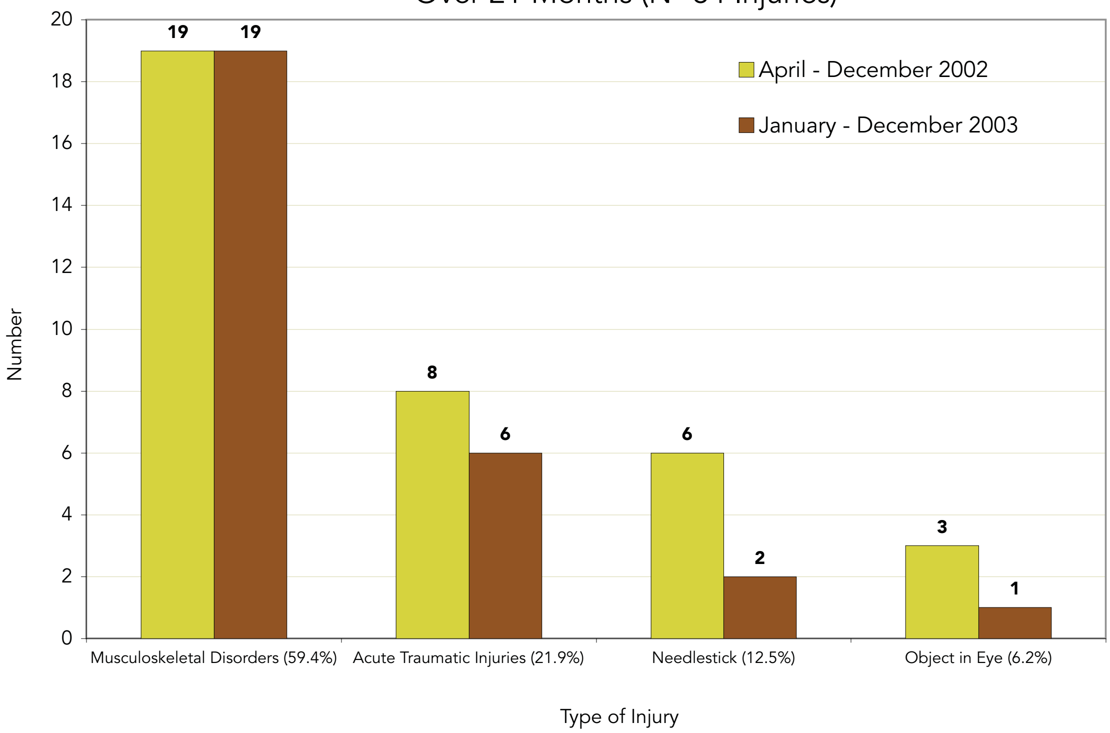
Workers received training about hazards, exposure control measures, and safe work practices, at the time of hire and at least annually from supervisory staff fluent in English and Spanish. There were also periodic informal safety meetings. Workers could ask questions during trainings. Other forms of safety communications included posters, pamphlets, tailgate meetings, and letters. There was no functioning Health and Safety Committee. There were no mechanisms for tracking issues and corrective actions or anonymous reporting of safety and health issues. Material Safety Data Sheets were compiled and accessible in a binder near the break room.

Specific training was provided to Autoclave Operators. The training topics and exam included equipment safety-related issues such as responding to abnormal or emergency conditions, detecting faulty pressure monitors, alarms, conditions under which the emergency stop switch should be used, inspection, maintenance, and autoclave door safety.

G. WORKER ILLNESS AND INJURY

Over the 21-month period between April 2002 and December 2003, a total of 64 injuries were recorded by the steam autoclave employer (Figure 46). During the period April to December 2002, the injury rate was 62 per 100 full-time workers. In 2003, the injury rate was 46 per 100 full-time workers.[19]

Figure 46. Worker Injuries by Injury Type Over 21 Months (N=64 Injuries)



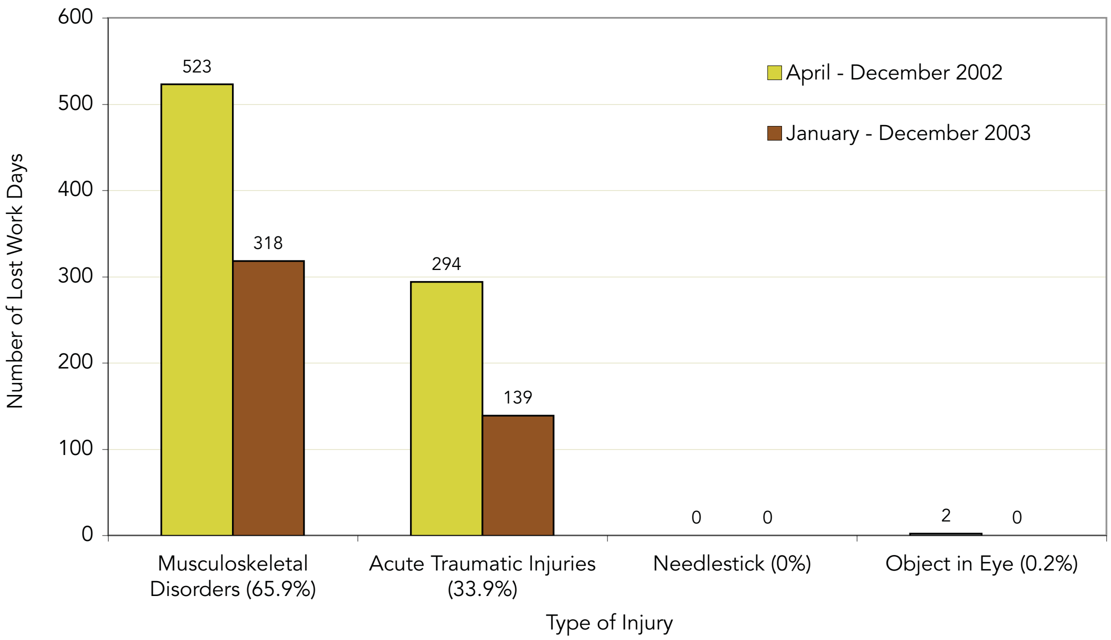
Source: Employer OSHA 200/300 Logs 2002/2003

The majority of injuries (59.4 percent) were musculoskeletal sprains and strains, followed by acute traumatic injuries, i.e., contusions, lacerations, fractured elbow, smashed fingers and hands (21.9 percent), needlesticks (12.5 percent), and eye injuries (6.2 percent). The 64 injuries resulted in a loss of 1,276 workdays, virtually all of which were related to musculoskeletal injuries (65.9 percent) and acute traumatic injuries (33.9 percent) (Figure 47). No vehicular-related injuries or work-related illnesses were recorded.

Virtually all of the musculoskeletal injuries were related to routine, repetitive tasks, i.e., lifting, pulling, pushing, or otherwise moving tubs of waste (Table 5). Three sets of identical injuries among two or more workers performing the same repetitive tasks occurred each year. In 2002, two workers suffered lower back pain while lifting tubs in the plant; three workers strained their shoulder while moving tubs in the truck; and two workers sprained their wrists while lifting tubs in the truck. In 2003, two workers

19 Injury incidence rates were calculated as follows: (N/EH) X 200,000 where N = number of injuries and illnesses, EH = total hours worked by all employees during the calendar year, and 200,000 = total hours base for 100 equivalent full-time workers (working 40 hours a week, 50 weeks per year). Rates calculated do not include injuries or hours worked by salaried and temporary workers; no temporary workers were used after March 2003. Accordingly, the injury rate for the period April to December 2002 = (30/73148.57) X 150,000 = 61.52 per 100 full-time workers. The injury rate for January to December 2003 = (27/118657.05) X 200,000 = 45.51 per 100 full-time workers.

Figure 47. Lost Work Days by Injury Type Over 21 Months (N=1276 Lost Work Days)



Source: Employer OSHA 200/300 Logs 2002/2003

sprained their back while dumping waste into the tipper, two sprained their back while pulling tubs, and two sprained their shoulder while lifting tubs onto the conveyor.

Of 14 acute traumatic injuries, five were related to falls, five involved a worker being struck by a broken steel collar attached to roller, a falling tub, a roll-off box, or a lift-gate, and for four there were insufficient data to identify how the injury occurred.

In addition to the injuries recorded among the Drivers and Plant Workers at the autoclave, one needlestick injury related to medical waste disposal was reported in an employee at a landfill where waste from the steam autoclave facility had been dumped in the past. The injury occurred when a Heavy Equipment Operator was pushing rubber tires over medical waste for cover. A piece of rebar concealed in the load became tangled in the hydraulic lines in the front of the bulldozer. The worker climbed down from the cab to remove the rebar. When the worker stepped up to re-enter the cab, a hypodermic needle concealed on the underside of the bulldozer track went through his coveralls and punctured his calf. Representatives of the landfill where the waste was subsequently dumped reported no related injuries to workers or other landfill customers during the approximately two-year period they had been disposing medical waste.

TABLE 5: MUSCULOSKELETAL DISORDER (MSD) INJURIES BY TASK RECORDED OVER 21 MONTHS (N=38) APRIL 2002 TO DECEMBER 2003

Task	Number of Recorded MSD Injuries	Type(s) of Injuries
Pulling tubs up a hill, onto truck	2	Back sprain
Opening trailer door	1	Lower and upper back pain
Pushing tubs onto truck	1	Inflamed knee
Sorting, moving, lifting, stacking tubs in trailer	10	Upper arm, shoulder, knee, back, and/or wrist sprain
Moving tubs at loading dock	1	Wrist sprain
Lifting, pulling, handling, moving tubs in plant	8	Back, shoulder, and/or wrist sprain; shoulder dislocation
Tubs stacked 3 high on hand cart; shoulder used to catch tipping tub	1	Shoulder sprain
Stacking tubs, caught a falling tub	1	Shoulder sprain
Lifting tubs onto conveyor	2	Shoulder sprain
Scanning incinerator-bound waste	1	Back strain
Dumping waste into tipper	2	Back and shoulder sprain
Unknown/unreported	8	Back, knee, chest, shoulder, and/or wrist sprain; torn rotator cuff; bone spurs in toes
Total	**38**	

Source: Employer OSHA Logs

DISCUSSION

ERGONOMIC HAZARDS

Workers at the steam autoclave had a very high rate of injury. Workers at this facility were injured at a rate 3.4 and 5.8 times higher than the rate of injury among California waste treatment and disposal workers, and health care workers, respectively.[1] The majority (59.4 percent) of the documented injuries were musculoskeletal injuries inherent to the rapid manual handling of approximately 2,000 tubs of medical waste having an average weight of approximately 42 pounds[2] on a daily basis. This result is consistent with a 1996 study by NIOSH that found the principal sources of worker exposure to hazards at a steam autoclave to be the many intensive manual material handling steps combined with unsafe acts (NIOSH 1996a, p. A–8).

The task of handling untreated medical waste is not treatment process specific (NIOSH 1996a, p. i), and ergonomic hazards are not unique to the steam autoclave work process. NIOSH also identified the strong potential for worker injury due to unassisted repetitive manual handling of waste tubs at a facility that utilized microwave technology (NIOSH 1996a, p. B–35).

Recognized contributors to work-related musculoskeletal injuries include frequent or heavy lifting, pushing, pulling, or carrying heavy objects, and jobs that combine risk factors increase worker risk (Bernard 1997; NIOSH 1997). The greatest risk for back injury is when loads are lifted from low heights, when the distance of the load from the body is great, and when the torso assumes a flexed, asymmetric posture (NRC/IOM 2001). Heavy physical work is also associated with back disorder (Bernard 1997). Procedures to correctly assess the physical demands of a manual lifting job have been described (Waters 1994). Musculoskeletal injuries lead to large and persistent earnings losses (Biddle 2004; Waehrer 2005).

At the steam autoclave observed by CDHS researchers, many ergonomic hazards had been reduced or eliminated by the design of the work process. However, many risk factors for injury were still present, including: (1) extensive, repetitive manual handling of heavy waste containers; (2) picking up tubs of waste stored at generators in inaccessible areas or locations that required unassisted moving of tubs on stairs; (3) transporting very heavy tubs, reportedly resulting from the disposal of large volumes of liquids in single tubs; and (4) the

1 The 2003 incidence rate of nonfatal occupational injury and illness at the steam autoclave facility was 46 per 100 full-time employees. For California workers, the comparable 2003 incidence rate was 13.5/100 for waste treatment and disposal workers, and 7.9/100 for health care workers. For all U.S. workers, the comparable 2003 incidence rate was 8.2/100 for waste treatment and disposal workers and 6.5/100 for health care workers (California Department of Industrial Relations 2005; U.S. Bureau of Labor Statistics 2005).

2 The weighted average of 95 percent of the tubs (Figure 38).

practice of stacking two or three tubs on top of each other, that also posed considerable safety hazards, as the height of the tubs made the load precarious and obscured the workers' field of vision. Although administrative controls such as job rotation and training provide some benefit, they are insufficient measures when manual handling of tubs is a task common to virtually all aspects of the work process (Appendix 3).

The annual injury data for the steam autoclave facility in this investigation reflect a pattern of physician-diagnosed injuries among two or more workers performing the same repetitive tasks. Workplaces with such an injury profile are subject to the provisions of the Cal/OSHA Ergonomics Standard (California Code of Regulations, Title 8, Section 5110) that require employers to establish and implement a program designed to minimize repetitive motion injuries. The program must include a worksite evaluation, control of the exposures that caused repetitive motion injuries, and worker training. In response to the CDHS investigation, in May 2004 the employer conducted a worksite ergonomic evaluation.

It has been shown to be feasible and is apparently cost-effective to engineer out most if not all manual handling of the tubs from the steam autoclave work process: the employer reported that 24 of the approximately 40 steam autoclaves operated by this employer nationally are fully automated so that no waste tubs are touched by workers; other facilities use forklifts or ramps to move tubs. In general, many waste treatment technologies include automatic feed assemblies such as cart lifters or bin dumpers to eliminate the handling of red biohazard bags by workers (Emmanuel 2001, p. 81).

However, the facility investigated by CDHS had been retrofitted, rather than designed for, steam autoclave treatment capabilities. The employer reported that significant capital expenditures would be required to address the ergonomic hazards through re-designing the facility. The employer also cited a tension between meeting the perceived needs of generators to have a wide range of tub sizes, and meeting the requirement of an automated system for standardized waste containers.

INFECTIOUS AGENTS

The work process design at the facility investigated by CDHS involved manual handling of open tubs of infectious waste, and led to the dispersal of solids and liquids from untreated waste into the workplace environment. As a result, workers had the potential for direct contact with untreated waste during routine and maintenance activities. Workers can be exposed to bloodborne and other pathogens through sharps injuries, and when infectious agents come into contact with broken skin, eyes, or are inhaled or ingested. These exposures can lead to occupationally-acquired infection with Hepatitis B, Hepatitis C, Human Immunodeficiency Virus, *Mycobacterium tuberculosis*, and other infectious agents, depending on the contents of the waste stream. Workers' exposures to infectious agents at the facility in the CDHS investigation were reduced by waste packaging, and by implementation of hygiene, housekeeping, personal protective equipment, and training.

Waste Packaging

The role of waste packaging in preventing workers' exposure to infectious agents is well recognized by the red biohazard bag and sharps containers provisions of the Medical Waste Management Act (California Health and Safety Code, Sections 117600–118360) and Cal/OSHA Bloodborne Pathogen Standard (California Code of Regulations Title 8, Section 5193). The use in health care facilities of leakproof, puncture-resistant containers for sharps began around the late 1970s to avoid the recapping of needles, a practice that has been associated with needlestick injuries among health care workers. Sharps containers have the added benefit of protecting housekeeping staff, waste handlers, and transporters from being exposed to contaminated sharps.

The worker protection afforded by waste packaging was integrated into the design of the work process at the steam autoclave facility investigated by CDHS/OHB in two ways:

(1) Waste was generally contained by packaging prior to autoclaving. NIOSH found that work processes that required extensive manual handling of waste resulted in frequent blood splashes at two off-site commercial treatment facilities, while a third facility that had the waste pre-packaged for ease of handling had a smaller likelihood of leaks (NIOSH 1996a, p. ii).

(2) The efficacy of steam autoclave treatment did not rely on shredding or other "unpackaging" of infectious waste. Compaction or shredding of untreated medical waste has been strongly discouraged or prohibited due to the demonstrated risk of aerosolizing infectious agents (Boyland 1989; Emery 1992). At least one case of work-related *Mycobacterium tuberculosis* resulted from exposure to contaminated medical waste at an off-site treatment facility where the efficacy of the electro-thermal deactivation (ETD™) waste treatment technology in use, and achievement of an 80 to 85 percent reduction in waste volume, were contingent on shredding and compacting infectious waste prior to treatment (Washington State Department of Health 1998; Weber 1998; Johnson 2000).

However, the final step in the steam autoclave work process, post-treatment compaction, resulted in the breaking of sharps containers and the discharge of the treated needles and syringes from their packaging. Treated sharps waste is a safety hazard and a biological hazard in that sterility is not maintained in the ambient environment.

Post-treatment compaction of treated medical waste, for the purpose of reducing the volume of treated waste sent to the landfill, is allowed and commonly done in the steam autoclave treatment process. However, the disposal of these uncontained sharps led to a worker's injury at one landfill. This same landfill was open to the public, and several members of the public were also injured when they came into contact with sharps at this landfill. In response to this problem, the County Environmental Health Department prohibited the disposal of medical waste at that site. Subsequently, a landfill in another county was engaged to receive the autoclaved waste. Public access to the landfill currently receiving treated waste from the steam autoclave investigated by CDHS is restricted, and treated medical waste is immediately covered with soil to prevent its dispersal. However, the potential for injury as a result of disposal of massive volumes of uncontained treated sharps remained for Heavy Equipment Operators and other workers dumping non-medical waste at that landfill.

Hygiene, Housekeeping, and Personal Protective Equipment

On the day of the CDHS site visit, housekeeping was generally good, and clean work clothes, gloves, safety glasses, face shields, showers, lockers, and hand washing stations were readily accessible and freely available to workers.

Weaknesses of these measures were: (1) wearing short sleeve shirts left workers' arms exposed; (2) eye protection was not required and/or consistently used by all workers who handled waste; (3) there was no written policy about the use of gloves at the control panel; (4) the timing and frequency of cleaning floors and surfaces were not specified (i.e., every shift, daily, weekly, etc.) and documented; and (5) contaminated poles and shovels were placed haphazardly at the dumping station.

A historical lack of, or inconsistent implementation of, one or more hygiene and housekeeping exposure control measures may explain the number of needlestick injuries among the autoclave workers in our investigation. NIOSH researchers found that deficient implementation of personal protective equipment, policies and procedures, and worker training, contributed to workers' exposures to untreated waste at the treatment facility where at least one worker acquired tuberculosis (Weber 1998).

CHEMICAL AGENTS

We found that medical waste treatment facilities are subject to the same paradox as hospitals: the cleaning agents used to protect worker health may also introduce hazardous exposures into the work environment. At the facility investigated by CDHS, strong respiratory and eye irritants, including quaternary ammonium compounds, bleach, sodium hydroxide, and butoxyethanol, were used routinely for cleaning. Occupational exposure to quaternary ammonium compounds,[3] and other cleaning agents used in the health care industry, is a recognized cause of asthma (Association of Occupational and Environmental Clinics 2005; Rosenman 2003).

Health-protective work practices for the use of cleaning agents that had been implemented at the steam autoclave facility in this investigation included: (1) an enclosed system for tub washing to prevent workers' exposures to asthma-causing quaternary ammonium compounds; (2) use of a low concentration of bleach and other respiratory irritants; (3) the required use and availability of gloves and eye protection by workers using these chemicals; and (4) the prohibition on the use of phenol-based compounds for disinfection. However, health-protective cleaning work practices had not been fully incorporated into purchasing and operating procedures. For example, a carcinogen (i.e., paradichlorobenzene) (Cal/EPA 2004) was used to deodorize floors (Appendix 2). Safer substitutes for the most hazardous solvent-based aerosol lubricants and cleaners in use, such as those that use trichloroethylene,[4] are also available (CDHS 2005b), and should be considered for their applicability to the steam autoclave maintenance functions.

3 Specifically, benzalkonium chloride, dodecyl-dimethyl-benzylammonium chloride, and lauryl dimethyl benzyl ammonium chloride.

4 Occupational exposure to trichloroethylene has been associated with an increased risk for kidney cancer, liver cancer, and non-Hodgkin's lymphoma, as well as for cervical cancer, Hodgkin's disease, and multiple myeloma (Wartneberg 2000).

Maintenance workers at the steam autoclave were especially at risk for exposure to hazardous chemicals because they: (1) may circumvent engineering controls during equipment maintenance and repair, i.e., manual handling of the quaternary ammonium compounds when maintaining the enclosed system for tub washing; and (2) routinely use large quantities of acutely hazardous chemicals (i.e., sodium hydroxide, sodium sulfite, sodium metabisulfite, and solvent-based aerosol cleaners) to maintain the boiler and conveyor system (Appendix 2).

In addition to the chemicals used for maintenance and cleaning, workers were also exposed to high levels of carbon monoxide from a forklift.[5] Carbon monoxide is a colorless, odorless gas produced by all internal combustion engines including propane-powered engines. Forklift trucks are a major source of work-related carbon monoxide poisoning (Lofgren 2002; Comstock 2000; NIOSH 1996b). The symptoms of carbon monoxide poisoning are non-specific and include headache, nausea, lethargy, weakness, abdominal discomfort/pain, confusion, dizziness, visual disturbances [including blurred vision], numbness and tingling, ataxia, irritability, agitation, chest pain, dyspnea on exertion, palpitations, seizures, and loss of consciousness (Comstock 2000). Carbon monoxide exposure can cause acute illness, permanent neurological damage, and death; persons with pre-existing heart disease are at increased risk (NIOSH 1996b). Forklift maintenance, ventilation, and carbon monoxide monitoring procedures are needed when propane-powered forklifts are used in enclosed settings (Comstock 2000; NIOSH 1996b).

PHYSICAL AGENTS

At the facility investigated by CDHS, workers were exposed to noise at or above the Cal/OSHA action level while engaged in routine tasks and as a result of equipment failure; however, workers were not enrolled in a hearing conservation program.[6] The potential for hot, malodorous working conditions existed. Dilution ventilation supplied to the facility by the HVAC system was poor. The open loading docks provided additional airflow, although the amount and distribution of additional air flow would vary depending on how fully the doors were open and local wind and weather conditions. Depending on their route, Drivers encountered considerable traffic hazards while picking up and transporting waste although, notably, no vehicular accidents had been reported.

5 A carbon monoxide level of 175 ppm was measured over a four-minute period using a Draeger direct-reading colorimetric tube. The variability of the method is +/- 15 percent, so the actual four-minute level could be as high as 201 ppm. The Cal/OSHA Ceiling Limit for carbon monoxide is 200 ppm. This means that legally, exposures must never exceed 200 ppm for *any* period of time.

6 Cal/OSHA requires that employers administer a continuing, effective hearing conservation program whenever employee noise exposures equal or exceed an eight-hour time-weighted average sound level (TWA) of 85 decibels measured on the A-scale (California Code of Regulations Title 8 Section 5097).

WORKERS' EXPOSURES RELATED TO IMPROPER WASTE SEGREGATION AND PACKAGING

Rate of Improper Waste Segregation and Packaging

Only when proper precautions are taken to exclude hazardous materials (i.e., antineoplastic agents, toxic chemicals, radioisotopes, and chemicals volatilized by steam), do steam autoclaves produce minimal emissions (Emmanuel 2001, p.25). In our investigation, waste segregation errors were identified in approximately 0.24 percent of the medical waste containers received for steam autoclave treatment, equal to about five containers of discrepant waste every day.[7] Due to the superficial nature of the detection system for all but radiation-related segregation errors, the 0.24 percent error rate underestimates the true amount of discrepant waste that arrived at this steam autoclave. Because vast quantities of infectious waste are produced by the health care industry, a "small" segregation error rate can have a large cumulative downstream impact. The off-site facility in this investigation treated over 600,000 containers and five million pounds of waste annually; an estimated 100 million pounds (50,000 tons) of medical waste are generated annually in California (McGurk 2004). The generation of medical waste is projected to increase as a result of the aging of the U.S. population and associated increase in delivery of medical tests and procedures (Stericycle 2004).

The number of radioactive waste containers detected at the autoclave facility in this investigation varied by month; the apparent increase during the second quarter of the year may have been due to the re-calibration of the detection equipment (Figure 33). If this were the case, the number of radioactive containers detected during the first quarter of the year may underestimate the true incidence.

The finding that two of every three containers identified with discrepant waste contained radioactive materials (Figure 32), is likely an artifact of the ability to efficiently detect radioactive materials in any part of the tub, in contrast to detecting chemotherapeutic, pharmaceutical, or other waste not suitable for the steam autoclave only through visual inspection of the top of the open tub. We do not know what the true relative contributions of these various materials were to the waste stream.

Workers' Exposures to Chemicals Related to Improper Waste Segregation and Packaging

Results of the employer's air sampling at the facility in the CDHS/OHB investigation demonstrated that on the days that sampling was conducted chemicals that might be volatilized in the steam autoclave were all below detectable levels. However, the wastewater sampling data demonstrated that chemical hazards such as mercury, that should have been excluded from this waste stream by the generators, made their way into the autoclave. Air sampling conducted by the employer may have been limited in its ability to fully characterize workers' exposures because: (1) no personal air samples were collected from workers while opening the autoclave door

7 The facility received 155,702 total containers in three months for steam autoclave treatment = 467,106/9 months; the facility received 1114 discrepant containers in nine months: 1114/467,106 containers = 0.24 percent error rate; 1114 containers in nine months = six days a week X 4.3 weeks per month X nine months = 1114/232.2 days = 4.79/day

after processing waste, the time when the potential for exposure could be highest; and (2) in general, airborne chemical exposures from the autoclave would result from the unpredictable presence of a hazardous material in the waste stream; it is difficult to accurately characterize exposures that are intermittent.

The primary health effects of chronic exposure to mercury vapor are on the central nervous system, i.e., tremors, changeable emotional state, insomnia, headaches, sensory loss, memory loss and impaired cognitive function (Cal/EPA 2005a; DTSC 2002). Moreover, relatively low levels of mercury that leave the facility can enter the marine environment, be transformed into methylmercury,[8] and result in highly concentrated levels of mercury contamination in fish. Methylmercury is a potent developmental and neurological toxin in humans. Consumption of contaminated fish is the primary route of methylmercury exposure in humans (DTSC 2002).

An investigation of mercury release during autoclave sterilization of dental amalgam underscores the potential for hazardous worker exposures (Parsell 1996). Parsell et al. documented measurable amounts of mercury vapor in room air when the autoclave was vented and when the door was opened. They also found that some portion of mercury vapor did not reach the room air, but may have been deposited in the autoclave chamber walls and the water in the reservoir tank; if this were the case, mercury could accumulate and concentrate at these locations. The study concluded that mercury concentrations generated by steam autoclave treatment of dental amalgam could potentially reach levels that would constitute a health risk.

Mercury exposure of steam autoclave workers would be reduced by the presence of dilution and local exhaust ventilation, and by being located at a distance from the autoclave door as it opens. All of these conditions were present at the facility in the CDHS investigation. However, autoclaves operating in small, enclosed spaces, having poor dilution and local exhaust ventilation, and involving work practices which permit workers to stand close to the autoclave when the doors are opened after the treatment process, have an increased potential for workers to be exposed to mercury if it is present in the waste stream.

In addition to airborne exposure, workers who have contact with accumulated solids from work processes have the potential for skin exposure to mercury. At the facility investigated by CDHS, mercury was measured in accumulated solids at concentrations above hazardous waste levels.

The opportunity for worker exposure to hazardous chemicals that enter the waste stream was also demonstrated in a study conducted by NIOSH at another steam autoclave facility (NIOSH 1996a). Area air sampling by NIOSH found formaldehyde at emission points near the control panel, over the autoclave, and at the compactor at levels ranging from 0.08 to 0.18 milligrams per cubic meter of air (mg/m^3);[9] measured formaldehyde levels exceeded

8 The Office of Environmental Health Hazard Assessment explains, "Once mercury gets into water, much of it settles to the bottom where bacteria in the mud or sand convert it to the organic form of methylmercury. Fish absorb methylmercury when they eat smaller aquatic organisms. Larger and older fish absorb more methylmercury as they eat other fish. In this way, the amount of methylmercury builds up as it passes through the food chain. Fish eliminate methylmercury slowly, and so it builds up in fish in much greater concentrations than in the surrounding water. Methylmercury generally reaches the highest levels in predatory fish at the top of the aquatic food chain." (Cal/EPA 2005b)

9 0.08 to 0.18 mg/m^3 is equal to 0.10 to 0.23 parts formaldehyde per million parts air.

NIOSH's Recommended Exposure Level.[10] Overexposure to formaldehyde irritates the eyes, nose, throat, and skin (Suh 2000). Formaldehyde can cause allergic reactions of the skin (dermatitis) and the lungs (asthma), and it probably causes cancer in humans (Suh 2000; AOEC 2005; U.S. EPA 1991; CDHS 2005c). NIOSH also found acetaldehyde and acetone levels were approximately 0.07 mg/m^3, and minimal levels of mercury and other metals were present in the air over the autoclave and at the compactor. A wide range of volatile organic compounds were detected in excess of 0.05 mg/m^3.

All of the chemicals measured in the NIOSH study were at levels well below their respective permissible occupational exposure limits on the days that sampling occurred. However, the area samples collected over a seven and a half-hour time period do not reflect workers' personal short-term (15-minute) formaldehyde exposures; therefore the NIOSH results do not rule out the potential for short-term, intermittent exposures at, or above, permissible occupational limits.[11] Moreover, the presence of formaldehyde, mercury, and other hazardous chemicals at even very low levels in workplace air underscores the inter-relationship between what goes into the autoclave and the air that waste treatment workers breathe.[12]

Workers' Exposures to Ionizing Radiation Related to Improper Waste Segregation

Radioactive medical waste was transported to the autoclave facility due to the improper disposal of materials used in, and radioactive body fluids created by, diagnostic and therapeutic treatments. Radioactive isotopes used for diagnostic and therapeutic medical treatment are primarily short-lived, with half-lives in the range of hours to days (U.S. EPA 1990; Smith 1998).

Radioactive materials can enter the medical waste stream directly as a result of disposal of materials prior to decay, and indirectly through the disposal of tissues, diapers, linens, utensils, plates, cups, and other materials that contain body fluids from patients receiving these treatments. Radioactive materials enter the medical waste stream via facilities that are licensed to use radioisotopes, as well from unlicensed generators who provide services to patients who have recently received such treatments.

The primary health effects of exposure to ionizing radiation are an increased risk of cancer or harmful genetic effects. Any exposure to radiation can be harmful, and the risks of exposure are believed to be proportional to the dose, i.e., the higher the exposure, the greater the risk (U.S. EPA 2004b; NAS 2005). The National Academy of Sciences Committee to Assess the Health Risks from Exposure to Low Levels of Ionizing Radiation estimates that one out of 100 people exposed to 100 millisievert (100 millisievert = 10,000 mrem) of radiation over a lifetime probably would develop solid cancer or leukemia. Lower doses would produce proportionally lower risks (NAS 2005).

10 The NIOSH Recommended Exposure Limits for formaldehyde are 0.016 ppm for an eight-hour average exposure and 0.1 ppm for a 15-minute average exposure (NIOSH 2005a).

11 The Cal/OSHA Permissible Exposure Limit for formaldehyde is 0.75 ppm for an eight-hour time-weighted average exposure and 2 ppm for a 15-minute average exposure (California Code of Regulations. Title 8 Section 5217. Formaldehyde).

12 The volatile organic compounds in the air arise from both the waste stream and truck exhaust.

There should be no work-related exposure to radiation for individuals transporting and treating medical waste.[13] Assuming that the radiation dosimetry results were representative of workers' monthly exposures, workers' maximum exposures were approximately 300 mrem/year (three millisievert). However, the dosimetry data may not be representative of all workers' cumulative exposures to radiation because: (1) one-third of the workers did not have a valid measurement; (2) exposures were measured at a time when fewer radioactive tubs were being received compared to previous months; and (3) intermittent and unpredictable exposures cannot be fully characterized in a short (i.e., three-month) time frame.

Moreover, the health risk from workers' exposures is most accurately related to the quantity of radiation absorbed per unit time (i.e., dose-rate). Calculating the dose-rate requires knowledge of which radionuclide was the source of the exposure, and the existing monitoring system did not have such capacity.[14] Therefore, the risk for the workers' exposures is not known.

Detecting, Evaluating, and Correcting Waste Segregation and Packaging Errors

Methods to detect, evaluate, and correct waste segregation errors were present but inadequate. There was only limited capacity to detect chemical hazards. The concentration and commingling of large volumes of waste at the off-site treatment facility made it virtually impossible to trace back the source(s) of chemically hazardous substances detected in water discharged to the sanitary sewer and landfill. Implementation of a photoionization detector at this autoclave facility had limited success in identifying chemicals in the waste tubs;[15] however, the photoionization detector did not provide useful data about the source(s) of chemicals in the waste stream, and did not fully prevent hazardous chemicals from entering the facility's wastewater. The subsequent installation of a wastewater treatment system did bring the sanitary sewer discharge into regulatory compliance, and will prevent the discharge of some chemically hazardous materials into the sanitary sewer; however, the system does not control worker exposure to these chemicals prior to their release into the water, it does not prevent airborne emissions, nor does it prevent the diversion of contaminated wastewater (via the water bound to the treated medical waste) to the landfill.

Under the current system, Drivers rely on the generators to properly screen the waste for radiation before pick-up. Follow-up conducted by the employer and the CDHS Radiologic Health Branch of the containers

13 There are at least two reasons why Drivers and Plant Workers at the steam autoclave should have no work-related exposure to ionizing radiation. First, there should be no radioactive materials in the medical waste stream. When biohazardous waste is mixed with radioactive waste it is no longer considered to be medical waste (Appendix 1). Second, employers who are licensed to handle radioactive materials must control the dose to individual members of the public to an effective dose of 100 mrem in a calendar year (California Code of Regulations. Title 17, Section 30253. Standards for Protection Against Radiation; Code of Federal Regulations. Title 10, Part 20).

14 In June 2005, at the request of the California Department of Health Services' Radiologic Health Branch, the steam autoclave purchased an isotope analyzer and dose rate meter (Berkeley Nucleonics SAM Model 935-1B). This instrument provides the ability to determine the isotope in question and an energy-compensated dose rate.

15 Over the approximately two-month period that the photoionization detector was in use, 70 items were removed from the waste stream in response to the detector's alarm. Of the 70 items removed: five were evaluated as being hazardous materials (i.e., formaldehyde, toluene, xylene, etc.) and these items were returned to the generator; one item was evaluated to be pathology waste and was sent for incineration; and the remaining 64 items were primarily suspected of containing alcohol and were processed in the autoclave (Source: Employer VOC Log August 1 to October 8, 2003).

removed from the waste stream indicated that, at the time of this investigation, some hospitals were not sensitive to the problem, and either were not screening their waste, did not have a radiation detector, or did not have a detector that was working properly. The carbon-14 and tritium sources in use by biotechnology firms are not detectable by the autoclave employer with the current system. In addition, patients undergoing treatment may have inadvertently introduced radioactive materials into the waste stream of facilities that do not handle radioactive isotopes. As a result of these practices, the Drivers incurred intermittent, unrecognized, and largely unmeasured exposures to ionizing radiation.

CDHS also found that Drivers often encountered waste that is not properly packaged for transport. Drivers are authorized and trained to refuse to pick up waste that is not suitable for transport. However, Drivers are also obliged to provide excellent service to their customers, and they do this by taking away the generator's waste without complaint before it piles up. The Drivers' daily negotiating of this dilemma illustrates the systemic contradictory roles of the off-site waste treatment provider: "policing" waste generator practices while marketing services to its customers.

Off-site medical waste treatment service providers are required to notify CDHS when radioactivity above specified levels is detected in waste (CDHS 2000a). There was no other established mechanism, and no requirement, to systematically compile, evaluate, and report data regarding the discrepant waste stream, and few economic or other incentives for prevention. Although the waste acceptance protocol states that waste must be segregated properly, the waste treatment service provider in this investigation rarely fined its customers for waste segregation or packaging errors, but would provide training to generators on waste segregation and reduction on a fee-for-service basis.

HEALTH AND SAFETY TRAINING AND COMMUNICATION

At the facility in the CDHS investigation, workers had received initial and ongoing health and safety training in their primary language, and Material Safety Data Sheets were readily available. A critical weakness of the employer's overall safety efforts was the lack of a Health and Safety Committee, inclusive of labor and management representatives, which would establish an ongoing and accountable mechanism for workers to contribute their hands-on observations and knowledge of the work process, raise concerns, and to document and track the disposition of health and safety issues that are identified.

MEDICAL MONITORING

At the facility investigated by CDHS, workers' health was monitored through pre-placement and periodic physical examinations at which time workers were offered Hepatitis B vaccinations and received relevant laboratory and other tests. The most notable deficiency of the Medical Monitoring Program was that it did not fully incorporate the expectation that workers would encounter considerable ergonomic hazards. Job descriptions and pre-placement physicals did not directly assess the specific physical requirements of the job. Prior to the CDHS investigation, there had been no ergonomic evaluation of each job duty and function to assess the physical requirements of performing each task, and to make recommendations to minimize adverse impact on the workers' health. For example, job descriptions did not specifically state job requirements regarding weight, distance, height, frequency, or duration of lifting, and the pre-placement examination also did not address these elements in an ergonomic context.

Additional limitations of the Medical Monitoring Program were: (1) the specific elements of Post Exposure Protocol were not well defined in an Exposure Control Plan to ensure that employees exposed to bloodborne pathogens would have adequate counseling and follow-up; and (2) inconsistent recordkeeping of medical documents. There was also no effective Return-To-Work program that would have permitted injured employees to return to work with limited job duties during recovery.

Monitoring injuries of workers involved in the generation, handling, and processing of medical waste is a recommended parameter for evaluating the effectiveness of a healthcare facility's medical waste management plan (CDHS 1999, pp. 8–9). This parameter is equally applicable to medical waste treatment facilities. Although injuries at the facility investigated by CDHS were recorded as required on OSHA logs, injury rates were not calculated, evaluated, and reported to impacted workers. Moreover, effective health and safety programs are designed to identify problems and attempt to correct them. Incentive pay related to the occurrence of illnesses and injury can have the effect of discouraging illness and injury reporting; for this reason, such incentives are to be discouraged.

No work-related respiratory, dermal, infectious, or other acute, or chronic illnesses were recorded among the workers at this facility. In general, cases reported by physicians of work-related illness are likely to be an underestimate of the true incidence for several reasons: (1) workers are not routinely required to be examined by physicians as part of Medical Monitoring Programs for symptoms of potential health outcomes associated with their workplace exposures. For example, at the treatment facility in the CDHS investigation, health questionnaires administered did not include questions related to all potential exposures, including non-segregated and discrepant waste (i.e., radioactive, chemotherapeutic, pharmacologic, heavy metals, etc.); (2) physicians may not recognize symptoms and signs of work-related illness and report these cases as work-related; and (3) individuals who develop symptoms of asthma or other illnesses may leave the workplace before physician diagnosis. In addition, workers' fear of retaliation inhibits full reporting of illnesses and injuries.

CONCLUSIONS

Workers had a very high rate of injury.

Workers at this facility were injured at a rate 3.4 and 5.8 times higher than the rate of injury among California waste treatment and disposal workers, and health care workers, respectively. The hazardous exposures that resulted in these injuries may be present in other off-site medical waste treatment facilities.

Injuries resulted from ergonomic stressors, sharps, and safety hazards.

Almost three-quarters (72 percent) of the injuries were caused by exposure to ergonomic stressors and sharps hazards. Acute traumatic injuries accounted for more than one in five documented injuries. The documented injuries likely understate the health risks for these workers because many barriers to acute illness recognition and chronic disease reporting exist.

Workers encountered a variety of hazardous exposures.

Workers' primary exposures were to ergonomic stressors, infectious agents, and safety hazards, as well as to chemicals used for cleaning and maintenance activities, carbon monoxide from operating forklifts, noise, heat, odor, and ionizing radiation.

Generators sent waste unsuitable for a steam autoclave to the facility for treatment.

Waste segregation errors made by generators were identified in approximately 0.24 percent of the medical waste containers received for steam autoclave treatment, equal to about five containers of discrepant waste every day. Due to the superficial nature of the detection system for all but radiation-related segregation errors, the 0.24 percent error rate underestimates the true amount of discrepant waste that arrived at this steam autoclave. Because vast quantities of infectious waste are produced by the health care industry, an estimated 100 million pounds annually in California alone, a "small" segregation error rate can have a large cumulative downstream impact.

The failure of waste generators to properly segregate medical waste can lead to occupational and environmental exposures to hazardous chemicals and ionizing radiation.

Chemical hazards such as mercury made their way into the autoclave and left the facility in wastewater. The subsequent installation of a wastewater treatment system did bring the sanitary sewer discharge into regulatory compliance, and will prevent the discharge of some chemically hazardous materials into the sanitary sewer; however, the system does not control worker exposure to these chemicals prior to their release into the water, it does not prevent airborne emissions, nor does it prevent the diversion of contaminated wastewater (via water bound to the treated waste) to the landfill.

Autoclaves operating in small, enclosed spaces, having poor dilution and local exhaust ventilation, and involving work practices which permit workers to stand close to the autoclave when the doors are opened after the treatment process, have an increased potential for workers to be exposed to airborne mercury if it is present in the waste stream. Workers who have contact with accumulated solids from work processes have the potential for skin exposure to mercury.

Radioactive medical waste was transported to the autoclave facility due to the improper disposal of materials used in diagnostic and therapeutic treatments. As a result of these practices, the Drivers incurred intermittent, unrecognized, and largely unmeasured exposures to ionizing radiation.

The primary occupational hazards documented at the steam autoclave facility were related to the design of the work process, not to the steam autoclave technology.

The occupational health impacts of the steam autoclave were related to work processes upstream, on-site, and downstream of the autoclave. Workers' most significant exposures were a predictable consequence of a work process design that involved extensive manual handling of untreated waste. Some design features of the medical waste treatment work processes (such as compaction of treated sharps waste) that may be advantageous from an environmental perspective, or required by regulation, may introduce occupational hazards into the overall waste disposal process.

The employer had implemented many measures to prevent hazardous worker exposures.

Many ergonomic hazards associated with handling waste had been designed out of the work process through the use of conveyors, a tipper that mechanically dumped waste into the autoclave bin, and handcarts. The autoclave was fully automated. Waste packaging, hygiene and housekeeping procedures, and the availability and use of personal protective equipment reduced workers' exposures to bloodborne pathogens. Workers received training and were part of a Medical Monitoring Program. Steps were taken to identify and remove materials unsuitable for autoclaving from the waste stream.

The major weakness of the exposure control measures was that they disproportionately relied on controlling exposure after the hazard was created, rather than on eliminating the hazard from the work process.

Although it is feasible to design a fully-automated steam autoclave work process, the facility in this investigation had been retrofitted, rather than designed for, steam autoclave treatment capabilities. Engineering controls were used to eliminate many, but not all ergonomic hazards, with control of the remaining hazards reliant on job rotation and training. These secondary measures were an inadequate match for the heavy physical demands of the job.

Workers' direct contact with infectious materials had not been eliminated from the work process, and these exposures were controlled by "end-of-pipe" measures, i.e., housekeeping, hygiene, and personal protective equipment. The number of needlestick injuries at the facility demonstrates that these measures were not fully protective.

The steam autoclave employer had implemented few incentives or other primary prevention measures to eliminate hazardous chemical and radioactive materials from entering the autoclave waste stream prior to pick-up. Secondary methods to detect, evaluate, and correct waste segregation errors at the waste treatment facility were inadequate.

Feedback mechanisms necessary to identify, evaluate, and prevent occupational hazards were inadequate, fragmented, or absent.

An industrial hygiene and ergonomic assessment of the steam autoclave work process was not required nor performed as part of the permitting process when the facility began operations. There was no Health and Safety Committee, or other strong, ongoing, and reliable mechanism for workers to communicate freely about hazards without fear of retaliation. Detection of radioactive materials in waste occurred after the materials had been transported, and the system did not have the capacity to provide accurate information to workers about the health risks of their exposures to ionizing radiation. Worker injury rates were not calculated, evaluated, or reported to impacted workers. There was no comprehensive electronic tracking and reporting system for waste segregation errors or environmental emissions at the treatment facility.

LIMITATIONS

We observed only one steam autoclave facility at one point in time.

This "snapshot" may not be representative of all current practices, types of generators, or treatment facilities. A major obstacle to any efforts to evaluate the worker health and safety impacts of steam autoclaves, or other waste treatment methods, is the lack of systematically compiled and reported data related to the occupational and environmental impacts of medical waste disposal.

However, our findings are consistent with the limited available research primarily reported by NIOSH, reflect consistency among multiple and diverse reporting sources, i.e., employers, workers, written records, etc., and have been reviewed by regulatory and technical experts with breadth and depth of technical and practical knowledge of the medical waste stream. The waste segregation and packaging errors identified in our investigation are not unique to the facility investigated by CDHS. Among the most frequently found violations of the California Medical Waste Management Act are a failure of large generators to properly containerize biohazard bags, a failure to use red biohazard bags to containerize and store medical waste, and a failure to segregate pathology, trace chemotherapeutic, radioactive, or hazardous waste from the biohazardous waste stream (CDHS 1999, pp.56–59).

As of September 2005, the employer reported that the company had taken the following steps to reduce ergonomic injuries: (1) re-decked the dumping platform to reduce the drag on tubs; (2) shortened the railing between the autoclave carts and the dumping platform to allow for a shorter lift of containers when dumping manually; (3) virtually eliminated the use of 90 gallon containers; and (4) met with customers and requested their help with heavy containers. The employer reported that, as a result of phasing out the 90 gallon tubs and customer education efforts, 94.7 percent of the waste tubs weighed less than 30 pounds and the average weight of all tubs was down to 26.5 pounds per tub. In general, reducing the weight of the tubs should provide some benefit to worker health and safety. However, whether these changes were sufficient and/or appropriate to address the ergonomic hazards identified in this investigation was not subsequently evaluated by CDHS researchers.

As of September 2005, the employer also reported these additional changes: (1) implementation of two engineering projects undertaken to reduce employee exposure to noise, i.e., removal of spray condensers, and utilization of autoclave bin liners which reduce the ambient noise levels caused by banging carts while dumping; and (2) upgrading the ventilation system to provide cool air in the plant and to increase air changes from two to six per hour. The potential impacts of these changes on workers' exposures to noise, heat, and odor were also not evaluated by CDHS researchers.

In November 2005, following a review of the dosimetry results contained in this report, the CDHS Radiologic Health Branch (RHB) was concerned regarding the exposures to employees who may be considered non-radiation exposed workers. These individuals were not trained in radiation effects or how to handle hazardous waste containing small amounts of radioactive materials. Consequently, the CDHS/RHB has requested the employer re-monitor the Drivers' exposures to ionizing radiation and provide CDHS/RHB with these data. The earlier monitoring results indicate that some exposures would be greater than California limits and that changes are required. The employer indicated to CDHS/RHB that shipments containing radioactive materials have decreased in the last few years due to greater controls instituted by medical facilities and exposure to radiation should not be a problem. CDHS/RHB will also follow-up to ensure that the employer makes all necessary changes to prevent any worker exposure to ionizing radiation from exceeding the limits described in California regulations.

Because the CDHS/OHB investigation described employee exposures to chemical, physical, and biological agents and ergonomic stressors during only one period of time, it will be essential that the employer reassess the work process in a timely manner to evaluate the impacts of all of the above changes on worker health and safety.

We did not take independent measurements of potential physical, biological, or chemical hazards.

The scope of our investigation was limited to the occupational hazards at the facility discernible through observation, record review, and worker and employer representative interviews.

We did not thoroughly assess safety hazards and maintenance activities.

Acute traumatic injuries comprised one in five injuries; we did not investigate the causes of these injuries. NIOSH found safety hazards at other off-site waste treatment facilities (NIOSH 1996a). We did not observe maintenance activities, which may involve the most hazardous exposures to safety hazards, chemicals, and infectious agents. These important issues should be addressed in future investigations. The limited nature of our investigation was resource-driven and does not imply there are, or are not, other health and safety issues at this workplace.

Worker participation in the investigation was low.

The lack of a union, except during the very early part of the investigation, Health and Safety Committee, or other pre-established mechanism for direct worker input limited our ability to gather workers' perspectives on health and safety. We conducted individual interviews in the worker's primary language, outside of the workplace and working hours, and did not record any identifying information on the interviews to ensure the confidentiality of the information. Despite these resource-intensive efforts, we interviewed only slightly more than one in four workers. Possible explanations for the low participation rate are workers' fears of job loss, government officials, and researchers.

RECOMMENDATIONS FOR PREVENTION

A safe healthcare practice does no harm to the recipient, does not expose the healthcare worker to any risk and does not result in waste that is dangerous for the community (Wilburn 2001).

GENERAL RECOMMENDATIONS

Primary prevention activities seek to maintain health by removing the precipitating causes and determinants of departures from good health (Last 1998). The industrial hygiene "hierarchy of controls"[1] is a recognized method to apply control measures for the primary prevention of occupational injury and disease. The accepted strategy for controlling workplace hazards is to first attempt to eliminate the generation source, hazardous materials, and dangerous activities (Burgess 1994). The industrial hygiene approach to prevention is analogous to the environmental maxim, "pollution is best prevented at its source" (Quinn 1998).

Primary prevention of the occupational hazards of the off-site medical waste treatment work process involves undertaking activities to: (1) generate less medical waste; and (2) incorporate the prevention of work-related hazards into the design of medical waste treatment technologies and associated work processes. Education, feedback, and incentive mechanisms are needed to support the goal of primary prevention.

1 Under the industrial hygiene "hierarchy of controls" strategy, the first priority for controlling workplace hazards is to implement engineering control measures that prevent or eliminate a hazard (i.e., by replacing or redesigning unsafe equipment or processes to make them safer or intrinsically safe). When a hazard cannot be fully eliminated with engineering controls, the second priority in the hierarchy is to implement administrative controls (i.e., job rotation, training, medical surveillance, etc.). When engineering and administrative control measures cannot adequately control a hazard, the strategy of last resort in the hierarchy is to implement personal protective equipment, such as respiratory protection, gloves, eye protection, etc.

Each of these measures is described below, followed by CDHS/OHB's recommendations for specific activities that medical waste treatment service providers, facilities that generate medical waste, and agencies that regulate aspects of the medical waste stream, can do to realize these goals.

Generate less medical waste.

Steps that generators can take to produce less medical waste are well described, and in order of priority are: source reduction, re-use, and recycling (U.S. Office of Technology Assessment 1990; Hospitals for a Healthy Environment 2003). Source reduction focuses on two fundamental characteristics of waste: (1) toxicity, i.e., eliminating or finding benign substitutes for substances that pose a risk when discarded; and (2) quantity, i.e., changing the design or use of products to minimize the amount of waste generated when they are discarded (U.S. Office of Technology Assessment 1990, pp. 19–21).

Eliminate the use of needles or sharp components wherever feasible. The greatest risk for transmission of bloodborne pathogens is from skin-puncturing injuries involving hollow-bore needles and other sharp medical devices contaminated with patient blood (Hibberd 1995). The best method for preventing sharps injuries for waste stream and other health care workers is to eliminate the use of needles or sharp components wherever feasible (CDHS 2002, p.28; CDC 2004). Substantial progress has been made toward developing innovative design improvements in medical devices, alternative medication delivery systems, and injection alternatives (CDHS 2002; Clements 2004).

Decontaminate infectious laboratory waste (i.e., cultures and stocks) within the laboratory where the waste is generated. Worker protection can also be achieved by steps that reduce the potential for other (non-sharps) waste to transmit infectious diseases, such as through the decontamination of infectious laboratory waste (e.g., stocks and cultures) prior to disposal (Weber 1998; Johnson 2000). The U.S. Centers for Disease Control and Prevention recommends that microbial and biomedical laboratories decontaminate cultures, stocks, and other regulated wastes by an approved decontamination method such as autoclaving prior to disposal (CDC 1999).

Participate in, monitor, and evaluate pollution prevention activities. Pollution prevention involves reducing or preventing pollution at the source rather than focusing on treatment and disposal. Source reduction is fundamentally different and more desirable than waste management and pollution control (U.S. Pollution Prevention Act of 1990). State, federal, and related pollution prevention activities can greatly benefit the health and safety of workers throughout the medical waste stream by preventing hazardous materials such as mercury from entering the waste stream (page 75).

POLLUTION PREVENTION ACTIVITIES CAN BENEFIT THE HEALTH AND SAFETY OF WORKERS THROUGHOUT THE MEDICAL WASTE STREAM

The California Department of Health Services (CDHS) Medical Waste Management Program works with hospitals statewide to develop source reduction plans, including goals for the virtual elimination of mercury, and lessening the creation of medical waste. In conjunction with the Integrated Waste Management Board, and partially supported by U.S. Environmental Protection Agency (U.S. EPA) and the California Department of Toxic Substances Control, the Medical Waste Management Program has developed pollution prevention and waste minimization guidance documents for the health care industry (CDHS 2005d; CDHS 2000b).

The California Environmental Protection Agency, Department of Toxic Substances Control (DTSC) Pollution Prevention Program, promotes pollution prevention by providing state leadership, guidance, and assistance to industry, local government, and other environmental agencies. To this end, the Department of Toxic Substances Control sponsors many activities directed at the health care industry, for example, the Mercury Elimination Leadership Program (HELP). The HELP program provides local training, on-site assistance, and state awards recognizing hospitals reaching the national goal of eliminating mercury from hospitals by 2005 (DTSC 2005).

The California Sharps Injury Control Program is sponsored by the CDHS/OHB and the California Department of Industrial Relations, Division of Occupational Safety and Health (Cal/OSHA). The Program develops and maintains the "California List of Needleless Systems and Needles with Engineered Sharps Injury Protection," assesses trends in the incidence and mechanisms of sharps injuries among California acute care hospitals, conducts focus groups with clinicians to evaluate user satisfaction with selected safety enhanced needle devices, and consults with health care facilities, health care workers, and employee representatives on the Cal/OSHA Bloodborne Pathogen Standard, sharps exposure incident documentation, and interpretation of sharps exposure incident data (CDHS 2005e).

The 2002 Needlestick Safety Prevention Act directed the federal Occupational Safety and Health Administration to ensure more widespread use of safer medical devices to prevent dangerous sharps injuries (CDHS 2002; NIOSH 2005b).

A landmark agreement between the American Hospital Association and the U.S. EPA calls for reducing the overall volume of all hospital waste by 33 percent by 2005, and by 50 percent by 2010, virtually eliminating mercury-containing waste from health care facilities' waste streams by 2005, and identifying hazardous substances for pollution prevention and waste reduction opportunities (Hospitals for a Healthy Environment 2005).

Incorporate the prevention of work-related hazards into the design of all medical waste treatment technologies and associated work processes.

Anticipate and prevent technology and work process design features that pose a risk to worker health and safety. Technology and work process design features that pose a risk to worker health and safety should be anticipated and prevented. These factors include but are not limited to: repetitive, unassisted lifting and lowering heavy tubs; direct contact with waste during routine or maintenance activities; "unpackaging" untreated waste from the safety of sharps and red biohazard bag containers; shredding untreated waste; aerosolizing infectious agents; and compacting untreated or treated sharps containers. Particular attention should be given to anticipating and preventing the incorporation of high-risk activities into maintenance tasks.

Segregate and package medical waste properly. Our findings underscore that proper waste segregation is a critical component of medical waste management practices due to the public health impacts of improper disposal of hazardous materials in a steam autoclave. By not segregating waste, one nullifies the environmental benefits of non-incineration technologies and, in some cases, may violate the law (Emmanuel 2001, p.6). Proper waste segregation is also cost-effective. Commingling solid waste with medical waste also increases the cost of handling the solid waste portion by a factor of at least 20 times (CDHS 1999, p. 17). Overfilled waste containers, or red biohazard bags that are not properly sealed, pose a hazard to workers collecting the waste.

Build interdisciplinary partnerships between frontline workers and infection control, industrial hygiene, engineering, regulatory, environmental health, and other relevant disciplines to create comprehensive, lasting solutions. Designing technologies and work processes that protect occupational health will require the active participation of frontline workers. Their familiarity with work processes provides a unique perspective on process design and counters the tendency to address hazards through end-of-pipe pollution control measures[2] (Quinn 2003a). To this end, lessons learned from successful efforts to build partnerships between labor and public health programs to prevent morbidity and mortality from tobacco use are instructive, including the need to: (1) involve workers from the start of the process; (2) frame the issue around occupational health; (3) identify a worker representative(s) who is/are interested in the issue; (4) build trust; (5) engage key leaders; and (6) build a partnership (DeLaurier 2004). The participation of infection control, industrial hygiene, engineering, regulatory, environmental health, and other relevant disciplines are equally essential to creating comprehensive, lasting solutions.

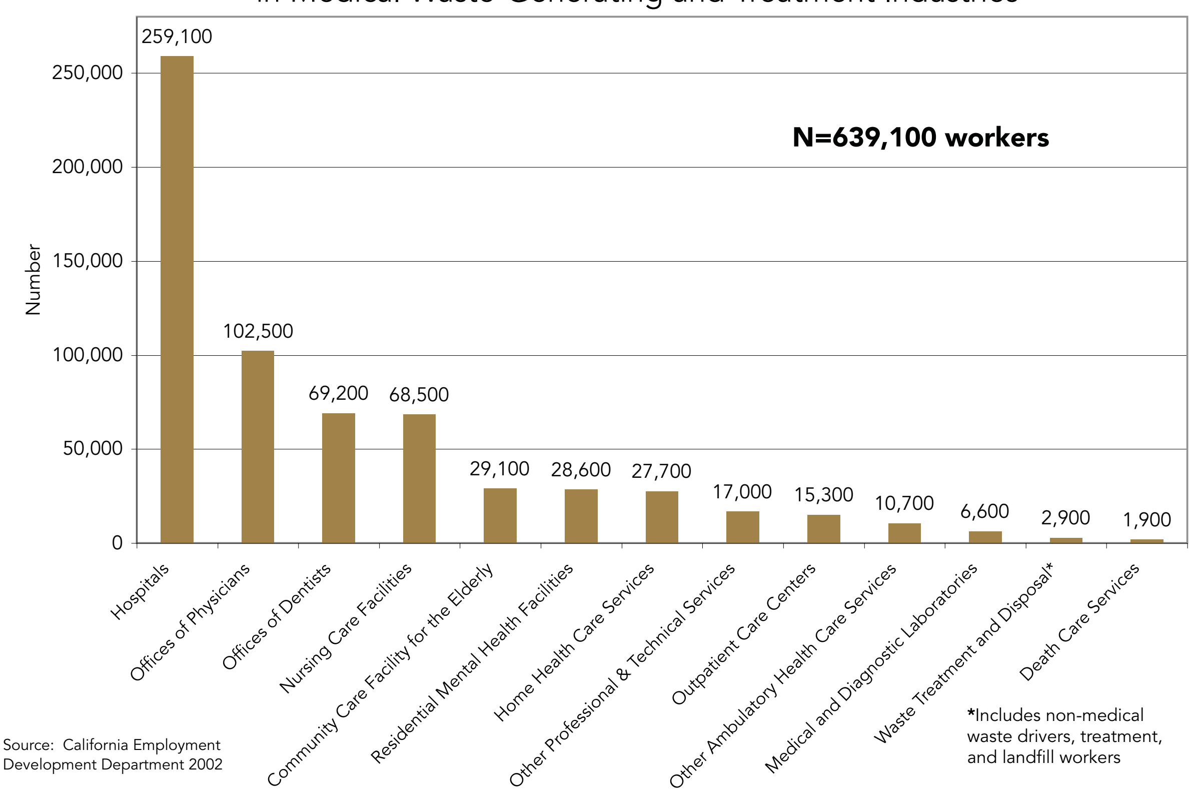
2 "End-of-pipe" systems involve activities such as treating water, air, noise, and solid wastes to remove contaminants.

Adopt education, feedback, and incentive mechanisms to support primary prevention.

Educate decision-makers and end-users about the worker health and safety consequences of product purchasing, use, and waste disposal practices. A red bag of treated medical waste at its final resting place in a landfill represents the accumulation of decisions made by a wide range of people working in a complex system. Some individuals make decisions about what materials get purchased in a health care facility, while still others determine how products are used, how they are thrown away, and what services will be purchased to treat and dispose of the waste. All of these systems must be aligned to achieve regulatory compliance, community, and worker protection (CDHS 1999, pp. 3–4).

Whereas the waste stream is determined by the practices of a very large number of workers across many industries and occupations, relatively few workers are at the ultimate receiving end of these upstream decisions. Of 639,100 individuals working in California in industries that generate and/or dispose of medical waste, 30,300 (4.7 percent) are Janitors, Cleaners, Housekeeping, and Maids and 2,900 (0.5 percent) are Waste Treatment and Disposal workers (Figures 48 and 49). Mechanisms are needed to

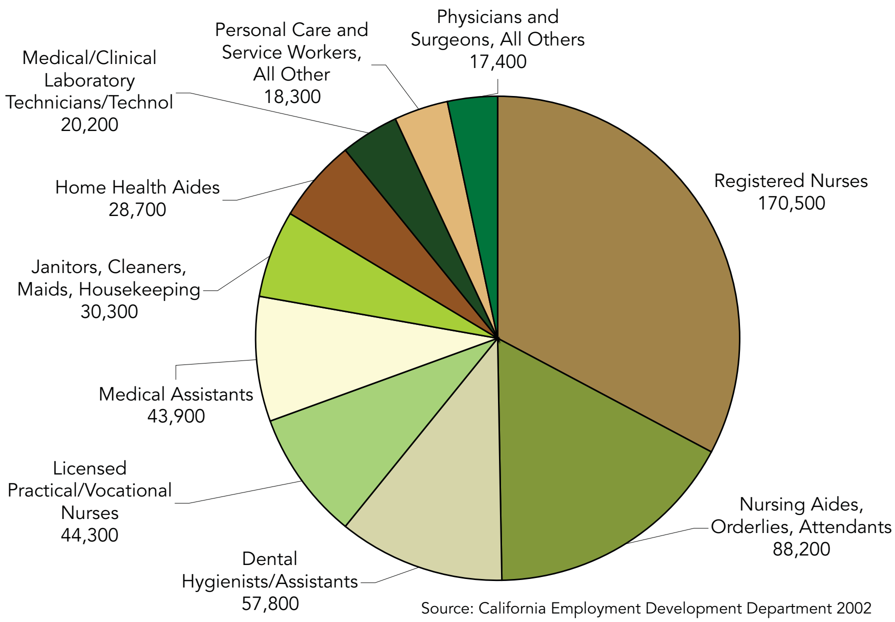
Figure 48. Number of California Workers in Medical Waste-Generating and Treatment Industries



*Includes non-medical waste drivers, treatment, and landfill workers

Source: California Employment Development Department 2002

Figure 49. Top Ten Occupations With Potential Exposure to Medical Waste Stream by Number of Workers, California, 2002



Source: California Employment Development Department 2002

systematically provide education and feedback to the numerous individuals who influence the content of the medical waste stream about the downstream worker health and safety consequences of their product purchasing, use, and waste disposal practices.

Educational campaigns that link the health and safety of workers throughout the system, such as one conducted at Beth Israel Hospital in New York City, (Brown 2004) exemplify the needed approach (Figure 50). Trainings that emphasize the connection between work practices upstream and worker health and safety downstream may also help to overcome the misperception among many health care workers that disposing of all known or potentially hazardous materials in a red biohazard bag is health protective.

Figure 50. Educational Campaign Poster Beth Israel Hospital, New York City

Scrutinize medical waste disposal technologies and work processes to ensure that hazards are not transferred across populations, and over time, but rather, are eliminated. The intent of the Medical Waste Management Act is to assure the health and safety of all segments of the population, including health care and solid waste workers, hospital patients, and members of the general public (CDHS 1999, p.21). Consistent with this goal, medical waste disposal technologies and work processes will require scrutiny to ensure hazards are not transferred across populations, and over time, but rather, are eliminated. As previously described, a major obstacle to any efforts to evaluate the worker health and safety impacts of steam autoclaves or other waste treatment methods is the lack of systematically compiled and reported data related to occupational and environmental impacts of medical waste disposal. Systematic collection, evaluation, and public reporting of data are essential to objective evaluation of relevant measures across technologies and facilities.

Adopt industry-wide incentives to foster public reporting and evaluation of occupational and environmental health data related to the medical waste stream. Industry-wide regulatory, economic, and other incentives are needed to foster public reporting and evaluation of occupational and environmental health data. However, because effective health and safety programs identify problems and attempt to correct them, paradoxically, a large proportion of injuries and/or illnesses reported by an employer can sometimes be a measure that the health and safety program at the company may be effective relative to other employers that do not efficiently collect these data. Therefore, incentives must be developed to ensure that public reporting does not have the unintended consequence of discouraging reporting, but rather encourages evaluation and system-wide improvements.

Adopt industry-wide incentives to overcome the substantial barriers to primary prevention. Regulatory, economic, and other incentives are also needed to overcome substantial barriers to primary prevention including the: (1) lack of a prevention-based regulation for ergonomic hazards in the workplace. In California, more than one worker must be systematically injured before employers are required to abate hazards (California Code of Regulations, Title 8, Section 5110), and there is no specific federal regulation of workplace ergonomic hazards (U.S. Department of Labor 2004); (2) limited number of interdisciplinary mechanisms for collaboration. The regulatory frameworks that address environmental and occupational health issues are separated, and historically there has been little cross-disciplinary collaboration among professionals addressing the health impacts of the work and ambient environments (Quinn 1998); (3) limitations of current regulatory review processes with respect to occupational and environmental health. Current regulatory approval mechanisms of waste treatment technologies are focused almost exclusively on the efficacy of technology to treat waste. Except for air emissions from medical waste incinerators and wastewater discharges from some treatment technologies, regulatory approval of treatment systems generally does not consider environmental emissions. Criteria to prevent occupational and other health impacts, such as transporting waste over long distances, are not directly considered by the approval process; and (4) absence of comprehensive, uniform national standards governing medical waste management. State regulations vary. Many regulatory agencies contribute to one or more aspects of medical waste management, but systems of proactive coordination may be limited.

WHAT CAN OFF-SITE MEDICAL WASTE TREATMENT SERVICE PROVIDERS DO TO PROTECT WORKERS' HEALTH AND SAFETY?

Identify and prevent hazardous worker exposures.

- Proactively identify and implement engineering/design measures to prevent hazardous worker exposures at the time a facility is acquired or built. Planning for worker health and safety prior to retrofitting a facility may decrease long-term costs. Some health care industry research and development organizations that have embraced environmental product design in other areas report cost savings, sustainability benefits, improvements in environmental manufacturing or redesign, and increased customer satisfaction (Messelbeck 2005).

- Adopt technology features and work processes that eliminate risk factors for hazardous worker exposures including but not limited to: repetitive, unassisted, lifting and lowering of heavy tubs; the practice of stacking two or three tubs on top of each other; direct contact with waste during routine or maintenance activities; "unpackaging" untreated waste from the safety of sharps and red biohazard bag containers; shredding untreated waste; aerosolizing infectious agents; uncontained placement of contaminated poles and shovels in the work area; and compacting untreated and treated sharps waste. Pay attention to the potential for hazardous maintenance activities, i.e., working in confined spaces, having direct contact with untreated medical waste, and exposure to safety hazards. Identify, evaluate, and implement work processes that avoid the hazards of post-treatment compaction of treated sharps containers, including working with waste generators and landfill operators to ensure segregation of sharps waste and safe disposal of sharps containers in landfills.

- Conduct a baseline industrial hygiene assessment at each treatment facility including but not limited to: an assessment of safety hazards, and exposures to ergonomic stressors, sharps, infectious agents, ionizing radiation, noise, heat, odors, and chemical exposures, including routine and maintenance activities. Workers' first-hand knowledge of the work process, hazards, and control measures should be included as part of these assessments. Identify and implement prevention measures based on the industrial hygiene hierarchy of controls.

- Re-assess the work process in a timely manner after any changes are made. Employers should evaluate the impacts of changes to the work process on employee exposures and the rate of ergonomic injuries, and to ensure that new safety hazards were not introduced into the work environment by these changes. For example, the employer in the CDHS investigation should evaluate the impact of changes made to improve workplace ventilation, reduce employee exposure to noise and ionizing radiation, and reduce ergonomic injuries (i.e., reducing the weights of tubs and lowering the railing and changing the floor surface at the dumping station). Establish and maintain strong, ongoing mechanisms to directly involve workers in the design and implementation of a safe and healthy workplace. Reliable mechanisms for workers to communicate freely without fear of retaliation are essential. Establish a worker Health and Safety Committee inclusive of labor and management representatives. Keep minutes of the meetings that reflect committee membership, issues discussed, and actions taken to address health and safety concerns identified. Seek and utilize the first-hand experience and knowledge of workers who are/will carry out the tasks in the design phase of new work processes and technologies.

- Support cross-disciplinary mechanisms, for example through federal, state, and local pollution prevention activities, to develop and implement medical waste treatment strategies that optimize the protection of workers, community members, and the environment.

- Proactively establish and implement a program designed to prevent repetitive motion injuries. The program should include a worksite evaluation, control of the exposures known to cause repetitive motion injuries, and worker training. Support a proactive regulation to control ergonomic hazards in the workplace.

- Establish and implement a "cleaning and maintenance for health" policy and procedure, consistent with regulatory requirements, and in collaboration with frontline workers, infection control, engineering, industrial hygiene, and other appropriate disciplines. Meeting the inter-related goals of optimizing infection control while minimizing worker and environmental exposure to hazardous cleaning chemicals can be achieved through product evaluation, purchasing the least toxic products, consideration of efficacy and purpose of disinfectants, introducing safer work practices, and effective worker education (Culver 2002). Minimum standard operating procedures should: (1) specify the frequency and extent of cleaning (i.e., every shift, daily, weekly, floors, surfaces, truck interiors, shovels, etc.); (2) evaluate and purchase cleaning and maintenance products based on least-toxic health impacts, as well as efficacy. Eliminate the use of chemicals that contain ingredients that can cause cancer, and identify and implement safer substitutes for the most hazardous solvent-based aerosol lubricants and cleaners; (3) clean surfaces prior to disinfection; (4) use an enclosed system for tub washing to prevent workers' exposures to cleaning agents; (5) use the lowest concentration of bleach or other respiratory irritants necessary for the purpose of infection control; (6) require, provide, and ensure the use of gloves and eye protection by workers using cleaning and maintenance chemicals; (7) implement safe work practices and effective worker education; and (8) document implementation of housekeeping measures.

- Document compliance with the Cal/OSHA Bloodborne Pathogen and Hazard Communication Standards, the California Medical Waste Management Act, and all other applicable federal, state, and local government occupational and environmental regulations.

- Ensure a well-ventilated facility. Provide sufficient dilution ventilation through the HVAC system to control odors and heat. Document and maintain the efficacy of the dilution and local exhaust ventilation systems. Replace the carbon bed on the adsorption system regularly. Do not rely on odor as the sole indicator that the carbon bed has become saturated; base the frequency of replacing the carbon bed on objective information or data that will ensure that it is replaced before the end of its service life, and document the rationale for the change schedule.

- Tune up, repair, or replace forklifts to prevent worker exposure to carbon monoxide. The amount of carbon monoxide produced by propane-powered forklifts can usually be reduced by frequent tuning and maintenance, but constant vigilance is required to keep emissions low. Catalytic converters are also available for forklifts. Electric forklifts may be the best solution (NIOSH 1996b; Washington State Department of Labor and Industries).

- Mitigate potential worker exposure to mercury. Provide adequate dilution ventilation and local exhaust ventilation with sufficient capacity to capture vapors that are released from the autoclave when the door is opened after treatment. Implement work practices to ensure that workers are not located near the door of the autoclave when it opens after treatment. Implement the use of personal protection equipment while handling solids accumulated in facility processes, especially in the tub washer, trenches, and sumps. Implementation of these interim measures alone will not fully prevent occupational and environmental exposures to mercury. The long-term solution to mercury emissions from steam autoclaves is for waste generators to prevent the introduction of mercury into the medical waste stream.

- Implement a hearing conservation program. Cal/OSHA requires that employers administer a continuing, effective hearing conservation program whenever employee noise exposures equal or exceed an eight-hour, time-weighted average sound level (TWA) of 85 decibels measured on the A-scale (California Code of Regulation, Title 8, Section 5097).

- Include health hazards of exposure to ergonomic stressors, infectious agents, and safety hazards, as well as chemicals used for cleaning and maintenance activities, carbon monoxide from operating forklifts, noise, heat, odor, and ionizing radiation in workers' hazard communication training.

- Provide and require the use of work clothes (including arm protection), steel-toed boots, eye protection (safety glasses, or safety glasses coupled with face shields when splashes are possible), and gloves (resistant to puncture by sharps) for all workers who handle waste. All personal protective equipment should be in use at all times when workers are handling waste. Provide uniforms and laundry service and other personal protection equipment at no charge to workers. Provide lockers and shower facilities, and require workers to shower and change clothes before they leave the job for the day. Establish a written policy to ensure consistent use of gloves at the autoclave control panel.

Implement monitoring and feedback mechanisms about the occupational health impacts of medical waste disposal.

- Calculate, evaluate, and report annual injury and illness rates at each treatment facility to impacted workers and to the public (i.e., via Web site, annual report, etc.). Avoid practices that may lead to under-reporting; for example, do not include illness and injury reporting as part of employee incentive programs. Utilize the results of these evaluations as a feedback mechanism to improve worker health and safety.

- Compile, evaluate, and publicly report all OSHA and other regulatory investigations, actions, and violations at each treatment facility. Utilize the results of these evaluations as a feedback mechanism to improve worker health and safety.

- In consultation with applicable state and local regulatory agencies, including Publicly Owned Treatment Works, monitor the waste stream for mercury and other chemical hazards in the air and water. Chemical detection devices should have the capability of detecting a wide range of chemicals, including chemicals commonly used in health care practice, with alarm limits set below the concentration limits of the most common chemicals.

- Characterize potential occupational exposures to mercury. Incorporate the following measures as part of standard operating procedures: (1) monitor workers' short-term (Ceiling) exposures during their routine tasks when the autoclave door is opened after waste treatment; (2) measure area mercury levels in the air released from the autoclave when the door is opened after treatment; (3) measure the exposure of workers to mercury during maintenance activities; (4) measure mercury levels on surfaces that come into contact with mercury vapor, including inside the autoclave, in the ventilation hoods, and on the roof; and (5) measure the level of mercury in accumulated solids, especially in tub washer, trenches, and sumps. Biological monitoring for mercury should be considered if the potential for worker exposure is confirmed by the results of well-conducted airborne and surface sampling.

- Require (via service contracts) that any facility licensed to use radioactive materials monitor its waste to verify that radioactive materials have been excluded from the medical waste stream. Generators should either conduct monitoring in the presence of the Driver, or provide documentation to the Driver that the waste has been monitored for radiation.

- Monitor waste for radioactive materials. To ensure that radioactive materials in the medical waste stream have been identified and excluded before the waste is transported for off-site treatment, waste treatment providers should monitor all waste for radioactivity at the time of pick up from the generators. Drivers should use a multi-channel scanner to identify the radionuclide and the level of radioactivity to permit quantification of workers' exposures and to facilitate tracing the origin of the improperly disposed of radioactive materials. Drivers should not transport waste that is found to be above pre-established "background" radiation levels. Also monitor waste at the off-site treatment facility. Install and maintain area radiation dosimeters at treatment facilities to verify the effectiveness of monitoring waste at the time of pickup, and to ensure the absence of work-related exposures to radiation at the facility.

- Monitor Drivers' exposures to radiation. Workers transporting and treating medical waste should have no occupational exposure to ionizing radiation.

- Implement carbon monoxide detectors with alarms as a warning device. Carbon monoxide monitors should supplement proper worker training, ventilation, and replacement or tuning of propane-powered forklifts. Do not rely on monitors as the only means of protection from carbon monoxide poisoning.

- Monitor workers' health. Conduct medical monitoring in accordance with the Cal/OSHA Bloodborne Pathogen Standard (California Code of Regulations, Title 8, Section 5193), including offering Hepatitis B vaccinations. Provide tetanus immunizations and tuberculosis skin testing at no charge to employees. Job descriptions should be based on an ergonomic evaluation of each job duty and function, and specify the physical requirements of performing each task. Health questionnaires administered to workers at baseline and then periodically should include questions related to all potential exposures, including those only intermittently encountered. Explicitly define the specific elements of the Post Exposure Protocol to: (1) prevent future bloodborne pathogen exposures and incidents; and (2) ensure that injured workers are provided adequate counseling and follow-up. Ensure that employees' records contain copies of all necessary medical forms. Document which employees (if any) are included under the Cal/OSHA respiratory protection standard and establish a written respiratory protection program to describe the scope of and need for the program.

- Establish an electronic tracking system for waste segregation errors and environmental emissions at each treatment facility and publicly report (via Web site, annual report, etc.) the findings on an annual basis.
- Require consultants and other contractors responsible for medical monitoring and other employee health care services to visit the facility, observe the work process and tasks, and review policies and procedures relevant to worker health and safety.
- Implement a Return-To-Work program with limited duties for injured workers.

Provide pollution prevention education and incentives to waste generators.

- Require the sales force responsible for generating business for an off-site waste treatment facility to visit the facility and observe the work process, tasks, and to review policies and procedures relevant to worker health and safety. Train the sales force about the positive worker health and safety implications of pollution prevention, and the negative implications of waste segregation, containment, and packaging errors.
- Provide all customers with basic educational materials about the positive worker health and safety implications of pollution prevention, and the negative implications of waste segregation, containment, and packaging errors.
- Provide all customers with economic and other incentives to undertake pollution prevention and waste reduction activities. Fee structures should reward mercury-free facilities and waste reduction efforts, and provide incentives to reduce the use of sharps when feasible. Fee structures should penalize waste segregation and packaging errors.

WHAT CAN FACILITIES THAT GENERATE MEDICAL WASTE DO TO PROTECT THE HEALTH AND SAFETY OF MEDICAL WASTE TREATMENT WORKERS?

Reduce the danger and quantity of medical waste.

- Eliminate the use of needles or sharp components where feasible.
- Decontaminate infectious laboratory waste (e.g., stocks and cultures) within the laboratory where they are generated.
- Participate in, monitor, and evaluate pollution prevention activities. Eliminate mercury from the waste stream. Identify other hazardous substances for pollution prevention and waste reduction opportunities, including hazardous chemicals and persistent, bioaccumulative, and toxic pollutants. Compile and publicly report data on the volume of medical waste generated, measures implemented to reduce the waste, and the outcome of these efforts.

Segregate and package medical waste properly.

- Monitor waste to ensure hazardous chemical materials have been excluded and waste is properly packaged. Facilities licensed to use radioactive materials should also monitor waste to verify that radioactive materials have been identified and excluded from the medical waste stream.

Explicitly integrate measurable worker health and safety criteria into decision-making about the use and selection of off-site medical waste treatment providers.

- Adopt and utilize criteria for selecting a waste treatment provider that reflect demonstrated implementation of prevention measures, as previously described on pages 80–85, under steps that "off-site medical waste treatment service providers [can] do to protect workers' health and safety."
- Observe the design of the work process and working conditions through an on-site walkthrough of the off-site treatment facility prior to initiation of a service agreement.
- Ask the Drivers who pick up your waste, sales employees, and other representatives of your waste treatment service provider for suggestions about what your facility

can do to make the work safer and more efficient for them, while maintaining compliance with all applicable regulations. For example, generators can store waste in well-ventilated areas that do not require the use of stairs, properly segregate and bag waste, accommodate the use of smaller tubs, and identify safe areas for parking the pick-up truck to reduce Drivers' exposures to hazardous traffic conditions.

- Support a proactive regulation to control ergonomic hazards in the workplace.

Train employees about the occupational and environmental health impacts of medical waste disposal practices.

- Train all individuals involved in purchasing decisions, infection control, and in the use and disposal of hazardous chemical, radioactive, sharps, and infectious materials, about the worker health and safety implications of their activities throughout the life cycle of these products.
- Train health care providers and educate patients receiving radiation therapy and diagnostics services about proper isolation and disposal of contaminated waste and body fluids. Training should emphasize the potential for these relatively "small" upstream exposures to accumulate into potentially larger downstream occupational exposures if proper disposal practices are not followed.
- Train Environmental Services workers about the health hazards of exposure to ionizing radiation.
- Monitor the effectiveness of training. Conduct ongoing assessments of waste handling practices throughout the facility. Request feedback from your off-site treatment facility about waste segregation and packaging errors. Traceback the source of radioactive and other waste excluded by the waste treatment service provider to determine the cause and implement solutions.

Implement recommendations to ensure worker health and safety in the health care industry.

- Serve as a model for best practices by implementing recommendations to ensure worker health and safety in the health care industry proposed at the Setting Healthcare's Environmental Agenda Conference (Appendix 4) (Wilburn 2001).

WHAT CAN AGENCIES THAT REGULATE ASPECTS OF THE MEDICAL WASTE STREAM DO TO PROTECT THE HEALTH AND SAFETY OF MEDICAL WASTE TREATMENT WORKERS?

Build partnerships between labor and public health programs.

- Provide education and resources to foster interdisciplinary mechanisms for collaboration among worker representatives, the health care and waste treatment industries, infection control, governmental and non-governmental organizations, community members, and other potentially impacted populations, to strengthen mechanisms for implementing a primary prevention-based approach to ensure the health and safety of workers across the medical waste stream.

Explicitly encourage the development of public health protective waste treatment technologies and work processes.

- Evaluate existing and proposed waste treatment technologies and associated work processes for occupational hazards, across all job tasks, including maintenance activities.
- Gather and integrate the perspective of medical waste stream workers into the design and implementation of technology and work process design.
- Require an industrial hygiene assessment of the facility/technology/work process when a facility/technology is permitted/approved.
- Support research to: (1) compile and analyze industry-wide occupational and environmental health and safety data (i.e., injury and illness rates, workplace exposures, and air and water emissions) related to the medical waste stream, including but not limited to, investigating the prevalence and causes of safety hazards and the potential for injuries and illnesses related to maintenance activities; (2) identify safer methods for dealing with sharps treatment and disposal; (3) identify source(s), methods of detection, and methods to eliminate hazardous chemical agents in the medical waste stream; (4) determine if the autoclave process generates acetone as a by-product of the breakdown of isopropyl alcohol; and (5) describe job turnover and the nature and extent of long-term disability and other potential chronic health outcomes among workers who dispose of the medical waste stream.
- Continue to develop plans and incentives to support pollution prevention activities by facilities that generate medical waste.
- Support a proactive regulation to control ergonomic hazards in the workplace.

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APPENDIX 1

DEFINITION OF MEDICAL WASTE IN CALIFORNIA	
Laboratory waste	Human or animal specimen cultures from medical and pathology laboratories; cultures and stocks of infectious agents from research and industrial laboratories; wastes from the production of bacteria, viruses, spores, discarded live and attenuated vaccines used in human health care or research, discarded animal vaccines, and culture dishes and devices used to transfer, inoculate, and mix cultures
Liquid blood and bodily fluids, and articles contaminated with blood or bodily fluids	Fluid blood, fluid blood products, containers or equipment containing blood that is fluid, or blood from animals known to be infected with diseases that are highly communicable to humans
Sharps	Syringes, needles, blades, broken glass
Isolation waste	Waste contaminated with excretion, exudate, or secretions from humans who are isolated due to highly communicable diseases
Chemotherapeutic waste*	Sharps and other materials containing trace amounts of chemotherapeutic agents
Pathology waste*	Recognizable human anatomical parts, human surgery specimens or tissues

*Some chemically hazardous wastes produced in health care are regulated as biohazardous waste. Specifically, trace amounts of chemotherapeutic agents, outdated pharmaceutical wastes, and tissues with trace amounts of fixatives fall into this category. Although regulated as "medical" waste, materials containing trace amounts of chemotherapeutic agents (e.g., empty vials, IV bottles/bags, tubings, and sharps) and pathology specimens must be separated from other parts of the medical waste stream for disposal.

Note: Except as described above, when biohazardous or sharps waste is mixed with hazardous and/or radioactive waste it is no longer considered to be medical waste. Rather, such mixed waste is treated as hazardous or radioactive waste.

Source: The Medical Waste Management Act (California Health and Safety Code, Sections 117600–118360). The Medical Waste Management Act governs the management of medical waste in all jurisdictions of the State. http://www.dhs.ca.gov/ps/ddwem/environmental/Med_Waste/LawRegs/default.htm

APPENDIX 2

CHEMICAL USE AT A STEAM AUTOCLAVE

All plant personnel use the products except as noted:

* Maintenance Workers only ** Roll-off Driver only *** Product Representative only **** Janitor only

	TASK	PRODUCT	CHEMICALS	RATE OF USE
FLOOR CLEANING				
1	Clean and deodorize	D-Molish Now	liquid enzymatic cleaner/bacterial concentrate (proprietary)	1 gallon/day
2	Clean	CarboChlor	butoxyethanol 1-5%, sodium metasilicate 3-7%, ethoxylated alcohol 1-5%	1 quart/week
3	Clean	ZEP Extra	butoxyethanol 5-10%, sodium hydroxide <5%	1 quart/week
4	Degrease	14 Karat Expungent	butoxyethanol 6%, sodium hydroxide 1.5%	2 gallons/month
5	Deodorize	Cherry Odor	paradichlorobenzene	As needed 1 drum/year *
6	Clean concrete	TSP	tri-sodium phosphate	2 ounces/year *
7	Sanitize	ZEP FS formula 4665	sodium hydroxide <5%, sodium hypochlorite 10-20%	"not in use yet"
SPILLS				
8	Disinfect	Chlorine bleach	sodium hypochlorite	2 quarts/day
9	Chemical absorbants	Absorbent socks	vermiculite	2/day

APPENDIX 2 (CONT.)

CHEMICAL USE AT A STEAM AUTOCLAVE

All plant personnel use the products except as noted:

* Maintenance Workers only ** Roll-off Driver only *** Product Representative only **** Janitor only

	TASK	PRODUCT	CHEMICALS	RATE OF USE
DEODORIZING SYSTEM				
10	Deodorize	Ecosorb 606	"nontoxic, non-hazardous, biodegradable, and contains no harmful VOCs"	10 gallons/week*
11	Deodorize	Ecosorb 610	"nontoxic, non-hazardous, biodegradable, and contains no harmful VOCs"	5 gallons/month*
HANDWASHING/DISINFECTION				
12	Wash hands	GoJo Hand Sanitizer	denatured alcohol 40-70%	2-3 ounces/day
13	Hand lotion	Rich Pink	< 5% ethanolamine	1 bag/day
14	Disinfect minor cuts	Isopropyl alcohol	isopropyl alcohol	1 ounce/month
TUB WASHING				
15	Test tub washer	QAC Indicator solution	methyl orange, bromphenol blue	daily procedure*
16	Disinfect tubs	ZEP FS Amine Z	alkyl dimethylbenzyl ammonium chlorides, alkyl dimethylmethyl ammonium chlorides 10-20%, ethanol <10%	2-3 gallons/day

APPENDIX 2 (CONT.)

CHEMICAL USE AT A STEAM AUTOCLAVE

All plant personnel use the products except as noted:

* Maintenance Workers only ** Roll-off Driver only *** Product Representative only **** Janitor only

	TASK	PRODUCT	CHEMICALS	RATE OF USE
AUTOCLAVE				
17	Lubricate autoclave conveyor chains	Spray-On Dry Moly Lube (S002000)	propane (8%), butane (22%), heptane (5%), mineral spirits (2%), 2-propanol (26%), acetone (35%), molybdenum disulfide (2%)	1 can/day*
18	Lubricate autoclave conveyor chains	Spray-On Dry Moly Lube (S002004)	propane, mineral spirits	1 can/day* when in use (substitute for S00200)
19	Lubricate autoclave conveyor chains	ZEP dry Moly	trichloroethylene (60-70%), isopropyl alcohol (5-15%), isobutane/propane blend (20-30%)	1 can/day* when in use (substitute for S00200)
20	Lubricate chain conveyors	Chain and Cable Foaming Lubricant	mineral oil (30-50%), olefin polymer (15-30%), lithium grease (5-10%), oxidized petroleum hydrocarbon (5-10%), dipropylene glycol butyl ether (5-10%), liquified petroleum gas (40-60%)	1/3 can/day*
21	Lubricate conveyor chains	Lubrease aerosol	petrolatum, oil-soluble sodium sulfonate, hexylene glycol, Stoddard solvent, heavy and light napthenic petroleum distillate, propane, isobutane, polybutene polymer	1/3 can/day*
22	Lubricate conveyor bearings	Grease TF 1000	MSDS missing	1/4 tube/week*
23	Loosen metal joints	Gibbs Penetrating Blend	2-propanol, heptane, petroleum distillates	as needed, 1 can/month*
24	Clean Coil	Blast-A-Coil	carbon dioxide, chloroethylene 79-01-6	1 can every 6 months*

APPENDIX 2 (CONT.)

CHEMICAL USE AT A STEAM AUTOCLAVE

All plant personnel use the products except as noted:

* Maintenance Workers only   ** Roll-off Driver only   *** Product Representative only   **** Janitor only

	TASK	PRODUCT	CHEMICALS	RATE OF USE
25	Oil roll-off truck engine	Quaker State Motor Oil	MSDS missing	1.5 gallons every 6 months**
26	Oil autoclave conveyor hyraulics	Mobil SHC 626	hydrocarbons and additives NOS	27.5 gallons every 6 months*
27	Oil compactor, dumper, autoclave door hydraulics	AW 46 Premium	petroleum hydrocarbons	27.5 gallons every 6 months*
28	Test PID	Klean-Stri Acetone	acetone	as needed, yearly*
29	Lubricate door hydraulics	76 Super ATF	petroleum hydrocarbons	5 gallons/year*
30	Clean contacts	NF Lectric	trichloroethylene, isopropyl alcohol, carbon dioxide propellant	2 cans/year*

APPENDIX 2 (CONT.)

CHEMICAL USE AT A STEAM AUTOCLAVE

All plant personnel use the products except as noted:

* Maintenance Workers only ** Roll-off Driver only *** Product Representative only **** Janitor only

	TASK	PRODUCT	CHEMICALS	RATE OF USE
BOILER				
31	Sample sink tests	Boiler Test Reagents	MSDS missing	per procedure/day*
32	Anti-sieze and lubricate	Never-Seez	MSDS missing	1 ounce/year*
33	Maintain boiler	Caustric Soda Boiler Chemical	sodium hydroxide 20% - 51.5%	10 gallons/year variable, approximately bi-annual*
34	Maintain boiler	Oxygen Scavenger	sodium sulfite 60%-100%, sodium metabisulfite 1%-5%	15 pounds/week*
35	Maintain boiler	Onedo Nalco Energy Transport Plus 2858	sulfur dioxide, diethylethanolamine	67.5 gallons every 6 months***
36	Maintain boiler	Tri-Act 2813	cyclohexylamine, diethylethanolamine, morpholine	7.5 gallons/year*

APPENDIX 2 (CONT.)

CHEMICAL USE AT A STEAM AUTOCLAVE

All plant personnel use the products except as noted:

* Maintenance Workers only   ** Roll-off Driver only   *** Product Representative only   **** Janitor only

	TASK	PRODUCT	CHEMICALS	RATE OF USE
GENERAL				
37	Clean glass	Windex	ethoxylated alcohol 1-5%	1/6 bottle/day****
38	Synthetic diester oil for air compressor	All Seasons T30 select	diester	3 quarts every 6 months*
39	Seal joints on various equipment	RTV Silicone Sealant	hexamethyldisilazane	as required, 1 tube/year*
40	Solvent for painting	Klean-Strip Japan Drier	acetone	2 ounces/year*
41	Solvent for painting	Mineral Spirits	mineral spirits, Stoddard solvent type III	4 ounces/year*
42	Mark items	Spray Ink Orange	1-methoxy-2-propanol acetate, isobutane, butane, light aliphatic solvent naptha, propane, acetone	as required, 1 can/year*
43	Cutting or drilling metal	Tapping Compound	napthenic oils <80%, petroleum sulfonic, sulfurized parafins, petroleum olefins	as required, 1 can/year*
44	Thread joints	Teflon Thread Seal Tape	MSDS missing	1/4 roll/week*
45	Lubricate/loosen metal joints	Yield	aliphatic petroleum distillate, ethyl acetate, oil soluble sodium sulfonate, light napthenic hydrotreated distillate, n-butane, propane	daily use ~ 1 can/month
46	Degreaser	Zep True Blitz Aerosol	heptane, acetone, isopropyl alcohol	as required, 1 can/month*
47	Fire extinguisher	ABC Dry Chemcial		as needed
48	Wash eyes	Eye Wash Solution		as needed

Source: Employer Material Safety Data Sheets and Rate of Use Information

APPENDIX 3

ERGONOMIC RISK FACTORS BY JOB TASK

JOB TASK	ERGONOMIC RISK FACTOR						
	Awkward posture: working above shoulder level, asymmetric trunk twist while lifting, extended reach, deviated wrist posture, deviated shoulder posture	Force: high, low, or medium weight lifting and lowering	Repetition: repeating motions greater than two times per minute	Inconsistent coupling, i.e., the quality of the hand to container interface	Hand force	Contact stress	Pinch grasp
Unloading autoclave waste	yes	yes, high weight	yes	yes	yes, gripping unsupported objects	yes, using hand as support	no
Managing incinerator waste	yes	yes, high weight	yes	yes	yes, gripping unsupported objects	yes, using hand as support	no
Inspection, scan and weigh station	yes	yes, high weight, also pushing and pulling	yes	yes	Intense hand work, detail work and force	yes	yes
Tipping station	yes, also while pushing and pulling	yes, high weight	yes	yes	yes, gripping unsupported objects, also intense hand use	yes	no
Tub washing	yes	yes, low weight	yes	yes	no	yes, using hand as support	no
Loading clean containers	yes	yes, moderate weight, also pulling	yes	yes	yes, gripping unsupported objects	yes, using hand as support	no
Managing non-conforming waste	yes, asymetric trunk twist while lifting, deviated wrist posture	yes, moderate weight	no	yes	no	no	no

Source: Verliant. Ergonomic Evaluation May 2004

APPENDIX 4

Reprinted from: Wilburn S. Setting Healthcare's Environmental Agenda. Occupational Health and Safety. Papers and Proceedings from the October 16, 2000, Conference pages 57–58. April 2001. http://www.noharm.org/details.cfm?type=document&ID=477 Accessed October 18, 2005.

RECOMMENDATIONS FOR A SAFE AND HEALTHY WORK ENVIRONMENT MADE BY PARTICIPANTS AT THE 2000 "SETTING HEALTHCARE'S ENVIRONMENTAL AGENDA" CONFERENCE

The participants at the Setting Healthcare's Environmental Agenda Conference adopted the following principles and goals for worker health and safety recognizing that a cultural shift may be necessary. This shift should be towards a culture that values the health and safety of healthcare workers equally with patient safety and quality of care. A systematic occupational safety and health program must be in place in order for an organization to successfully recognize and control occupational hazards.

The overriding issue for healthcare worker health and safety is the same as for patient safety: sufficient and appropriate levels of staffing. Inadequate staffing became a major problem in the 1990s as cost containment drove decision-making. Inadequate staffing results in an increased risk of medical errors as well as injury to workers.

1. Adopt the principles from the World Health Organization Safe Injection Global Network (SIGN): "a safe injection does no harm to the recipient, does not expose the healthcare worker to any risk and does not result in waste that is dangerous for the community" and expand them to safe healthcare practices: *A safe healthcare practice does no harm to the recipient, does not expose the healthcare worker to any risk and does not result in waste that is dangerous for the community.*

2. Management Leadership—Visible top management leadership provides the motivating force for an effective health and safety program. "The most significant finding in terms of enhancing compliance and reducing exposure incidents was the importance of the perception that senior management was supportive of the bloodborne pathogen safety program. When employee safety is considered and valued, employees feel valued." An organization's commitment to health and safety is demonstrated by the assignment of responsibility and allocation of appropriate resources for the health and safety program. Adequate staffing (patient care and occupational health program staff), and materials for hazard controls are essential tools for safety. It is important to recognize that the business of providing quality healthcare to patients requires safe and healthy employees and that what is unsafe for workers is probably unsafe for patients.

3. Employee Participation—Involve frontline workers in an interdisciplinary process for the evaluation of hazards and the selection and implementation of control measures. Joint labor-management health and safety committees are effective vehicles provided they have the support and authority to implement decisions. Utilizing the considerable expertise of frontline workers increases the probability that the most appropriate safety devices and work practice controls will be selected and increases the likelihood that staff will be more accepting of new devices and practices.

The SHEA [Society for Healthcare Epidemiology of America] health and safety work group emphasized that a successful joint labor-management effort, as is required by the 1999 amendments to the OSHA Bloodborne Pathogens Standard for device selection, should incorporate the following principles:

- The committee has the authority to make and implement decisions in a timely manner.
- The committee reviews and analyzes exposure, illness and injury data.
- Training is provided to committee members for effective participation.
- Frontline staff chooses frontline staff representatives to the committee.
- Committee meetings occur during paid work time.
- The Health and Safety Committee has linkages to other institutional committees including product evaluation and purchasing.

4. Encourage reporting and recording of work-related symptoms, injuries and "near misses." Address issues that contribute to under-reporting by eliminating blame for injuries and other disincentives. Ensure prompt and immediate response to reported injuries and identify and address needs for institutional change. Utilize illness and injury data as a corrective feedback loop.

5. Prioritize prevention by utilizing the industrial hygiene hierarchy of controls. Focus on eliminating hazards and implementing engineering and work practice controls to prevent exposure to hazards.

6. Advocate for research on prevention and enforceable standards.

7. Incorporate an analysis of the impact on worker health and safety prior to the implementation of job changes, restructuring, new technology, new procedures, products, chemicals and medications. Request a NIOSH Health Hazard Evaluation when unknown products and procedures are initiated. Pay attention to the "canaries." Healthcare workers with work-related illness and injury may be the harbinger of risk for all healthcare workers and an indication of an unsafe environment for patients and/or the community.