HETA 91-0366-2453
SEPTEMBER 1994
DELAWARE COUNTY
RESOURCE RECOVERY FACILITY
CHESTER, PENNSYLVANIA

NIOSH INVESTIGATORS:
ERIC J. ESSWEIN, MSPH
ALLISON TEPPER, Ph.D.

I. SUMMARY

On December 19 and 20, 1991, and June 23 and 24, 1992, in response to a confidential request for a health hazard evaluation (HHE), investigators from the National Institute for Occupational Safety and Health (NIOSH) conducted investigations at the Delaware County Resource Recovery Facility (DCRRF), a municipal waste incinerator located in Chester, Pennsylvania. The HHE request was submitted in response to employees' concern regarding exposure to lead, incinerator ash dust, and heat stress. Health complaints reported include ear, nose, and throat problems, eye irritation, and skin rash. The DCRRF burns municipal waste and refuse-derived fuel (RDF) from Delaware County, the City of Philadelphia, and New York City.

Analytical results from bulk and wipe samples collected during the initial walkthrough survey in December 1991, confirmed that lead and other metals were present in settled dust throughout the plant. Samples of settled dust from walking and working surfaces were collected along with fly ash and conditioned bottom ash samples from the incinerators. Hand and table wipe samples taken in a contractor's break trailer located on site showed that lead, chromium, cadmium, and nickel were present on lunch tables and on workers' hands. Based upon the initial observations and analytical results, a decision was made to return to the DCRRF. On June 23-24, 1992, full-shift personal air monitoring was conducted to determine exposures to lead and other metals, respirable silica, and respirable dust. Heat stress measurements were also made in certain areas on the fourth, fifth, and sixth floors of the facility.

In comparison to other metals, lead was found in the greatest concentration on the bulk, wipe, and air samples taken at the facility. However, personal breathing zone (PBZ) samples taken during the investigation showed that airborne concentrations of lead, which ranged from non-detectable to
4.6 µg/m^3, were well below the Occupational Safety and Health Administration (OSHA) Permissible Exposure Limit (PEL) of 50 micrograms per cubic meter of air (µg/m^3) as an 8-hour time weighted average (TWA). Personal breathing zone samples for cadmium and chromium ranged from non-detectable to 0.11 µg/m^3 and 0.72 µg/m^3, respectively. The current OSHA PEL for cadmium (dust) is 5 µg/m^3. NIOSH recommends exposure to cadmium dusts and fumes be reduced to the lowest feasible concentration, or 10 µg/m^3, which is a concentration based on analytical limits of detection reported for the method. These concentrations can be subject to change as method sensitivities change and improve. The OSHA PEL for chromium (metal) is 1 mg/m^3 as an 8-hour TWA. NIOSH recommends that Cr(VI) compounds be considered potential carcinogens, the NIOSH REL for these compounds is 1 µg/m^3 for a 10-hour TWA. Nickel was not detected.

Respirable dust concentrations ranged from 0.02 mg/m^3 to 0.87 mg/m^3. The OSHA PEL for respirable dust is 5 mg/m^3 as an 8-hour TWA. Respirable crystalline silica (quartz and cristobalite) samples were all reported as not-detected.

Area measurements of indoor wet bulb globe thermometer ($WBGT_{IN}$) conducted on the fourth, fifth, and sixth floors indicate that heat stress is a potential hazard in certain locations on these floors. Fourth, fifth, and sixth floor hourly $WBGT_{IN}$ TWA measurements were 84.2°F, 91.1°F, and 99.4°F, respectively. The minimum NIOSH Recommended Alert Limit (RAL) for WBGT environmental heat stress in unacclimatized workers is 89°F. The American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV) for heat exposure and light work (75%/25% work/rest regimen) is 87°F $WBGT_{IN}$. The results indicate that in areas of the fifth and sixth floor the potential for heat stress exposures was in excess of the minimum NIOSH recommendations and the ACGIH TLV. Safety hazards, improper practices involving personal protective equipment, and inadequate personal hygiene practices (handwashing) were also noted during this investigation.

The results of this NIOSH HHE indicate that an occupational health hazard did not exist due to inhalation exposure to lead from incinerator ash. A possible occupational health hazard was determined to exist due to heat exposure on certain floors of the facility. While the presence of lead was found on bulk, wipe, and air samples, PBZ samples ranged from non-detectable (minimum detectable concentration, 0.002 $\mu g/m^3$) to 4.6 $\mu g/m^3$; airborne concentrations did not exceed the OSHA general industry PEL for lead which is 50 $\mu g/m^3$. Wipe samples taken on environmental surfaces (lunchtables) and from the hands of employees revealed the presence of lead, chromium, cadmium, and nickel. The presence of metals-containing dust on workers hands and on environmental surfaces poses an occupational risk factor for possible ingestion of these metals, all of which are toxic. PBZ samples for respirable dust did not exceed the OSHA PEL; however, due to the presence of toxic elements in incinerator ash, this PEL is probably insufficiently protective. Respirable silica (quartz and cristobalite) was not detected. Recommendations are included in Section VIII of this report to further evaluate worker heat stress and develop a heat stress management plan if exposures exceed occupational health criteria, enhance safety conditions, and improve workplace hygienic practices (specifically handwashing) at the DCRRF.

KEY WORDS: SIC 4953, (Incinerator operation, garbage: collecting, destroying and processing), incinerator ash, metals, lead, cadmium, chromium, silica, resource recovery facility, municipal waste incineration.

II. INTRODUCTION

On August 8, 1991, the National Institute for Occupational Safety and Health (NIOSH) received a confidential request to conduct a health hazard evaluation (HHE) at the Delaware County Resource Recovery Facility (DCRRF) located in Chester, Pennsylvania. The request—submitted on behalf of the contractors regarding conditions during construction and initial operation of the facility— identified complaints of eye irritation, ear, nose, and throat problems, skin rash, heat stress, and concern about exposure to the lead-containing dust of incinerator ash.

An initial site visit was conducted on December 19-20, 1991, at which time employees were interviewed, medical monitoring records were collected, a walkthrough survey was conducted, and bulk samples of incinerator ash and settled dust were collected. Based on the results of the initial walkthrough survey, along with analytical results from the samples collected during the initial walkthrough, a decision was made to return to the facility on June 23-24, 1992, and conduct full-shift personal monitoring to determine exposures to lead and other metals, respirable silica, respirable dust, and to obtain area heat stress measurements.

III. BACKGROUND AND PROCESS DESCRIPTION

The DCRRF is a waste-to-energy incinerator located in Chester, Pennsylvania. The plant is owned by Westinghouse Electric Corporation and employs 91 Westinghouse employees on-site. The facility incinerates municipal solid waste (MSW) and refuse derived fuel (RDF), a shredded form of MSW, to produce electrical power. The facility began burning waste on March 6, 1991. MSW in the United States consists mostly of paper products, yard wastes, food wastes, metals, rubber, and glass (Figure I).[1]

Packer trucks deliver waste to the DCRRF where it is unloaded onto the tipping floor. The MSW and the RDF are "sorted" using front-end loaders in an attempt to remove the larger, unacceptable metal objects such as water heaters, engine blocks, bicycles, etc. Sorting with the front-end loader consists of scooping and raising a bucket full of waste, and slowly backing the loader, while tipping the refuse back onto the floor. The operator listens for the sound of heavy objects hitting the tipping floor and then scans the refuse after it has been spread out. If unacceptable waste such as water heaters or pieces of metal are found, the waste is transferred to a scrap pile at the edge of the tipping floor. The sorted MSW is then moved by conveyor to an inclined feed chute and into a combustor. Combustors consist of a 13.3 foot (ft) diameter rotating inclined cylinder using induced draft fans to provide combustion air to the burners. Hot flue gases are used to power a steam turbine capable of generating up to 70 megawatts (MW) of electricity for sale to the Atlantic City Electric Company.

The facility can process 2,688 tons of MSW per day using six combustor-boiler trains, using proprietary design water-walled rotary combustors engineered to burn approximately 448 tons of MSW per day with a higher heating value (HHV) of 5,200 British thermal units per pound (Btu/lb). Each boiler has a design capacity of 130,000 pounds of steam per hour. Actual day-to-day throughput varies with the HHV of the MSW. The total design steam production capacity of the facility is 780,000 pounds of steam per hour at 800°F and 675 pounds per square inch water gauge (psig).

Air pollution is controlled using spray dryers and baghouses for each unit. Pulverized lime [$Ca(OH)_2$] slurry is injected into a reaction vessel where acid gases (mainly $S0_2$ and HCL) are absorbed. The system design incorporates flue gas evaporation in an atomized lime slurry to produce a dry calcium salt. A baghouse is used downstream of the spray dryer to collect the spray dryer reactant products, unreacted sorbent, and flyash.

During initial plant start-up, problems were encountered with the ash conditioning system according to several workers who were interviewed. On a number of occasions, ash was reportedly blown into the boiler building when it became too dry. During the initial NIOSH visit in December 1991, investigators noticed that settled dust, up to one-half inch thick, was visible on certain sections of piping, handrails, and other surfaces in the facility. This was evidence that ash had been airborne in the plant on previous occasions and suggested that inhalation and skin exposures were a possibility depending on the type of respiratory protection and protective clothing worn by workers in the area.

According to a DCRRF Municipal Incinerator Ash Residue Monitoring Report (Form 41) dated March 20, 1991, the lead content of ash was reported as 64,400 milligrams per kilogram (mg/kg) or 6.44% lead on a dry-weight basis. The pH of the ash was reported as 10.6. The primary sources of lead in MSW include lead-acid batteries and consumer electronics (Figure II).[2]

IV. METHODS AND MATERIALS

On December 19, 1991, NIOSH investigators interviewed sixteen workers selected by management at the DCRRF. The employees were selected to represent a cross-section of all trades, contractors, and Westinghouse employee job titles and included workers who reported health symptoms and workers who did not report symptoms. During the interview, workers were questioned about work practices including use of personal protective equipment, knowledge of potential work-related health hazards, and the occurrence of symptoms relating to skin exposure and respiratory irritants. In addition, copies of the 1991 Log of Occupational Injuries and Illnesses (Form 200) were obtained for Westinghouse employees and the employees of five contractors working on-site at the time of the NIOSH survey.

The industrial hygiene investigation involved collecting full-shift personal breathing zone (PBZ) and general area air samples to determine exposures to lead and other toxic metals, respirable dust, and respirable silica (quartz and cristobalite). Area heat stress measurements were also made in certain locations of the facility. Employees were asked to wear two personal sampling trains; one sampling train was configured to sample for respirable dust and silica, another was configured to sample for metals.

NIOSH investigators suspected that ash was being transported on employees' work boots and that metals contamination was a possibility in a carpeted administrative area at the DCRRF. Several dust samples from the carpet and one sample from a chair were taken with filter cassettes and personal sampling pumps using micro-vacuuming techniques. Square foot areas of the carpet and a chair in the plant office and the conference room were vacuumed and the samples submitted for analysis along with the personal and area samples.

A. Air Sampling for Metals

Sampling for metals consisted of a 0.8 micrometer (µm) mixed cellulose-ester membrane filter cassette connected with tubing to a Gilian® constant flow sampling pump. The sampling train was calibrated to 2 liters per minute (Lpm). The cassette was clipped to the uniform lapel in the worker's breathing zone. Pump calibration (including flow checks during the day and post-sampling calibration) was done using a Kurz mass flow meter. The method of analysis for metals was NIOSH Method 7300.[3] Samples were analyzed with a Thermo Jarrell Ash ICAP 61 simultaneous scanning inductively coupled plasma emission spectrometer controlled by a NEC personal computer-AT.

B. Respirable Particulate

All respirable particulate and respirable silica samples were collected on tared 37 millimeter (mm) 5-µm pore size PVC membrane filter cassettes mounted in 10 mm Dorr-Oliver nylon cyclones. The cassettes were connected with tubing to personal sampling pumps and the sampling train was calibrated to a flow rate of 1.7 Lpm. The samples were analyzed gravimetrically for total weight according to NIOSH Method 0600[4] with two modifications: (1) filters were stored in an environmentally controlled room to reduce the stabilization time between tare weighings to 5-10 minutes and, (2) the filters and backup pads were not vacuum desiccated. The instrumental precision of the weighings (using a microbalance) was reported at 0.02 mg.

After analysis for total weight, the samples were analyzed for silica (quartz and cristobalite) using x-ray diffraction. NIOSH Method 7500[5] was used with the following modifications: (1) filters were dissolved in tetrahydrofuran rather than ashed in a furnace and, (2) standards and samples were run concurrently and an external calibration curve was prepared from the integrated intensities rather than using the suggested normalization procedure.

C. Surface and Hand Wipe Samples for Metals

During the December 1991, visit to the DCRRF, a wet-wipe method was used as a qualitative determinant of surface contamination by metals and as an index of metals contamination to workers' hands. The samples were collected in a contractor's trailer using a commercially available disposable wipe pad (Wash-a-by-Baby®). For surface contamination of a lunch table, the procedure consisted of masking the boundaries of a 1 square foot (ft^2) area with a plastic template designed for surface sampling. Non-linear, unplasticized, polyethylene gloves were worn when sampling. The pads were wiped in two directions, one direction perpendicular to the other. Each pad was used for only one sample, and was then placed in a labeled polyethylene bag. Several media blanks were submitted with the exposed samples to provide controls for any background contamination. For hand wipes, the workers were asked to take a fresh wipe and clean their hands as thoroughly as possible for 30 seconds. Workers were also questioned as to whether they had washed their hands prior to coming into the break/lunch trailer.

D. Heat Stress Measurements

A Reuter-Stokes Model RSS-214 Wet Bulb Globe Thermometor (WBGT) was used to measure environmental factors contributing to heat stress. The RSS-214 was used to automatically datalog measurements at ten minute intervals. This direct reading instrument is capable of monitoring dry bulb, natural (unaspirated) wet bulb, and black globe temperatures in the range between 32 degrees Fahrenheit (°F) and 200°F, with an accuracy of ± 0.5°F. This meter also computes the indoor and outdoor WBGT indices in the range between 32°F and 200°F.

Heat stress monitoring was performed on June 24, 1992, and included locations on the fourth, fifth, and sixth floors. The survey locations included the fourth floor secondary combustion chamber, the fifth floor soot burner, and the sixth floor steam drum. These locations were chosen because they were in the immediate vicinity of machinery which appeared, or was confirmed, to be a location likely for maintenance operations to occur. Measurements were collected about four feet from the floor after the monitor was stable.

V. EVALUATION CRITERIA

As a guide to the evaluation of the hazards posed by workplace exposures, NIOSH field staff employ environmental evaluation criteria for the assessment of a number of chemical and physical agents. These criteria are intended to suggest levels of exposure to which most workers may be exposed up to 10 hours per day, 40 hours per week for a working lifetime without experiencing adverse health effects. It is, however, important to note that not all workers will be protected from adverse health effects even though their exposures are maintained below these levels. A small percentage may experience adverse health effects because of individual susceptibility, a pre-existing medical condition, and/or a hypersensitivity (allergy). In addition, some hazardous substances may act in combination with other workplace exposures, the general environment, or with medications or personal habits of the worker to produce health effects even if the occupational exposures are controlled at the level set by the criterion. These combined effects are often not considered in the evaluation criteria. Also, some substances are absorbed by direct contact with the skin and mucous membranes, and thus potentially increase the overall exposure. Finally, evaluation criteria may change over the years as new information on the toxic effects of an agent become available.

The primary sources of environmental evaluation criteria for the workplace are: (1) NIOSH Recommended Exposure Limits (RELs)[6], (2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs),[7] and (3) the U.S. Department of Labor, OSHA Permissible Exposure Limits (PELs).[8]

In July 1992, the 11th Circuit Court of Appeals vacated the 1989 OSHA PEL Air Contaminants Standard. OSHA is currently enforcing the 1971 standards which are listed as transitional values in the current Code of Federal Regulations; however, some states operating their own OSHA approved job safety and health programs will continue to enforce the 1989 limits. NIOSH encourages employers to follow the 1989 OSHA limits, the NIOSH RELs, the ACGIH TLVs, or whichever are the more protective criterion. The OSHA PELs reflect the feasibility of controlling exposures in various industries where the agents are used, whereas NIOSH RELs are based primarily on concerns relating to the prevention of occupational disease. It should be noted when reviewing this report that employers are legally required to meet those levels specified by an OSHA standard and that the OSHA PELs included in this report are the 1971 values or the appropriate PEL stated in a specific OSHA standard.

A time-weighted average (TWA) exposure refers to the average airborne concentration of a substance during a normal 8-to-10-hour workday. Some substances have recommended short-term exposure limits (STEL) or ceiling values which are intended to supplement the TWA where there are recognized toxic effects from higher exposures over the short-term.

Substance-Specific Evaluation Criteria and Health Effects Summary

A. <u>Lead</u>

Inhalation (breathing) of dust and fume, and ingestion (swallowing) resulting from hand-to-mouth contact with lead-contaminated food, cigarettes, clothing, or other objects are the major routes of worker exposure to lead. Once absorbed, lead (Pb) accumulates in the soft tissues and bones, with the highest accumulation initially in the liver and kidneys.[9] Lead is stored in the bones for decades, and may cause toxic effects as it is slowly released over time. Overexposure to lead results in damage to the kidneys, gastrointestinal tract, peripheral and central nervous systems, and the blood-forming organs (bone marrow).

The frequency and severity of symptoms associated with lead exposure increase with increasing blood lead levels (BLLs). Signs or symptoms of acute lead intoxication include weakness, excessive tiredness, irritability, constipation, anorexia, abdominal discomfort, colic, anemia, high blood pressure, irritability or anxiety, fine tremors, pigmentation on the gums ("lead line"), and "wrist drop."[10-11]

Overt symptoms of lead poisoning in adults generally begin at BLLs between 60 and 120 micrograms per deciliter (µg/dL). Neurologic, hematologic, and reproductive effects, however, may be detectable at much lower levels, and the World Health Organization (WHO) has recommended an upper limit of 40 µg/dL for occupationally exposed adult males.[12] The mean blood lead level for U.S. men from

1976-1980 was 16 µg/dL.[13-14] With the implementation of lead-free gasoline and reduced lead in food, the 1991 average serum lead level of U.S. men was expected to drop below 9 µg/dL.[15] Recent epidemiological data indicate an overall mean blood lead for the U.S. population of 2.8 µg/dL and a mean adult blood lead level of <5 µg/dL.[16]

An increase in an individual worker's BLL can mean that the worker is being overexposed to lead. While the BLL is a good indication of recent exposure to, and current absorption of lead, it is not a reliable indication of the total body burden of lead.[17] Lead can accumulate in the body over time and produce health effects long after exposure has stopped. Long-term overexposure to lead may cause infertility in both sexes, fetal damage, chronic kidney disease (nephropathy), and anemia.

Under the OSHA standard regulating occupational exposure to inorganic lead in general industry, the PEL is 50 micrograms per cubic meter (µg/m^3) as an 8-hour TWA.[18] The standard requires monitoring of BLLs for employees exposed to airborne lead at or above the Action Level of 30 µg/m^3 (8-hour TWA), specifies medical removal of employees whose average BLL is 50 µg/dL or greater, and provides economic protection for medically removed workers. Medically removed workers cannot return to jobs involving lead exposure until their BLL is below 40 µg/dL. The construction industry was initially exempted from this regulation when it was promulgated in 1978; the current OSHA PEL for the construction industry (29 CFR 1926.62) is 50 µg/m^3.

Recent studies suggest that there are adverse health effects at BLLs below the current evaluation criteria for occupational exposure. A number of studies have found neurological symptoms in workers with BLLs of 40 to 60 µg/dL. Blood lead levels are associated with increases in blood pressure, with no apparent threshold through less than 10 µg/dL. Studies have suggested decreased fertility in men at BLLs as low as 40 µg/dL. Prenatal exposure to lead is associated with reduced gestational age, birthweight, and early mental development at prenatal maternal BLLs as low as 10 to 15 µg/dL.[19]

In recognition of the health risks associated with exposure to lead, a goal for reducing occupational exposure was specified in *Healthy People 2000*, a recent statement of national consensus and U.S. Public Health Service policy for health promotion and disease prevention. The goal for workers exposed to lead is to eliminate, by the year 2000, all exposures that result in BLLs greater than 25 µg/dL.[20]

In homes with a family member occupationally exposed to lead, lead dust may be carried home on clothing, skin, and hair, and in vehicles. High BLLs in resident children, and elevated concentrations of lead in the house dust, have been found in the homes of workers employed in industries associated with high lead exposure.[21] Particular effort should be made to ensure that children of workers with lead poisoning, or who work in areas of high lead exposure, are tested for lead exposure (BLL) by a qualified health-care provider.

B. Nuisance Dusts

Varying amounts of toxic metals are commonly found in incinerator fly ash. Although TLVs and PELs have been established for nuisance dusts (particulates not otherwise regulated/classified), these criteria are not appropriate when specific toxic elements are present. NIOSH does not have an REL for nuisance dusts. The OSHA PELs are 15 mg/m^3 and 5 mg/m^3 for total dust and the respirable fraction, respectively.[8]

C. Cadmium

Because cadmium (Cd) is considered a potential human carcinogen, NIOSH recommends that exposure to cadmium dusts and fumes be reduced to the lowest feasible concentration, in this case, 10 µg/m^3, a concentration based on the analytical limits of detection for the NIOSH method.[3] NIOSH based this recommendation on epidemiologic evidence of a significant excess of cancer deaths among a group of cadmium production workers.[22] Chronic human exposure to Cd has also been associated with a range of effects including "itai-itai" disease, a condition of extreme bone fragility. Gastrointestinal symptoms, pulmonary emphysema, kidney disease, and rhinitis are also associated with cadmium exposure.[23] The OSHA PEL-TWA for cadmium (dust) is 5 µg/m^3. The ACGIH TLV-TWA is 10 µg/m^3 for total dust and 2 µg/m^3 for respirable fractions.

D. Chromium

Chromium (Cr) exists in a variety of chemical forms, and toxicity varies among the different forms. For example, elemental chromium is relatively non-toxic.[24] Other chromium compounds may cause skin irritation, sensitization, and allergic dermatitis. In the hexavalent form [Cr(VI)], Cr compounds are corrosive, and possibly carcinogenic. Until recently, the less water-soluble Cr(VI) forms were considered carcinogenic, while the water-soluble forms were not considered carcinogenic. Recent epidemiological evidence however, indicates carcinogenicity among workers exposed to soluble Cr(VI) compounds.[25-29] Based on this new evidence, NIOSH recommends that all Cr(VI) compounds be considered as potential carcinogens.[30] The NIOSH REL for Cr(VI) compounds is 1 µg/m^3 for a 10-hour TWA. The current OSHA PEL does not address Cr specifically as Cr(VI) and lists the PEL-TWA for chromium metal and insoluble salts as 1 mg/m^3. The NIOSH REL for chromium (II and III) compounds is 0.5 mg/m^3 as a TWA.

E. Crystalline Silica

Crystalline silica or free silica (quartz and cristobalite) causes silicosis, a disabling, progressive, and sometimes fatal pulmonary fibrosis. This disease generally occurs after years of exposure and is characterized by nodulation in the lungs.[31] Symptoms include cough, wheezing, shortness of breath, and non-specific chest illness.[24] Impairment of pulmonary function is generally progressive, with disease continuing to occur after dust exposures have ceased. The NIOSH REL for respirable quartz and christobalite is 50 µg/m^3. The OSHA PEL-TWA for respirable quartz is 10 mg/m^3.

F. Heat Stress

A number of heat stress guidelines are available to protect against heat-related illnesses. These include the wet bulb globe temperature (WBGT), Belding-Hatch heat stress index (HSI), and effective temperature (ET).[32-34] The underlying objective of these guidelines is to prevent a worker's core body temperature from rising excessively. Many of the available heat stress guidelines, including those proposed by NIOSH and the ACGIH, use a maximum core body temperature of 38 degrees Celsius (°C) as the basis for the environmental criterion.[35-36]

Both NIOSH and ACGIH recommend the use of the WBGT index to measure environmental factors because of its simplicity and suitability in regards to heat stress. The WBGT index takes into account environmental conditions such as air velocity, vapor pressure due to atmospheric water vapor (humidity), radiant heat, and air temperature, and is expressed in terms of degrees Fahrenheit (or degrees Celsius). Measurement of WBGT is accomplished using an ordinary dry bulb temperature (DB), a natural (unaspirated) wet bulb temperature (WB), and a black globe temperature (GT) as follows:

$WBGT_{in}$ = 0.7 (WB) + 0.3 (GT) for inside or outside without solar load,

OR

$WBGT_{out}$ = 0.7 (WB) + 0.2 (GT) + 0.1 (DB) for outside with solar load.

Originally, NIOSH defined excessively hot environmental conditions as any combination of air temperature, humidity, radiation, and air velocity that produced an average WBGT of 79°F (26°C) for unprotected workers.[37] However, in the revised criteria for occupational exposure to hot environments, NIOSH provides diagrams showing work-rest cycles and metabolic heat versus WBGT exposures which should not be exceeded.[35]

Similarly, ACGIH recommends TLVs for environmental heat exposure permissible for different work-rest regimens and work loads.[36] The NIOSH REL and ACGIH TLV criteria assume that the workers are heat acclimatized, are fully clothed in summer-weight clothing, are physically fit, have good nutrition, and have adequate salt and water intake. Additionally, they should not have a pre-existing medical condition that may impair the body's thermoregulatory mechanisms. The use of alcohol and certain therapeutic and social drugs may interfere with the body's ability to tolerate heat.

Selection of a protective NIOSH WBGT exposure limit is contingent upon identifying the appropriate work-rest schedule and the metabolic heat produced by the work. The work-rest schedule is characterized by estimating the amount of time the employees work to the nearest 25%. The most accurate assessment of metabolic heat production is to actually measure it via calorimetry. However, this is impractical in industrial work settings. An estimate of the metabolic heat load can be obtained by separating a work activity into individual tasks and using a time-weighted energy rate for each component. The estimate of metabolic heat load would be the sum of the time-weighted rates. Because of the error associated with estimating metabolic heat, NIOSH recommends using the upper value of the energy expenditure range to allow for a margin of safety.

VI. RESULTS AND DISCUSSION

A. Employee Interviews

The sixteen workers who were interviewed ranged in age from 26 to 58 years; all were male. Nine workers were employed by contractors, three were employed by temporary employment services, and four were employed by Westinghouse. Contract workers included those in the following trades: ironworker, carpenter, electrician, millwright, steam fitter, sheet metal worker, boilermaker, and insulator. Westinghouse and temporary employees had the following job titles: maintenance mechanic, auxiliary operators, front end loader operator, and laborer.

Workers appeared to be knowledgeable about health and safety hazards on the job. Most were familiar with Material Safety Data Sheets (MSDSs) and were aware of the presence of on-site caustics and acids, although training was reportedly not offered to some contract workers until after they had been on the job for several months. Both contract and Westinghouse employees indicated that routine safety meetings were held.

All workers reported that respiratory protection was made available; Westinghouse employees and most, but not all, contractor employees were fit-tested. The majority of workers, however, did not wear a respirator. Many reported keeping paper dust masks in their hard hats in the event of an emergency. Some workers were unaware that respirators were required in specific areas of the facility. NIOSH investigators noted that some workers had beards. Hearing protection was reportedly provided but was not worn by most of the interviewed workers.

Workers were asked whether they had irritant symptoms affecting the eyes, nose, throat, and skin and whether they had a cough. The most frequently reported symptom (four of 14 workers, 29%) was a dry or sore throat. Many workers reported that co-workers who were no longer employed at the site had experienced skin irritation. During the interview, workers reported several other safety and health concerns. The items most frequently mentioned were: (1) excessive water on the floor, (2) lack of first aid supplies and equipment, and (3) inadequate provisions for work in a hot environment.

Employees reported the presence of excessive water on the ground floor of the DCRRF and felt the situation presented a general safety hazard when walking through the plant or when the water was present in areas where welding occurred. Workers reported standing in puddles of water to hook up welding equipment.

Concerns about hydraulic oil and acids in the water were also mentioned. Many workers noted damage and shrinking of their work boots.

Several deficiencies in the areas of first aid and medical emergencies were reported. This included the lack of first aid supplies and a stretcher, and eye wash stations covered in ash. The need for a key to operate the elevator and the locking of doors onto the roof were mentioned as concerns in the event of an emergency evacuation.

During the summer months, workers reported that the work environment at higher elevations in the plant was extremely hot, with temperatures allegedly reaching up to 140°F. Workers reported that fluids (water and electrolyte replacement drinks) were provided to all workers, but that breaks were not routinely taken.

Employees of several contractors and Westinghouse had baseline and periodic blood tests to assess lead exposure. Contract employees reported that they had received written results of their blood tests, Westinghouse employees reported that they had not received these results. Most workers could not recall their blood lead levels, but had been told that the levels were normal. One worker described blood lead levels below 9 µg/dL for the men working in his crew.

No obvious pattern of reported illnesses and injuries were apparent in the OSHA Form 200s. Eye injuries (ash or metal in the eye) were common (22 log entries) accounting for 34 percent of all reported injuries (n=64). Of the 22 reported eye injuries, only three injuries (14%) resulted in any lost work time.

B. Air Sampling Results

Air sampling results for metals are presented in Tables I and II.
Thirty-four PBZ and general area samples were collected during day-shift operations over the period of two days. The sample results for lead indicate that no PBZ exposures exceeded the OSHA PEL of 50 µg/m^3 for an 8-hour TWA. Only five of the PBZ samples for lead were above the minimum detectable concentration (MDC) of 0.002 µg/m^3, based on an average sample volume of 965 liters. The MDC was calculated by dividing the analytical limit of detection (LOD) by the average air sample volume for the sample set. The highest PBZ exposure measured was sample #18, for a mechanic working near the residue incline.

Two samples for Cd dust (#15 and #34) were reported at the analytical LOD of 0.1 µg. Airborne concentrations of Cd dust for these samples were (0.10 µg/m^3 and 0.11 µg/m^3, respectively) were below the OSHA PEL of 5 µg/m^3, the ACGIH TLV of 10 µg/m^3, and the NIOSH REL of 10 µg/m^3. NIOSH considers cadmium to be a potential human carcinogen and therefore recommends that exposures be reduced to the lowest feasible concentration or 10 $\mu g/m^3$ a concentration which considers the analytical LOQ reported for the NIOSH method for elements.[3]

In the three samples for which Cr was present (#4, #15, and #41), all were below the OSHA PEL of 100 $\mu g/m^3$ [for Cr (VI)], and the ACGIH TLV of 10 $\mu g/m^3$. NIOSH considers Cr(VI) to be a human carcinogen; and because of this, the NIOSH recommendation is that personal exposures should not exceed 1.0 $\mu g/m^3$ as a 10-hour TWA. In this case, PBZ exposures ranged from 0.38 $\mu g/m^3$ to 0.72 $\mu g/m^3$. The LOD for the sample set was 0.5 µg, equivalent to a MDC of 0.0005 $\mu g/m^3$ based on average sample volumes of 965 liters. While NIOSH method 7300 (elements) is not specific for chromium in the (VI) valence state, the results of this investigation conservatively assume that chrome (VI) may be present as a part of the total chromium present on the PBZ filter samples. This is a reasonable assumption given that chromium (VI)-containing materials include commonly manufactured products, such as paints, graphic arts supplies, wood preservatives and corrosion inhibitors; any of which could be present in a municipal wastestream. Additionally, in the high heat and oxidative state of incineration, lower oxides of chromium could become oxidized to the chromium (VI) valence state. These results then, assume worst-case exposure situations considering the NIOSH criterion for Cr(VI).

PBZ concentrations for nickel were all reported as not detected. The LOD for the sample set was 1 µg/sample or a MDC of 1 $\mu g/m^3$ (0.001 mg/m^3) based on an average sample volume of 993 L.

PBZ and area samples for respirable dust ranged from 0.11 mg/m^3 to 0.87 mg/m^3 with a mean concentration of 0.22 mg/m^3. The four highest PBZ exposures were taken on two Loader Operators working on the tipping floor, (0.45 mg/m^3 and 0.54 mg/m^3), an Auxiliary Operator (0.54 mg/m^3), and a Mechanic C working throughout the plant, (0.87 mg/m^3). While the samples were all below the OSHA PEL of 5 mg/m^3 for respirable dust as indicated in Tables III and IV, this criteria may not be appropriate because exposure to these dusts also involves a potential exposure to toxic metals.

The respirable dust samples were also analyzed for respirable quartz and cristobalite. All of the samples were reported as not detected for quartz and cristobalite to a MDC of 0.00001 mg/m^3 based on an average sample volume of 837 L.

C. <u>Carpet and Chair Dust Samples</u>

The results from carpet and chair sampling using micro-vacuuming techniques showed that microgram amounts of Pb, Cd, Cr, and Ni were present on all the samples collected in the main office area at the DCRRF. Pb was the metal found in greatest abundance; samples ranged from 45 µg/sample to 260 µg/sample. In order of decreasing amounts of analyte found per sample, Cr, Ni, and Cd ranged from 12 to 1.2 µg/sample. Background carpet samples were taken in the NIOSH project officer's hotel room and were reported as not detected for the metals of concern. These data point to a connection between the metals found in samples of incinerator ash and metals found in samples of carpet dust from the administrative office. However, this does not imply that exposure to these metals is occurring in the administrative office. While it is likely that the ash is being transported from the plant to the administrative office via foot traffic, one PBZ sample (# 40), taken on a janitor while he vacuumed the carpeting in the administrative area, was reported not detected for the presence of any of the metals listed in Tables I and II. The sample on the janitor was taken to evaluate the likelihood of airborne exposure to metals in the administrative area. Vacuuming was believed to represent a worst case situation since airborne concentrations of fine dusts are likely to increase following vacuuming using a normal (low efficiency) commercial vacuum cleaner, which was the case when the office was being vacuumed.

D. Hand and Surface Wipes

During the initial NIOSH visit, wipe samples were taken from the hands of workers eating lunch and from square foot areas on the tops of lunch tables in the contractor's break/lunch trailer. Lead, Cr, Cd, and Ni were present on wipe samples from the workers' hands and from the top of the lunch tables. These metals were present on the wipes from hands of workers who said they washed their hands as well as those who said they did not wash their hands prior to taking the lunch break (Figure III.) Lead was the metal found in greatest abundance; it ranged in concentration from 42 to 480 µg/sample in those workers who said they failed to wash their hands. For the workers who said they did wash their hands, Pb ranged from 41 µg/sample to 68 µg/sample. On table-top surfaces, Pb ranged from 65 µg/sample to 80 µg/sample. This information indicates an increased risk of ingestion of toxic metals for workers having skin contact with incinerator ash. Ingestion of metals is a route of exposure that contributes to the overall dose that a worker may receive. These findings suggest that workers may not be adequately washing their hands prior to breaking for lunch. The results also indicate that surface contamination is present on lunch tables.

E. Safety Hazards

Tripping hazards were noted in the facility. Long metal bars, scraps of welding rod and a number of weldable metal eyelets were found on the floor on several upper decks at the facility where foot traffic is common. Beside posing a slip, trip, or fall hazard, these materials (particularly the welding rod scrap and the metal eyelets) are small enough that they could fall through the floor decking and possibly strike workers on the floors below.

A partially full gas cylinder was found unsecured in the turbine room. Pressurized gas cylinders pose serious safety hazards when unsecured. If the cylinder is knocked over and the regulator stem becomes damaged, or is broken off, the resultant pressure release can cause the cylinder to become a missile capable of tremendous damage.

A dump-truck driver (employed by a scrap metal hauling contractor) was observed in the residue building standing atop the sides of his truck as it was being loaded by a crane using an electromagnetic pick-up. Aside from the obvious danger of being hit by a load of scrap and then falling from the truck, he lacked an appropriate work uniform for this location. The driver wore shorts, running shoes, and a tee shirt. He did not wear a hard hat in a posted area, nor did he use hearing or eye protection.

F. Heat Stress

The heat stress data collected on June 24, 1992, for locations on the fourth, fifth, and sixth floors day shift are presented in Table V. The area $WBGT_{in}$ measurements ranged from 84.2°F to 102.1°F, with the dry bulb air temperature as high as 124.8°F and the radiant (globe) temperature reaching 137.6°F. These two highest temperatures were measured at locations near the sixth floor steam drum, a result that is not surprising as the steam drum serves as a radiant heat source and heated air from the entire plant will naturally rise to those higher locations within the building's enclosure. This is reflected by the dry bulb and globe temperature measurements shown in Table V.

VII. CONCLUSIONS

The results of this investigation indicate that inhalation exposures to Pb, Cd, Cr(VI), and Ni from incinerator ash and residues were below the applicable OSHA PELs and the NIOSH REL criteria. Exposures to respirable dust were also below the OSHA PEL, but this PEL is not an appropriate evaluation criterion for dusts containing toxic substances such as lead and cadmium. NIOSH does not have a REL for respirable dust. Respirable silica (quartz and cristobolite) was not detected. Ingestion of metals-containing dust was determined to be a possible hazard posing increased risk factors for those employees having skin contact with incinerator ash and who fail to thoroughly wash their hands before eating or smoking. Employee complaints of upper respiratory and skin irritation were consistent with an irritant, or perhaps the effect of the alkaline nature of the incinerator ash (a material confirmed to have a pH of 10) which would be caustic to skin and mucous membranes if exposure to these areas were to occur.

Certain locations on the fifth and sixth floors were found to have the potential for heat stress exposures in excess of ACGIH TLVs. It was the opinion of the NIOSH investigators that heat stress conditions could be worse during later periods of the summer when ambient temperatures and humidity could conceivably be higher, posing increased risk for heat stress exposures.

VIII. RECOMMENDATIONS

The following recommendations are made based on observations made during the HHE. These recommendations are made in the interest of improving health and safety conditions for all employees at the DCRRF.

1. Certain areas of the facility were found to exceed the NIOSH and ACGIH criteria for heat stress. Further evaluation should be made to investigate these and any other areas of the facility which may have the potential for workers to be overexposed to heat stress during routine or emergency maintenance and operations procedures. If it is determined that areas of the facility exceed the heat stress criteria, a comprehensive heat stress management program should be developed at the DCRRF. As a part of this program, a written heat stress policy and procedure should be developed. Guidance for this can be obtained in the NIOSH criteria document Criteria for a recommended standard: Occupational Exposure to Hot Environments. Appendix A is offered as a part of this report and lists the various components of such a program.

2. All Westinghouse contractors should be informed of the DCRRF policy regarding personal protective equipment (PPE). Requirements for PPE such as appropriate dress, including footwear and the necessity for the use of hearing or eye protection in posted areas, should be provided to all contractors conducting business on Westinghouse premises.

3. Housekeeping can be improved within the boiler building and the turbine room. The decks in the boiler building should be kept clear of materials which pose tripping hazards. It is important to stress the necessity of keeping small items off the walking surface, from which they can easily fall through the decking material and pose a hazard to workers on the decks below. Ash accumulating on surfaces where skin contact is likely (such as handrails) should be periodically removed with a vacuum cleaner equipped with a high efficiency particulate air (HEPA) filter.

Pressurized gas bottles in the turbine room should be secured to the wall or mounted in wheeled carts to prevent tip-over.[38]

4. All employees should be notified, in writing, of the results of their blood lead tests. The OSHA regulations, concerning occupational exposure to lead, state that employees will be provided with monitoring results regardless of the blood lead level, within five working days after the company receives the results of the blood test.[18]

5. The "Lead Hazard" signs posted at the entrance to the sump area should be maintained so that the signs are clean enough to be easily readable. This area was not posted at the time of the initial NIOSH visit in December 1991. The signs which were installed prior to the NIOSH follow-up visit in June 1992, were quite dirty and difficult to read.

6. A characterization should be made of fugitive ash emissions coming from the residue building. During the second NIOSH visit, airborne fly ash was noticeable as it escaped from the residue building and appeared to be blown toward the neighborhoods in nearby Chester, Pennsylvania. The situation appeared to be compounded by the wind coming off of the Delaware River. The layout and construction of the residue building, with large doors opened at either end of the building, favors wind funneling through the building as the scrap trucks are loaded. Since the dust from the residue building is known to contain toxic metals, fenceline monitoring may be an appropriate measure to characterize and monitor fugitive emissions of metals-containing dusts, specifically lead-containing dust, which is a contemporary and important public health concern.

IX. REFERENCES

1. U.S. Environmental Protection Agency [1989]. The Solid Waste Dilemma: An Agenda for Action. Final Report of the Municipal Solid Waste Task Force, Office of Solid Waste. February. Appendix C.

2. Brunn, D.M., [1992]. Evaluation and Control of Occupational Lead Exposures at Resource Recovery Cogeneration Facilities. Paper presented at the 1992 American Industrial Hygiene Conference & Exposition, Boston, MA.

3. NIOSH [1989]. Manual of Analytical Methods. Method 7300, Elements (ICP). 3d. ed. Vol. 1. Cincinnati, Ohio. National Institute for Occupational Safety and Health.

4. NIOSH [1989]. Manual of Analytical Methods. Method 0600. Nuisance Dust, respirable. 3d. ed. Vol. 2. Cincinnati, Ohio. National Institute for Occupational Safety and Health.

5. NIOSH [1989]. Manual of Analytical Methods. Method 7500. Silica, Crystalline, respirable. 3d. ed. Vol. 2. Cincinnati, Ohio. National Institute for Occupational Safety and Health.

6. NIOSH [1992]. Recommendations for Occupational Safety and Health: Compendium of Policy Documents and Statements. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 92-100.

7. ACGIH [1992]. American Conference of Governmental Industrial Hygienists. Threshold limit values and biological exposure indices for 1992-93. Cincinnati, Ohio.

8. OSHA [1992]. Occupational Safety and Health Administration. Occupational safety and health standards. 29 CFR 1910.1000. Occupational Safety and Health Administration, revised.

9. Hernberg S, et al [1988]. Lead and its compounds. In: Occupational medicine. 2nd ed. Chicago, IL: Year Book Medical Publishers.

10. Landrigan PJ, et al [1985]. Body lead burden: Summary of epidemiological data on its relation to environmental sources and toxic effects. In: Dietary and environmental lead: Human health effects. Amsterdam: Elsevier Science Publishers.

11. Proctor NH, Hughes JP, Fischman ML [1988]. Lead. In: Chemical hazards of the workplace. 2nd ed. Philadelphia, PA: J.B. Lippincott Company, Philadelphia, pp 294-298.

12. World Health Organization [1980]. Recommended health-based limits in occupational exposure to heavy metals. Geneva: Technical Report Series 647.

13. Mahaffey K, Annest J, Roberts J, Murphy R [1982]. National estimates of blood lead levels. United States, 1976-1980. New Engl J Med 307:373-9.

14. Annest J, Dirkle J, Makuc C, Nesse J, Bayse D, Kovar M [1983]. Chronological trends in blood lead levels between 1976 and 1980. New Engl J Med 308:1373-77.

15. CDC [1991]. Strategic plan for the elimination of childhood lead poisoning. U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control.

16. Brody, D.J., Pirkle, J. Kramer, R. et.al. [1994]. Blood Lead Levels in the U.S. Population. Phase 1 of the Third National Health and Nutrition Examination Survey (NHANES III, 1988 to 1991). JAMA 272:277-283.

17. NIOSH [1978]. Occupational exposure to inorganic lead. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 78-158.

18. Code of Federal Regulations [1989]. OSHA lead standard. 29 CFR, Part 1910.1025. Washington, DC: U.S. Government Printing Office, Federal Register.

19. ATSDR [1990]. Toxicological profile for lead. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, Agency for Toxic Substances and Disease Registry. DHHS (ATSDR) Publication No. TP-88/17.

20. DHHS [1990]. Healthy people 2000: National health promotion and disease objectives. Washington, DC: U.S. Department of Health and Human Services, Public Health Service, DHHS Publication No. (PHS) 91-50212.

21. Grandjean, P and Bach, E [1986]. Indirect exposures: The significance of bystanders at work and at home. Am. Ind. Hyg. Assoc. J. 47(12):819-824.

22. NIOSH [1984]. National Institute for Occupational Safety and Health. Current Intelligence Bulletin 42--Cadmium (Cd). DHHS (NIOSH) publication no. 84-116.

23. NIOSH [1977]. National Institute for Occupational Safety and Health. Occupational Diseases--a Guide to their Recognition. Revised Edition. DHEW (NIOSH) publication no. 77-181.

24. Proctor NH, Hughes JP, and Fischman ML [1988]. Chemical Hazards of the Workplace, 2nd Edition. Lippincott: Philadelphia.

25. Blair A, Mason TJ [1980]. Cancer mortality in the United States counties with metal electroplating industries. Arch Environ Health 35(2):92-94.

26. Franchini I, Magnani F, Mutti A. [1983]. Mortality experience among chrome plating workers. Initial findings. Scand J Work Environ Health 9:247-252.

27. Royle H. [1975]. Toxicity of chromic acid in the chromium plating industry. Environ. Res. 10:39-53.

28. Silverstein M, Mirer F, Kotelchuck D, Silverstein B, Bennett M. [1981]. Mortality among workers in a die-casting and electroplating plant. Scand J Work Environ Health. 7 (supplement 4):156-165, 1981.

29. Sorahan T, Burges DCL, Waterhouse JAH. A mortality study of nickel/chromium platers. Br J Ind Med 44:250-258.

30. NIOSH [1990]. National Institute for Occupational Safety and Health. NIOSH Pocket Guide to Chemical Hazards. Cincinnati, Ohio. DHHS (NIOSH) publication no. 90-117.

31. NIOSH [1975]. National Institute for Occupational Safety and Health. Criteria for a recommended standard--occupational exposure to crystalline silica. DHEW (NIOSH) publication no. 75-120.

32. Yaglou C, Minard D [1957]. Control of heat casualties at military training centers. Arch Indust Health 16:302-316.

33. Belding H, Hatch T [1955]. Index for evaluating heat stress in terms of resulting physiological strain. Heat Pip Air Condit 27:129.

34. Houghton F, Yaglou C [1923]. Determining lines of equal comfort. J Am. Soc. Heat. and Vent. Engrs. 29:165-176.

35. NIOSH [1986]. Criteria for a recommended standard: occupational exposure to hot environments, revised criteria. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, National Institute for Occupational Safety and Health. DHHS(NIOSH) Publication No. 86-113.

36. ACGIH [1990]. Threshold limit values and biological exposure indices for 1990-1991. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

37. NIOSH [1972]. Criteria for a recommended standard: occupational exposure to hot environments. Cincinnati, OH: U.S. Department of Health, Education and Welfare, Health Services and Mental Health Administration, National Institute for Occupational Safety and Health, DHEW(NIOSH) Publication No. 72-10269.

38. Code of Federal Regulations [1992]. OSHA, Regulations relating to labor. 29 CFR, Part 1910.253. Washington, DC: U.S. Government Printing Office, Federal Register.

X. AUTHORSHIP AND ACKNOWLEDGEMENTS

NIOSH Project Officers/
Investigators: Eric J. Esswein, MSPH
Industrial Hygienist
Industrial Hygiene Section

Allison Tepper, Ph.D.
Supervisory Epidemiologist
Medical Section

Field Assistance by: Gregory M. Kinnes, M.S., CIH
Industrial Hygienist
Industrial Hygiene Section

Anthony Zimmer, CIH
Industrial Hygienist

Teresa Buchta, M.S.
Industrial Hygienist

Report Prepared by: Kate L. Marlow
Office Automation Assistant

Originating Offices: Hazard Evaluations and Technical Assistance Branch
Division of Surveillance, Hazard Evaluations, and Field Studies

XI. DISTRIBUTION AND AVAILABILITY OF REPORT

Copies of this report may be freely reproduced and are not copyrighted. Single copies of this report will be available for a period of 90 days from the date of this report from the NIOSH Publications Office, 4676 Columbia Parkway, Cincinnati, Ohio 45226. To expedite your request, include a self-address mailing label along with your written request. After this time, copies may be purchased from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161. Information regarding the NTIS stock number may be obtained from the NIOSH Publications Office at the Cincinnati address.

Copies of this report have been sent to:

1. Confidential Requestors
2. Manager, Westinghouse Operating Plants
3. Westinghouse Plant Manager, Chester, PA.
4. OSHA, Region III
5. EPA, Region III

For the purpose of informing affected employees, copies of this report shall be posted by the employer in a prominent place accessible to the employees for a period of 30 calendar days.

Appendix A
Elements of a Comprehensive Heat Stress Management Program.

1. **Written program** - A detailed written document is necessary to specifically describe the company procedures and policies in regards to heat management. The input from management, technical experts, physician(s), labor union, and the affected employees should be considered when developing the heat management program. This program can only be effective with the full support of plant management.

2. **Environmental monitoring** - In order to determine which employees should be included in the heat management program, monitoring the environmental conditions is essential. Environmental monitoring also allows one to determine the severity of the heat stress potential during normal operations and during heat alert periods.

3. **Medical examinations and policies** - Preplacement and periodic medical examinations should be provided to all employees included in the heat management program where the work load is heavy or the environmental exposures are extreme. Periodic exams should be conducted at least annually, ideally immediately prior to the hot season (if applicable). The examination should include a comprehensive work and medical history with special emphasis on any suspected previous heat illness or intolerance. Organ systems of particular concern include the skin, liver, kidney, nervous, respiratory, and circulatory systems. Written medical policies should be established which clearly describe specific predisposing conditions that cause the employee to be at higher risk of a heat stress disorder, and the limitations and/or protective measures implemented in such cases.

4. **Work schedule modifications** - The work-rest regime can be altered to reduce the heat stress potential. Shortening the duration of work in the heat exposure area and utilizing more frequent rest periods reduces heat stress by decreasing the metabolic heat production and by providing additional recovery time for excessive body heat to dissipate. Naturally, rest periods should be spent in cool locations (preferably air conditioned spaces) with sufficient air movement for the most effective cooling. Allowing the worker to self-limit their exposure on the basis of signs and symptoms of heat strain is especially protective since the worker is usually capable of determining their individual tolerance to heat. However, there is a danger that under certain conditions, a worker may not exercise proper judgement and experience a heat-induced illness or accident.

5. **Acclimatization -** Acclimatization refers to a series of physiological and psychological adjustments that occur which allow one to have increased heat tolerance after continued and prolonged exposure to hot environmental conditions. Special attention must be given when administering work schedules during the beginning of the heat season, after long weekends or vacations, for new or temporary employees, or for those workers who may otherwise be unacclimatized because of their increased risk of a heat-induced accident or illness. These employees should have reduced work loads (and heat exposure durations) which are gradually increased until acclimatization has been achieved (usually within 4 or 5 days).

6. **Clothing** - Clothing can be used to control heat stress. Workers should wear clothing which permits maximum evaporation of perspiration, and a minimum of perspiration run-off which does not provide heat loss, (although it still depletes the body of salt and water). For extreme conditions, the use of personal protective clothing such as a radiant reflective clothing, and torso cooling vests should be considered.

7. **Buddy system** - No worker should be allowed to work in designated hot areas without another person present. A buddy system allows workers to observe fellow workers during their normal job duties for early signs and symptoms of heat intolerance such as weakness, unsteady gait, irritability, disorientation, skin color changes, or general malaise, and would provide a quicker response to a heat-induced incident.

8. **Drinking water** - An adequate amount of cool (50-60°F) potable water should be supplied within the immediate vicinity of the heat exposure area as well as the resting location(s). Workers who are exposed to hot environments are encouraged to drink a cup (approximately 5-7 ounces) every 15-20 minutes even in the absence of thirst.

9. **Posting** - Dangerous heat stress areas (especially those requiring the use of personal protective clothing or equipment) should be posted in readily visible locations along the perimeter entrances. The information on the warning sign should include the hazardous effects of heat stress, the required protective gear for entry, and the emergency measures for addressing a heat disorder.

10. **Heat alert policies -** A heat alert policy should be implemented which may impose restrictions on exposure durations (or otherwise control heat exposure) when the National Weather Service forecasts that a heat wave is likely to occur. A heat wave is indicated when daily maximum temperature exceeds 95°F or when the daily maximum temperature exceeds 90°F and is at least 9°F more than the maximum reached on the preceding days.

11. **Emergency contingency procedures** - Well planned contingency procedures should be established in writing and followed during times of a heat stress emergency. These procedures should address initial rescue efforts, first aid procedures, victim transport, medical facility/service arrangements, and emergency contacts. Specific individuals (and alternatives) should be assigned a function within the scope of the contingency plan. Everyone involved must memorize their role and responsibilities since response time is critical during a heat stress emergency.

12. **Employee education and training** - All employees included in the heat management program or emergency contingency procedures should receive periodic training regarding the hazards of heat stress, signs and symptoms of heat-induce illnesses, first aid procedures, precautionary measures, and other details of the heat management program.

13. **Assessment of program performance and surveillance of heat-induced incidents** - In order to identify deficiencies with the heat management program a periodic review is warranted. Input from the workers affected by the program is necessary for the evaluation of the program to be effective. Identification and analysis of the circumstances pertinent to any heat-induce accident or illness is also crucial for correcting program deficiencies.

Tables I and II
Metals Sampling
June 23-24, 1992
HETA 91-0366

Table I Delaware County Resource Recovery Facility
Air Sampling (Metals)

Sample Number	Job Title or Location	Lead (ug)	Cadmium (ug)	Chromium (ug)	Time (min.)	Volume (L)	Lead (ug/m^3)	Cadmium (ug/m^3)	Chromium (ug/m^3)
4	Aux. Operator 4th, 5th, 6th fl.	3	ND	0.5	666	1340	2.2	ND	0.37
5	Aux. Operator, whole plant	ND	ND	ND	542	1322	ND	ND	ND
6	Aux. Operator, 1st 2nd, 3rd fl.	3	ND	ND	669	1450	2.1	ND	ND
7	Shift Supervisor, all over	ND	ND	ND	683	1181	ND	ND	ND
8	Shift Supervisor, tipping fl.	ND	ND	ND	409	697	ND	ND	ND
9	Loader Operator, tipping fl.	ND	ND	ND	648	1458	ND	ND	ND
10	Loader Operator, tipping fl.	ND	ND	ND	320	576	ND	ND	ND
11	Loader Operator res. bldg.	ND	ND	ND	645	1290	ND	ND	ND
12	I & C Tech., control room	ND	ND	ND	480	1014	ND	ND	ND
13	Loader Operator, tipping fl.	ND	ND	ND	620	1236	ND	ND	ND
14	Mechanic B, ash control	ND	ND	ND	489	1075	ND	ND	ND
15	Mechanic C, all over	3	0.1	0.7	415	972	3.1	0.10	0.72
16	I & C Tech., trailers	ND	ND	ND	478	1052	ND	ND	ND
17	Mechanic A, 5th fl.	ND	ND	ND	485	1071	ND	ND	ND
18	Mechanic B, residue incline	3	ND	ND	221	658	4.6	ND	ND
21	Loader Operator, ash room	ND	ND	ND	182	400	ND	ND	ND
	Limits of Detection (LODs) in ug	2	0.1	0.5		MDC (ug/m3)	0.002	0.0001	0.0005

Table II Delaware County Resource Recovery Facility

Sample Number	Job Title or Location	Lead (ug)	Cadmium (ug)	Chromium (ug)	Time (min)	Volume (L)	Lead (ug/m^3)	Cadmium (ug/m^3)	Chromium (ug/m^3)
27	Aux. Operator , whole plant	ND	ND	ND	669	1314	ND	ND	ND
28	Shift Supervisor, all over	ND	ND	ND	682	1387	ND	ND	ND
29	Mechanic B, residue incline	ND	ND	ND	479	1008	ND	ND	ND
30	Aux. Operator , 4th, 5th, 6th fl.	ND	ND	ND	644	1268	ND	ND	ND
31	Loader Operator, tipping fl.	ND	ND	ND	630	1260	ND	ND	ND
32	Shift Supervisor, tipping fl.	ND	ND	ND	280	560	ND	ND	ND
33	I & C Tech., control room	ND	ND	ND	441	882	ND	ND	ND
34	Mechanic A, 5th fl.	3	0.1	ND	486	946	3.2	0.11	ND
35	Loader Operator, ash room	ND	ND	ND	164	344	ND	ND	ND
36	Mechanic B, 1st fl. 6th burner	ND	ND	ND	466	932	ND	ND	ND
37	Mechanic C, residue bldg.	ND	ND	ND	464	905	ND	ND	ND
38	Loader Operator, tipping fl.	ND	ND	ND	252	529	ND	ND	ND
39	Loader Operator, tipping fl.	ND	ND	ND	589	1178	ND	ND	ND
40	Janitor, vacuuming carpet	ND	ND	ND	480	1012	ND	ND	ND
41	On catwalk in ash room (area)	5	ND	0.7	441	880	5.7	ND	0.8
42	Ash Room/Shaker (area)	5	ND	ND	429	810	6.2	ND	ND
46	Loader Operator, ash room	ND	ND	ND	230	460	ND	ND	ND
52	On Loader (not personal)	ND	ND	ND	185	370	ND	ND	ND
	Limits of Detection (LODs) in ug	2	0.1	0.5		MDC (ug/m3)	0.002	0.0001	0.0005

	Lead	Cadmium	Chromium
NIOSH REL	100ug/m3	#	*
OSHA PEL	50 ug/m3	5 ug/m3	1 mg/m3
ACGIH TLV	150 ug/m3	10 ug/m3	50 ug/m3

REL = Recommended Exposure Limit
PEL = Permissible Exposure Limit
# = Lowest Feasible Concentration, (10 ug/m3 LOQ)
ND = Not Detected
MDC = Minimum Detectable Concentration
* varies with oxidation state, as Cr(VI) 1 ug/m3 as a 10 hr TWA

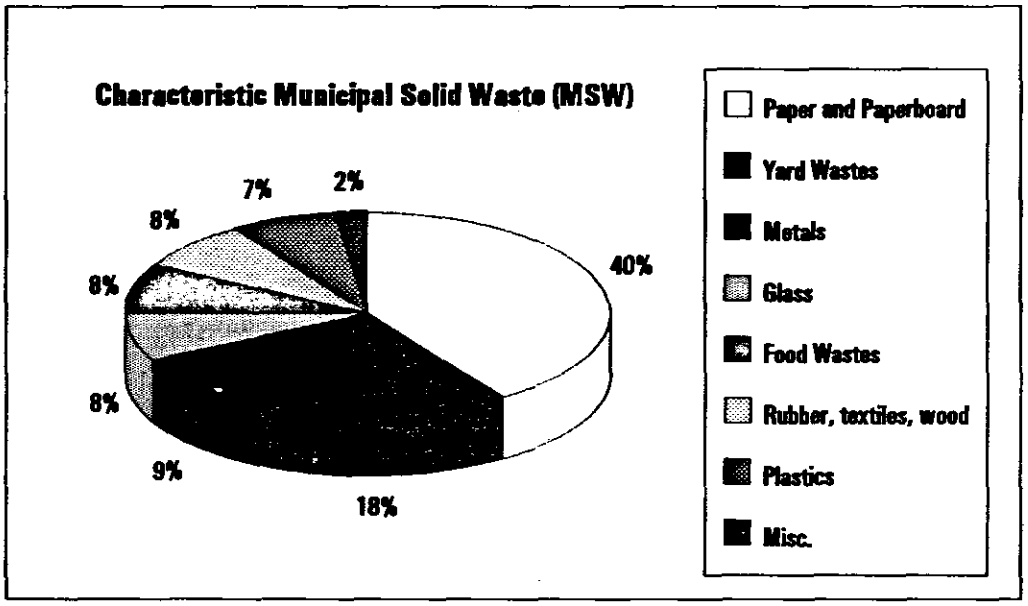
Tables III-V
Respirable Dust Sampling
and Heat Stress Monitoring HETA 91-0366
June 23-24, 1992

Table III		Respirable Dust	6/23/92	
Number	Job Title or Location	Total weight (mg)	Sample volume (L)	Mg/m3
9424	Auxiliary Operator	0.25	1136	0.22
9442	Auxiliary Operator	0.14	1225	0.11
9440	Shift Supervisor	0.03	968	0.03
9441	Auxiliary Operator	0.23	1368	0.17
9439	Shift Supervisor Tip FL	0.07	697	0.10
9438	Loader on Tipping Floor	0.07	1095	0.06
9437	Loader on Tipping Floor	0.26	576	0.45
9436	Loader in Residue Bldg	0.09	1076	0.08
9435	I & C Tech	0.03	819	0.04
9434	Loader on Tipping Floor	0.27	1058	0.26
9432	Mechanic B, Res. Incline	0.33	1058	0.31
9431	Mechanic B, Ash Control	0.07	898	0.08
9428	Mechanic A	0.02	826	0.02
9430	Mechanic C, All-over	0.62	715	0.87
9429	I & C Tech	0.04	860	0.05
9445	Loader on Ash Floor	0.04	337	0.12
	LOD (mg)	0.02		

Table IV			6/24/92	
	Job Title or Location	Total weight (mg)	Sample volume (L)	Mg/m3
9446	Auxiliary Operator	0.42	715	0.59
9449	Shift Supervisor	0.04	1203	0.03
9450	Mechanic B	0.18	631	0.29
9451	Auxiliary Operator	0.22	1131	0.19
9452	Loader Operator	0.30	1112	0.27
9448	Shift Supervisor	0.04	405	0.10
9453	I & C Tech.	0.02	427	0.05
9458	Mechanic A	0.09	740	0.12
9459	Loader Operator Ash Room	0.16	682	0.23
9460	Mechanic B	0.18	797	0.23
9461	Mechanic C	0.05	789	0.06
9462	Loader on Tipping Floor	0.23	428	0.54
9463	Loader on Tipping Floor	0.18	1069	0.17
9465	Catwalk above incline ramps	0.48	685	0.70
9470	Loader on ResidueFloor	0.16	488	0.33
	LOD (mg)	0.02		
			OSHA PEL	5 mg/m3

Table V				
	Heat Stress Monitoring			
Time	Wet Bulb	Dry Bulb	Globe Temp	WBGT in
	4th Floor Secondary Combustion Chamber			
9:55 AM	76.8	96.6	101.6	84.2
10:55 AM	77.6	98.2	102.9	85.2
11:55 AM	78.1	78.1	104.3	80.2
12:55 PM	78.4	100.6	106.3	86.7
	5th Floor Soot Burner			
	80.7	104.1	115.6	91.1
1100 AM	80.8	105.2	118.6	91.6
12:00 AM	81.4	106.6	118.4	92.5
	8th Floor Steam Drum			
10:03 AM	83.8	122.3	135.7	99.4
11:03 AM	87.9	125.1	136.1	102.4
11:50 AM	86.9	124.8	137.6	102.1

Figures I and II
Municipal Solid Waste (MSW) and Lead Contributors to MSW
HETA 91-0366



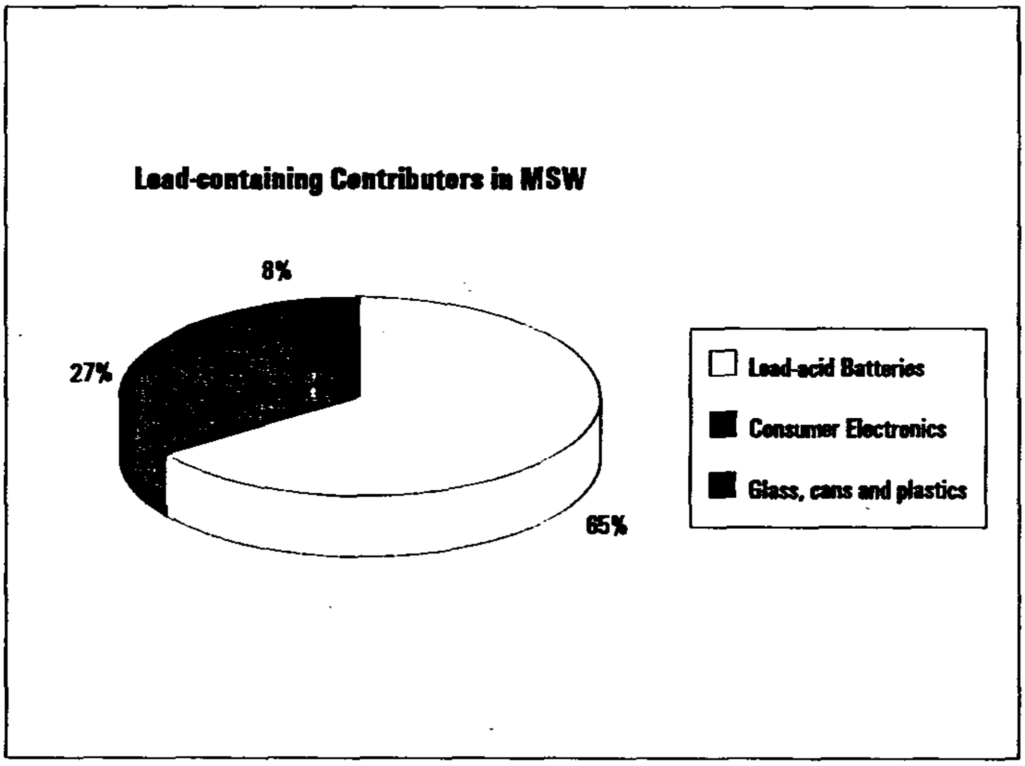


Figure III
Wipe Samples
June 23-24, 1992
HETA 91-0366