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I. SUMMARY

In July 1990, the National Institute for Occupational Safety and Health (NIOSH) received a joint request for a Health Hazard Evaluation (HHE) from the New York City Department of Sanitation and the American Federation of State, County, and Municipal Employees, Local 1795 of District 37 (AFSCME DC-37), to investigate employee exposures to polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) in fly ash generated at three municipal refuse incinerators. NIOSH investigators conducted an initial site visit on December 5, 1990, and a proposed environmental sampling protocol was jointly developed with the New York State Department of Health (NYDOH). Difficulties with analytical methods development resulted in a delay of a return site visit until September 15-18, 1992, when NIOSH investigators conducted environmental sampling to determine if a potential health hazard existed from employee exposures to PCDDs/PCDFs, metals, and respirable dust and silica.

Six area air samples and five bulk fly ash samples were collected and analyzed for the 2,3,7,8-tetra isomers and the total tetra- through octa-chlorinated PCDD and PCDF congeners. The PCDD/PCDF concentrations are reported as 2,3,7,8-TCDD equivalents (TEQ) and were calculated using both the 1987 Environmental Protection Agency (EPA) and the 1989 International Toxicity Equivalency Factors (I-TEFs). The TEQ concentrations calculated with the 1989 I-TEFs were all higher than the concentrations calculated with the 1987 EPA-TEFs. The calculated TEQ concentrations for the bulk samples ranged from 1.5 to 290 parts per trillion (ppt) using the 1987 EPA-TEFs and from 3.0 to 880 ppt using the 1989 I-TEFs. The bulk sample results indicated that greater amounts of PCDDs/PCDFs were present on the fly ash particulates collected from the electrostatic precipitator (ESP). The airborne TEQ concentrations ranged from 2.7 to 430 picograms per cubic meter (pg/m^3) using the 1987 EPA-TEFs and 4.6 to 800 pg/m^3 using the 1989 I-TEFs. The airborne TEQ concentrations for four of the six area samples were above the National Research Council (NRC) guideline of 10.0 pg/m^3 for PCDDs/PCDFs. All four of these samples were collected during cleaning operations at the Betts Avenue incinerator. Neither the Occupational Safety and Health Administration (OSHA) nor the American Conference of Governmental Industrial Hygienists (ACGIH) have evaluation criteria for PCDDs/PCDFs. However, NIOSH considers 2,3,7,8-TCDD to be a potential human carcinogen.

A total of eight personal breathing zone (PBZ) and nine area samples were collected for metals during the cleaning operations. The highest airborne concentrations of metals were measured during the cleanout of the ESP. The PBZ metal concentrations, calculated as 8-hour time-weighted averages (TWAs), approached or exceeded the criteria established by either NIOSH, OSHA, or ACGIH for arsenic (As), cadmium (Cd), lead (Pb), and nickel (Ni). The TWA concentrations for As, Cd, Pb, and Ni were 0.019, 0.099, 1.3, and 0.013 milligrams per cubic meter (mg/m^3), respectively. The analysis of area samples collected in proximity to work locations identified airborne metal concentrations that exceeded relevant evaluation criteria for aluminum, As, Cd, chromium, cobalt, Pb, manganese, and Ni. The environmental sampling also indicated that the airborne concentrations for several metals and PCDDs/PCDFs periodically exceeded the protection factors of the respirators worn by employees performing the cleanout operations.

A total of ten samples were collected for respirable dust/silica. These included two PBZ samples, three area air samples collected during the ESP cleanout, and five area air samples collected during other cleanout procedures. The average percent crystalline silica (as quartz) was 2.4%; cristobalite was not detected. The 8-hour TWA airborne concentrations of respirable quartz ranged from non-detected to 0.073 mg/m^3, with the highest concentration occurring during the ESP cleanout. One sample exceeded the NIOSH recommended exposure limit for respirable quartz of 0.05 mg/m^3. The respirable dust concentrations ranged from 0.063 to 2.4 mg/m^3, calculated as 8-hour TWAs.

Based on the results of this evaluation, NIOSH investigators determined that a health hazard exists when workers are involved in cleanout operations at the incinerators. The environmental sampling data collected during this investigation indicate that the airborne PCDD/PCDF concentrations for four of the six area samples exceeded the National Research Council guideline of 10.0 pg/m^3, one sample by a factor of 80. The PBZ and area metal samples indicated that the 8-hour TWA airborne concentrations of aluminum, arsenic, cadmium, lead, manganese, nickel, and respirable silica (as quartz) exceeded the relevant evaluation criteria during the ESP cleanout operations. The airborne concentration of lead during the lower chamber cleanout operations also exceeded the OSHA PEL. The airborne concentrations for aluminum, arsenic, cadmium, lead, and nickel during some periods of the ESP cleanout and for PCDDs/PCDFs during the cleaning of the lower chamber were high enough to exceed the protection capabilities provided by the powered air purifying respirators worn by the workers during these operations. Recommendations provided in Section VIII include installation of engineering controls, more effective respiratory protection, confined space entry, and medical surveillance programs, and the prohibition of tobacco smoking in exposure locations.

KEYWORDS: **SIC 4953** (Refuse Systems), fly ash, municipal incinerators, maintenance cleaning, metals, silica, aluminum, lead, cadmium, chromium, nickel, arsenic, cobalt, manganese, respirable dust, polychlorinated dibenzo-*p*-dioxins, polychlorinated dibenzofurans.

II. INTRODUCTION

In July 1990, the National Institute for Occupational Safety and Health (NIOSH) received a joint request for a Health Hazard Evaluation (HHE) from the New York City Department of Sanitation and the American Federation of State, County, and Municipal Employees, Local 1795 of District 37 (AFSCME DC-37), to investigate employee exposures to polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) in fly ash generated at three municipal refuse incinerators. The request was prompted by a reported finding of elevated levels of PCDDs/PCDFs in a pooled blood sample from 56 municipal incinerator workers when compared to a control group of volunteers with no known exposure to incinerator ash.[1] At the time of the report, the New York State Department of Health (NYDOH) expressed an interest in collaborating with NIOSH during this HHE.

In response to this HHE request, an initial site visit was conducted on December 5, 1990. NIOSH investigators met with representatives from the NYDOH, AFSCME DC-37, New York City Department of Sanitation, and New York City Mayor's Office of Operations. Following the opening conference, a walk-through survey of the three city incinerators was conducted. As a result of this initial visit, a proposed environmental sampling protocol was jointly drafted by NIOSH and NYDOH. This protocol included the collection of personal samples for PCDDs/PCDFs using an analytical method that was under development; therefore, a scheduled return visit to perform the environmental sampling was delayed until this method could be validated. However, the development of this method was never completed, so a revised protocol which included area sampling for PCDDs/PCDFs was drafted. It was decided that NIOSH investigators would return to perform the environmental sampling with analytical support from NYDOH. On September 15-18, 1992, NIOSH investigators made a return visit to conduct environmental sampling to determine if a potential health hazard existed from employee exposures to PCDDs/PCDFs, metals, and respirable dust and silica.

Although three New York City incinerators (Southwest Brooklyn, Betts Avenue, and Greenpoint) were specified in the initial request, only the Betts Avenue and Greenpoint incinerators were operational at the time of the return visit. The Southwest Brooklyn incinerator had been closed down. Since the greatest potential for employee exposure to fly ash occurs during the routine cleanout operations, attempts were made to schedule the environmental sampling at the Betts Avenue and Greenpoint incinerators during a period when both facilities were conducting these operations. However, the return visit had to be scheduled when only the Betts Avenue incinerator conducted the cleanout operations. Therefore, environmental sampling was performed during the cleanout operations at the Betts Avenue incinerator. In addition, limited environmental sampling was performed at the Greenpoint incinerator to evaluate exposure potential during normal operations.

III. BACKGROUND AND PROCESS DESCRIPTION

Each of the three incinerators consisted of four fixed, single-hearth furnace units. The Betts Avenue and Greenpoint incinerators were equipped with travelling grate conveyors, while the Southwest Brooklyn incinerator was equipped with a reciprocating grate conveyor. All three facilities were continuous feed, mass-burn incinerators where only limited screening of the incoming waste was performed to remove large objects that do not burn adequately.

At the Betts Avenue and Greenpoint incinerators (Figure 1), municipal refuse is hauled directly onto the tipping floor by the garbage trucks, dumped into the refuse receiving pit, and then loaded via a three-yard crane into the charging chutes located on the charging floor. The refuse then drops onto an inclined conveyor and is fed into the burning stoker (furnace) on the fire floor. The furnaces typically burn the refuse at temperatures ranging between 1700-1800 degrees Fahrenheit (°F). After burning, non-reducible refuse (bottom ash) drops onto another conveyor in the ash cellar where it is quenched with water, loaded onto a garbage truck or barge, and hauled to a landfill. Approximately 100 tons of refuse is burned during a normal day; a 70-72% reduction by weight of the refuse is typically achieved at these facilities. The combustion waste stream, consisting of gaseous and particulate phases, moves from an upper expansion chamber into a lower cooling chamber, into an electrostatic precipitator (ESP), and then out one of the two smoke stacks. Each smoke stack services two incinerators. The larger sized fly ash particulates fall out of the stream by gravity and accumulate in the expansion and cooling chambers. The smaller particulates which do not settle out of the combustion stream in these chambers are removed from the stream by the ESP. The particulates removed by the ESP fall out of the unit by vibration of the collection plates and are transported on conveyors which carry it down to the ash cellar for mixing with the bottom ash.

Each incinerator must be cleaned every four to six weeks. The cleaning operations are performed after the furnace and supporting equipment are allowed to cool for a minimum of 10-15 hours. Incinerator areas involved in the cleaning operations include the upper and lower chambers, the incinerator walls, and the interior of the electrostatic precipitator.

Once the incinerator unit has cooled, workers enter the burn chamber to remove slag that has accumulated on the walls. Two workers generally remove the slag by manually scraping it from the furnace walls and clearing away ash from the air inlet ports. The accumulated slag and ash is then swept to the end of the furnace chamber where it falls into the ash cellar for removal. After the burn chamber has been cleaned, the refractory bricks lining the walls and the air inlet ports are inspected to determine if the chamber was properly cleaned and if any corrective maintenance is required.

The cleaning of the upper and lower chamber generally requires three workers to remove the fly ash that has accumulated. One worker operates a vacuum ("super sucker") truck and rarely comes into contact with the ash, while two workers physically enter the chambers which are typically loaded with fly ash exceeding a height of 20 inches. The lower chamber is generally cleaned first as the employees must access the lower chamber through a small port at the bottom of the chamber. Prior to entry, employees have to remove the column of fly ash that is present near the access port. A hose from the vacuum truck is placed at the access port along with a water hose. The water hose is placed in the end of the vacuum hose to wet the fly ash as it is hand-shoveled into the end of the hose. The vacuum truck wets and vacuums the ash simultaneously through an 8 inch hose. When the vacuum truck is filled, the fly ash waste is hauled to the landfill. After entering the lower chamber, the workers hand-shovel the ash towards the vacuum hose near the access port for removal by the vacuum truck. After the lower chamber is sufficiently emptied, the workers relocate to the upper chamber to manually shovel the ash that has accumulated in this chamber down (approximately a 20 foot drop) into the lower chamber to repeat the vacuum process. This process takes approximately 2-3 days and involves constant contact with large amounts of fly ash.

NYDOS requires a confined space entry permit to enter the ESP for cleaning. This includes monitoring the atmosphere inside the ESP before entry. The cleaning process generally involves one worker who enters the electrically grounded ESP and one stand-by worker who remains outside of the confined space. One worker enters the ESP through various small access ports and uses a small sledge hammer to strike each metal ionizer and collecting plate in order to free fly ash that has adhered to the surfaces. The fly ash falls to the bottom of the ESP where it is removed by the conveyor. Each precipitator has several different port locations and interior platforms from which to perform the cleaning. This task also involves constant contact with large amounts of fly ash and requires movement in spaces that are narrow with awkward footing. The ESP cleaning process typically requires 1-2 days to complete.

IV. EVALUATION DESIGN AND SAMPLING METHODS

The environmental evaluation consisted of collecting full-shift personal breathing zone (PBZ) and area air samples to evaluate employee exposures during the periodic cleaning operations performed at the incinerators. Environmental sampling was intended to be conducted during cleaning operations at both of the incinerators still in operation. However, due to logistical and scheduling constraints, monitoring could only be conducted during the cleaning operations at the Betts Avenue incinerator. Environmental samples were collected during each of the tasks involved during the cleaning process of one complete furnace unit. These tasks included the slagging of the burn chamber, cleaning of the upper and lower chambers, and the cleaning of the ESP. On Wednesday, September 16, 1992, two employees were assigned to clean the lower and upper chambers of Unit #1 at the Betts Avenue facility. On Thursday, September 17, 1992, two employees were assigned to slag the walls of the burn chamber and then continue with the lower and upper chamber cleaning. One employee was assigned to enter and clean the ESP, while another employee was assigned as the stand-by worker to remain outside of this confined space.

Only general area samples were collected for PCDDs/PCDFs due to limitations in the current sampling techniques that requires a high flow pump and a very large sampling train that preempts personal monitoring. Five area samples for PCDDs/PCDFs were collected during the cleaning operations at the Betts Avenue incinerator, and one area sample was collected to evaluate exposure potential during normal operations at the Greenpoint incinerator. At the Betts Avenue incinerator, the samples were collected in close proximity to the employees performing the cleaning operations. The sample collected at the Greenpoint incinerator was placed in an area between the furnaces where workers generally perform monitoring operations. In addition, five bulk samples of the fly ash were collected and analyzed for PCDD/PCDF content.

Both area and PBZ samples were also collected for metals and respirable dust and silica. The workers assigned to the cleaning tasks wore one personal sampling pump to evaluate exposures to either metals or respirable dust/silica. Since the cleaning of the upper and lower chambers and the slagging of the stoker each involved two employees, a PBZ sample for metals was obtained from one of the workers while a PBZ sample for respirable dust/silica was collected from the other. Only one worker entered the ESP unit to perform the cleaning tasks. Due to the confined nature of cleaning the ESP, it was not practical for this employee to wear two personal sampling pumps. Therefore, a decision was made to collect only a PBZ sample for metals during this operation because the sampling device (filter cassette) for metals would be the less restrictive than the sampling device (filter cassette mounted in a nylon cyclone) for respirable dust/silica. Area samples were collected for both metals and respirable dust/silica during all the cleaning tasks and were placed in close proximity to the dioxin samples. Due to the presence of large amounts of airborne fly ash, several samples also included the use of multiple sample cassettes, used consecutively, to prevent overloading.

A. PCDDs and PCDFs

The air sampling device for PCDD/PCDF compounds consists of two stages. The first stage is a 47 millimeter (mm) glass microfiber filter (EM 2000) with a 0.3 micrometer (µm) pore size for collecting particulates. The second stage is used to collect vapors and contains a glass cartridge with eight grams of 140°C activated 30/70 mesh silica gel adsorbent. The silica gel cartridge is spiked with 2,3,7,8-tetrachlorodibenzo-*p*-dioxin and 2,3,7,8-tetrachlorodibenzofuran with radioactive $^{13}C_{12}$ or $^{37}Cl_{17}$ markers before sampling, both for quantification and to account for any retention losses during sampling. The glass cartridge containing the spiked silica gel adsorbent is sealed in a rugged Teflon® housing with fluorelastomer Viton® "O" rings.

For sample collection, the sampler is placed in a vertical position and attached via Tygon tubing to a 20 liters per minute (Lpm) rotary vane vacuum pump.

Flow rates are regulated and adjusted using precision control valves and rotometers.

The analytical methodology employed was generally that described by EPA 8290, and included the use of a high resolution gas chromatography/high resolution mass spectrometry (HRGC/HRMS) technique. The samples were desorbed with toluene for 16 hours using a Soxhlet apparatus to extract the PCDD and PCDF from the samples. An extensive purification process is then used to prepare the samples for analysis. This purification was accomplished by passing the extract through various columns containing silica gel, acid alumina, carbon, and neutral alumina columns using various mixtures of hexane, methylene chloride, and benzene to elute the analytes.

The samples were analyzed by HRGC/HRMS equipped with a DB-5 chromatographic column. For those samples (all except for the field blank) which had detectable amounts of 2,3,7,8-TCDF present, the analysis was repeated using OV-225, a confirming column which adequately resolves 2,3,7,8-TCDF from the other TCDF isomers. Selected ^{13}C or ^{37}Cl labeled PCDD and PCDF isomers are included as internal standards and recovery (surrogate) standards.

Analyses are performed to measure total tetra-, penta-, hexa-, hepta-, and octachlorinated dibenzofurans; total tetra-, penta-, hexa-, hepta-, and octachlorinated dibenzodioxins; and specific PCDD and PCDF isomers containing chlorine substitution in the 2, 3, 7, and 8 positions.

B. Metals

The samples for metals were collected on 37-millimeter (mm), 0.8 µm pore size cellulose ester membrane filters in clear cassette holders. The samples were attached via flexible Tygon® tubing to personal sampling pumps calibrated to draw air through the filter at a flow rate of 2.0 Lpm. The samples were analyzed for 30 elements (metals) using NIOSH Method 7300.[2] A Thermo Jarrell Ash ICAP 61 simultaneous scanning, inductively coupled, plasma (ICP) emission spectrometer controlled by an DEC Personal Computer-AT was used for all measurements. The analytical limits of detection (LOD) of this method for each of the metals are listed in Table I.

C. Respirable Particulate and Silica

The respirable particulate and silica samples were collected on tared 37 mm, 5 µm pore size polyvinyl chloride (PVC) membrane filters mounted in 10 mm nylon Dorr-Oliver cyclones. The samples were attached via flexible Tygon® tubing to personal sampling pumps calibrated to draw air through the filter at a flow rate of 1.7 Lpm. The samples were analyzed for total respirable weight by gravimetric analysis according to NIOSH Method 0600[2] with two modifications.

The filters were stored in an environmentally controlled room to reduce the stabilization time between tare weighings to 5-10 minutes, and the filters and backup pads were not vacuum desiccated. The instrumental precision of the weighings was 0.02 milligrams (mg).

After the gravimetric analysis, the samples were then analyzed for silica (quartz and cristobalite) using x-ray diffraction. NIOSH Method 7500[2] was used with the following modifications: 1) filters were dissolved in tetrahydrofuran rather than being 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. The LODs for quartz and cristobalite for this method were 0.01 mg/sample and 0.015 mg/sample, respectively.

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)[3], 2) the American Conference of Governmental Industrial Hygienists' (ACGIH) Threshold Limit Values (TLVs)[4], and 3) the U.S. Department of Labor, Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs).[5] 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 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 reflect the 1971 values.

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.

A. PCDDs/PCDFs

PCDDs and PCDFs are two series of tricyclic aromatic compounds. The number of chlorine atoms can vary between 1 and 8 (mono- through octa-chloro congeners), resulting in 75 PCDD and 135 PCDF positional isomers. The toxic effects of these compounds are associated with the number and specific placement of the chlorine atoms in the molecule. The tetra-, penta- and hexachlorinated isomer groups exhibit greater toxicity than the other chlorinated forms.[6-8] PCDDs and PCDFs with chlorine at positions 2,3,7, and 8 are particularly toxic.[9-11] PCDDs and PCDFs are highly toxic in experimental animals when administered acutely, subchronically, or chronically.[11-19] Toxic effects include severe weight loss, liver necrosis and hypertrophy, skin lesions, immunosuppression, reproductive toxicity, teratogenesis, and death. Of the 75 PCDD and 135 PCDF isomers, only 2,3,7,8-TCDD and a mixture of hexachlorinated dibenzo-*p*-dioxins with four of the six chlorines in positions 2,3,7, and 8 have been tested for carcinogenicity. Two independent studies of 2,3,7,8-TCDD showed significant increases in the incidence of liver and/or lung tumors in exposed rodents.[19,20] A mixture of two 2,3,7,8-substituted hexachlorinated dibenzodioxins was found to produce an increased incidence of liver tumors or neoplastic nodules in exposed rats and mice.[21] Exposure to PCDD can cause chloracne and liver toxicity in humans.[17,22] There is suggestive evidence of an association between increased incidence of cancer in people exposed to PCB-containing substantial amounts of PCDF[23,24] and in people exposed to phenoxyacetic herbicides contaminated with PCDD, including TCDD.[25,26] Due to the inadequately defined study populations and the influences of mixed exposures, definite causal relationships between exposure and carcinogenic effects in humans remain unclear.

NIOSH recommends that 2,3,7,8-TCDD be regarded as a potential occupational carcinogen, that occupational exposure to 2,3,7,8-TCDD be controlled to the lowest feasible concentration, and that decontamination measures be used for 2,3,7,8-TCDD-contaminated work environments. These recommendations are based on a number of reliable studies demonstrating carcinogenicity in rats and mice.[17]

Air and surface guideline criteria for PCDDs/PCDFs are expressed as 2,3,7,8-TCDD equivalents. The equivalents of 2,3,7,8-TCDD are defined as the concentration of 2,3,7,8-TCDD which, by itself, would exhibit the same biological potency as the mixture of structurally related compounds, PCDDs and PCDFs, actually present in a sample. The structurally related PCDDs and PCDFs that are considered in the calculation of 2,3,7,8-TCDD equivalents include the tetra- through octa-chlorinated congeners and 2,3,7,8-substituted isomers.[27] The concentrations of the PCDD and PCDF compounds are converted to 2,3,7,8-TCDD equivalents by multiplying measured concentrations by the appropriate factor. The 2,3,7,8-TCDD equivalents specific for each isomer are then summed and compared to the guideline value. This procedure, initially developed by the NYDOH, estimates the amount of 2,3,7,8-TCDD that would have to be present to exhibit a similar toxicity as the measured amounts of all of the other PCDDs and PCDFs. The procedure assumes certain weighting factors (ratios of toxicities) between 2,3,7,8-TCDD and the other PCDDs and PCDFs.[28] The weighting factors (called toxicity equivalency factors [TEFs] by the EPA) were those proposed in 1987 by the EPA.[29] In a 1989 update to this document, the EPA adopted the International TEFs (I-TEFs).[30] Both the 1987 EPA and 1989 I-TEFs are listed in Table II.

The dioxin subcommittee of the National Research Council (NRC) released a report on acceptable levels of dioxin contamination in office buildings following transformer fires.[31] The exposure guidelines adopted by the subcommittee were 10 pg/m^3 for air and 25 ng/m^2 for surfaces expressed as 2,3,7,8-TCDD equivalents calculated using the 1987 EPA TEFs. Reported lifetime cancer risk estimates were 9 x 10^{-8} to 2 x 10^{-4} at the recommended guideline. Risks correspond to a single source contamination, either air or surface. Risks and exposures for simultaneous exposure are additive. For example, risks apply for exposure to 10 pg/m^3 of air only, 25 ng/m^2 of surface only, or 5 pg/m^3 of air plus 12.5 ng/m^2 of surface. Simultaneous exposure at 10 pg/m^3 of air and 25 ng/m^2 of surface implies risks twice as large as the given values.

B. Metals

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 metals are present. A partial list of metals identified during this survey is presented in Table III along with a brief summary of their primary health effects and relevant evaluation criteria.[32-50] Only those elements which have the greatest toxicological significance or were present in significant amounts are included in this list.

C. Silica (Quartz, Cristobalite)

Crystalline silica (quartz) and cristobalite have been associated with silicosis, a fibrotic disease of the lung caused by the deposition of fine particles of crystalline silica in the lungs. Symptoms usually develop insidiously with cough, shortness of breath, chest pain, weakness, wheezing, and non-specific chest illnesses. Silicosis usually occurs after years of exposure, but may appear in a shorter period of time if exposure concentrations are very high.[51] The NIOSH RELs for respirable quartz and cristobalite, published in 1974, are 50 µg/m^3 as TWAs, for up to 10 hours per day during a 40-hour work week.[52] These RELs are intended to prevent silicosis. However, evidence indicates that crystalline silica is a potential occupational carcinogen, and NIOSH is currently reviewing the data on silica-induced carcinogenicity.[53-55] The ACGIH TLVs for respirable quartz and cristobalite are 100 and 50 µg/m^3 as 8-hour TWAs, respectively.[4] The OSHA PEL for respirable quartz is calculated using the formula: 10/(%quartz + 2), while the PEL for respirable cristobalite is half of the value determined for respirable quartz.[5]

D. Respiratory Protection

Respirators were used for worker protection against fly ash during the incinerator clean-out procedures. NIOSH recommends that respiratory protection be used for worker protection only when engineering controls are not technically feasible, during the interim while the controls are being installed or repaired, or when an emergency and other temporary situations arise.[56] Respirators are the least preferred method of worker protection to air contaminants because an effective respiratory protection program must be implemented to increase the reliability of the protection and the cooperation of the workers to adhere to the elements of the program is critical for respirators to afford adequate protection.

There are two general classes of respiratory protection, **air-purifying respirators** which remove contaminants from the ambient air before it is inhaled, and **air-supplied respirators** which deliver an independent source of respirable air (other than the surrounding atmosphere).[57] Both types of respirators can be subclassified based on the type of inlet covering (facepieces, helmet/shroud, suit, etc.) and the mode of operation. Regardless of the subclassification, air-purifying respirators only remove contaminants from the air; air-purifying respirators must <u>not</u> be used in oxygen deficient atmospheres. It is essential to fully characterize the hazardous atmosphere in which the respirators will be used, including the identity and concentration of the air contaminants and the oxygen level.

E. Confined Space Entry

Confined spaces, such as the incinerator chambers and ESP, present a number of potential occupational hazards for the workers who must enter, work within, or around these locations. Each year hundreds of confined space related accidents occur resulting in a number of injuries and deaths. A Recommended Standard for working in confined spaces has been published by NIOSH,[58] and additional technical information regarding recommended confined space procedures have been developed by the American National Standards Institute (ANSI), the American Petroleum Institute (API), and others.[59,60] Furthermore, on January 14, 1993, OSHA promulgated a final rule on permit-required confined spaces, which is the minimum requirements for employers to implement to maintain compliance with the General Industry standards enforced by OSHA.[61]

The potential hazards associated with confined spaces can be grouped into three general categories - hazardous atmospheres, safety hazards, and exposure to physical agents. Hazardous atmospheres encountered in confined spaces include oxygen deficient, explosive/flammable, toxic, and irritating atmospheres. Safety hazards may include mechanical trauma, electrocution, slips and falls, engulfment in materials, interference with communication, contact with sharp edges, and other hazards related to entering or exiting the space. Physical agents to which workers may be exposed while in confined spaces include thermal conditions (hot or cold), noise, vibration, and possibly radioactive materials.

The Fatal Accidents Circumstances & Epidemiology (FACE) project conducted by NIOSH focused on confined space accidents during the period 1984-1988 and one result of this initiative was the publication of a Hazard Alert.[62] These investigations discovered three recurring confined space program inadequacies - lack of recognition of confined space hazards, lack of testing and evaluation of the confined space prior to entry (and continued monitoring during occupancy), as well as unplanned and inappropriate rescue procedures.

A confined space is defined by NIOSH as "an area which by design has limited openings for entry and exit, unfavorable natural ventilation which could contain (or produce) dangerous air contaminants, and which is not intended for continuous employee occupancy."[58] The NIOSH criteria for working in confined spaces further classifies confined spaces based upon the atmospheric characteristics such as oxygen level, flammability, and toxicity. As shown in Table 1 of Appendix I, if any of the hazards present a situation which is immediately dangerous to life or health (IDLH), the confined space is designated Class A. A Class B confined space has the potential for causing injury and/or illness but is not IDLH. A Class C space would be one in which the hazard potential would not require any special modification of the work procedure. Table 2 of Appendix I lists the confined space program elements which are recommended (or must be considered by a qualified person, as defined by the criteria) before entering and during work within confined spaces based on the established hazard classification.

On January 14, 1993, the OSHA final rule for confined spaces was published in the Federal Register with the effective compliance date established as April 15, 1993.[61] The OSHA confined space rule is a versatile "performance oriented" standard that allows some latitude for employers to interpret and apply the confined space program requirements specific to their establishments providing the fundamental precautionary measures are implemented to prevent confined space injuries and deaths. The definition of a confined space determined by OSHA is any space:

1. that is large enough and is configured to allow an employee to bodily enter and perform work, <u>and</u>
2. has limited or restricted means of access into and egress from within, <u>and</u>
3. is not designed for continuous employee occupancy.[61]

OSHA further distinguishes confined spaces based on the potential of the space to pose hazardous exposure conditions and classifies these spaces as non-permit versus permit-required confined spaces. A space is a permit-required confined space if it meets the OSHA definition of a confined space as listed above and it contains or has the potential to produce at least one of the following hazardous conditions:

1. a hazardous atmosphere, <u>or</u>
2. a material which could engulf an entrant, <u>or</u>
3. has an internal configuration such that an entrant could be trapped or asphyxiated, <u>or</u>
4. any other recognized serious safety or health hazard.[61]

OSHA anticipates that the confined space rule in conjunction with the rule for control of hazardous energy (lock-out/tag-out) will effectively protect workers from electrical, mechanical and other energy safety hazards as well as atmospheric hazards.[61,63]

VI. RESULTS AND DISCUSSION

The workers at the Betts Avenue incinerator were required to wear personal protective equipment (PPE) during normal operations and additional PPE when performing any of the cleaning tasks. Workers typically wore hard hats, safety glasses, work uniforms, and steel-toe safety boots during normal operations. The additional PPE required during the cleaning tasks included a Tyvek® suit fitted with a hood, a powered air purifying respirator (PAPR) equipped with a full facepiece and high-efficiency particulate air (HEPA) filters, and leather work gloves. NIOSH recognizes a protection factor of 50 for these types of respirators.[56] It was observed that most of the workers did not wear their hard hats during the cleaning tasks, due to the confined nature of the work. All of the cleaning tasks involved worker contact with the fly ash, and it was observed that the cleaning operations did generate large quantities of airborne fly ash. All of the observed cleaning operations required workers to manually move fly ash with the use of various hand tools. Most of the workers became covered with ash during the course of these activities. Even though the workers wore Tyvek® suits, their work uniforms became dusty because the suits being used did not have elastic cuffs, methods of fastening (i.e., taping) were not employed, and boot coverings were not used. In addition, some employees were observed using compressed air to clean dust from their work uniforms after removing the Tyvek® suits.

Six area air samples and five bulk samples were collected for total tetra- through octa-chlorinated PCDD and PCDF congeners and the 2,3,7,8-tetrachlorinated isomers. The collection of PBZ samples was impractical due to the size of the sampling media and the high volume sampling pumps necessary for the PCDD/PCDF analytical method. The PCDD/PCDF concentrations in TEQs were calculated using both the 1987 EPA and the 1989 I-TEFs (Table II). The concentrations calculated with the 1989 I-TEFs were all higher than the concentrations calculated with the 1987 EPA-TEFs. The results for these samples are presented in Table IV. For all the bulk and area air samples, the concentrations of the specific tetra- through octa-chlorinated congeners is provided in Appendix II.

The calculated PCDD/PCDF TEQ concentrations for the bulk samples ranged from 1.5 to 290 parts per trillion (ppt) using the 1987 EPA-TEFs and 3.0 to 880 ppt using the 1989 I-TEFs. The results of the bulk samples indicated that the highest concentration of PCDDs/PCDFs were present on the particulates collected in the ESP. The results also seemed to indicate that the PCDD/PCDF concentration in the fly ash was dependent upon where the fly ash was deposited along the path followed by the combustion emissions. At the Betts Avenue incinerator, this path would first be the burn chamber, followed by the upper chamber, the lower chamber, and finally the ESP. The PCDD/PCDF concentrations, calculated using the 1989 I-TEFs, for these areas were 3.2 ppt, 3.0 ppt, 6.8 ppt, and 880 ppt, respectively. Although the PCDD/PCDF concentrations in the burn chamber ash were slightly higher than in the upper chamber ash, the results for the other areas seemed to indicate that higher PCDD/PCDF concentrations were found on the fly ash that deposited later along the path of the combustion emissions. Because the bulk sample collected at the Greenpoint incinerator was a composite of ash from the upper and lower chambers, the results could not be used for this comparison. However, the PCDD/PCDF concentration in this bulk sample (46 ppt) was higher than both the respective areas at the Betts Avenue incinerator.

The airborne PCDD/PCDF TEQ concentrations ranged from 2.7 to 430 pg/m^3 using the 1987 EPA-TEFs and 4.6 to 800 pg/m^3 using the 1989 I-TEFs. Four of the six samples had PCDD/PCDF concentrations that exceeded the NRC guideline of 10.0 pg/m^3. The sample with the highest concentration (800 pg/m^3) was 80 times higher than the NRC guideline and was collected over an entire shift during the cleaning of the lower chamber. Three other samples that were collected during the cleaning of the upper and lower chamber, from the exterior of the upper and lower chambers, and during the cleaning of the ESP, had concentrations of 25, 263, and 90 pg/m^3, respectively. The remaining two samples had concentrations below the NRC guideline of 10.0 pg/m^3, which included samples collected from the burn chamber (9.0 pg/m^3) and the Greenpoint plant during normal operations (4.6 pg/m^3). As expected, the PCDD/PCDF concentration for the sample collected from the interior of the lower chamber during the cleaning was higher than the concentration determined for the sample collected from the exterior. The exterior sample was collected directly outside the hatch during the chamber cleaning operations.

The airborne PCDD/PCDF concentration for the sample collected during the cleaning of the ESP may not be representative of the true exposure encountered during this operation. The amount of fly ash present during this operation was observed to be greater than the other cleaning operations. Because additional sample media for PCDDs/PCDFs were not available, consecutive samples could not be used during the sampling period. The flowrate for this sample decreased significantly from 20 to 12 Lpm over the duration of the sampling period due to the excessive amount of fly ash loading on the sampling media. This finding may provide an explanation for the deviation of these results from the trend observed for the bulk samples.

The air sampling results for metals are presented in Tables V and VI. Only the results for the metals with the greatest toxicological significance or found at the highest concentrations are presented in these tables. The analytical LODs for the metals are listed in Table I, and the minimum detectable concentrations (MDC) for each of the metals can be calculated by dividing the LODs by each individual sample volume in liters. An averaged sample volume was not used to calculate the MDC for each metal because the sample volumes varied significantly. A total of eight PBZ and nine area samples were collected during the cleaning operations. Because multiple sample cassettes were required to prevent overloading during the sampling periods, these samples were combined into three full-shift PBZ and six area samples collected during the completion of the specific cleaning operations. For the PBZ samples, two consecutive samples were collected from a worker who performed both the slag scraping (burn chamber) and the lower chamber cleanout as well as from a worker who cleaned the lower chamber during their shifts. Four consecutive samples were collected to evaluate the full-shift exposure of the worker performing the ESP cleanout. For the area samples, three consecutive samples were required during the ESP cleanout and two consecutive samples were collected from outside the lower chamber during cleaning. Only one sample from each area was needed for the remaining area samples. The airborne metal concentrations determined from each individual sample are provided in the tables, along with the actual (full-shift) TWA calculated for consecutive samples collected during each cleaning operation and the 8-hour TWA for each operation, assuming no further exposure. The assumption that no further exposure occurred to the sampled workers may not be appropriate. The workers were observed to be covered with the fly ash after completing their respective cleaning tasks. Although these workers were wearing PPE, the lack of proper doffing procedures and the use of compressed air to clean work uniforms increases the potential for additional exposure. In addition, the possibility of ingestion exposures and exposures from dust carried home on worker's clothing also exists.

The full-shift PBZ samples (Table V) indicated that airborne metal concentrations exceeded the relevant evaluation criteria for arsenic (As), cadmium (Cd), lead (Pb), and nickel (Ni) during the cleanout of the ESP. Only the criterion for Pb was exceeded during the lower chamber cleanout. None of the airborne metal concentrations exceeded relevant criteria during the slag scraping and lower chamber cleanout. The 8-hour TWAs calculated for the full-shift sample collected during the ESP cleanout were also equal to or above at least one of the listed evaluation criteria for As, Cd, Pb, and Ni. The actual and 8-hour TWAs calculated for arsenic (0.027 and 0.019 mg/m^3) during this cleaning operation were above the NIOSH ceiling REL of 0.002 mg/m^3, as well as the ACGIH TLV and OSHA PEL of 0.01 mg/m^3. Two of the individual samples for this operation indicated that exposure concentrations for As exceeded the NIOSH ceiling limit of 0.002 mg/m^3. NIOSH recognizes arsenic as a potential occupational carcinogen. NIOSH also recommends that exposures to potential occupational carcinogens be kept at the lowest feasible concentration. The actual and 8-hour TWAs for cadmium were 0.14 and 0.099 mg/m^3, respectively. These concentrations were at the ACGIH TLV of 0.01 mg/m^3. In addition, NIOSH also recognizes cadmium as a potential occupational carcinogen. The actual and 8-hour TWAs for lead during this cleaning operation were 1.9 and 1.3 mg/m^3, respectively, and were well above the evaluation criteria for this metal. The actual and 8-hour TWAs for nickel were calculated to be 0.018 and 0.013 mg/m^3, respectively. These concentrations were at the established NIOSH REL of 0.015 mg/m^3. NIOSH also recognizes nickel as a potential occupational carcinogen. In addition to the metals included in Table V, one of the individual samples collected during the ESP cleanout had concentrations above the relevant evaluation criteria for copper, silver, and tellurium, while another had a silver concentration above the criterion. Lead was the only metal with airborne concentrations of concern during the lower chamber cleanout and the combination of slag scraping (burn chamber) and lower chamber cleanout. The airborne lead concentrations on these samples were 0.038 and 0.053 mg/m^3 as actual TWAs, and 0.023 and 0.037 mg/m^3 as 8-hour TWAs. The higher of these lead concentrations was found during the lower chamber cleanout operation.

The sample results for the area samples (Table VI) also indicated that airborne metal concentrations calculated for several of the individual samples were above relevant evaluation criteria. These concentrations were observed for the consecutive samples collected during the ESP cleanout and outside the lower chamber during cleanout. The four samples collected during slag scraping, outside the upper chamber during cleanout, during lower chamber cleanout, and during the cleanout for both the upper and lower chambers did not indicate any excessive airborne metal concentrations. The full-shift sample collected outside the lower chamber during the cleanout operation and the individual sample collected during the lower chamber cleanout were collected on different days, thus explaining the difference in the results for these samples.

Aluminum, As, Cd, chromium, cobalt, Pb, manganese, and Ni were detected at excessive concentrations during the ESP cleanout and outside the lower chamber during cleanout. These two operations required consecutive samples to prevent sample overloading. The full-shift sample collected during the ESP cleanout had the highest concentrations for each of these metals. The 8-hour TWA concentrations for aluminum were 1.7 and 41 mg/m^3. The NIOSH REL and ACGIH TLV for aluminum is 10 mg/m^3, while the OSHA PEL is 15 mg/m^3. Arsenic was not detected on the lower chamber cleanout consecutive samples, while the 8-hour TWA during the ESP cleanout was 0.088 mg/m^3. This concentration was above the evaluation criteria for As. The 8-hour TWAs for Cd were determined to be 0.001 and 0.63 mg/m^3. The higher concentration was determined during the ESP cleanout and was above the relevant evaluation criteria. The airborne chromium concentrations were determined to be 0.11 and 0.40 mg/m^3, as 8-hour TWAs, with the latter concentration approaching the NIOSH REL and ACGIH TLV of 0.5 mg/m^3. The OSHA PEL for chromium is 1 mg/m^3. The evaluation criteria for chromium in the hexavalent oxidation state (Cr[VI]) are lower. However, the presence of Cr(VI) could not be determined because the analytical method used during this investigation could not differentiate Cr(VI) from the other forms. NIOSH recognizes Cr(VI) as a potential occupational carcinogen. The actual TWA concentrations for cobalt were 0.002 and 0.029 mg/m^3, while the 8-hour TWAs were 0.001 and 0.018 mg/m^3. The cobalt 8-hour TWA concentration for the ESP cleanout approached the ACGIH proposed TLV of 0.02 mg/m^3. The current ACGIH TLV and NIOSH REL for cobalt is 0.05 mg/m^3, while the OSHA PEL is 0.1 mg/m^3. The 8-hour TWA Pb concentrations during the lower chamber and ESP cleanouts were 0.052 and 6.3 mg/m^3, respectively, which were both above the OSHA PEL and proposed ACGIH TLV of 0.05 mg/m^3. The concentrations for manganese were determined to be 0.015 and 0.52 mg/m^3, as 8-hour TWAs. The latter concentration exceeded the proposed ACGIH TLV of 0.2 mg/m^3, but was below the current ACGIH TLV and OSHA STEL of 5 mg/m^3. The NIOSH REL for manganese is 1 mg/m^3. The 8-hour TWAs for nickel were 0.003 and 0.088 mg/m^3. The concentration during the ESP cleanout exceeded the NIOSH REL of 0.015 mg/m^3 and the proposed ACGIH TLV of 0.05 mg/m^3. The current ACGIH TLV and the OSHA PEL is 1 mg/m^3.

The air sampling results for respirable dust/silica are presented in Table VII. The respirable dust concentrations for all of the samples, excluding the samples collected during the ESP cleanout, ranged from 0.063 to 2.4 mg/m^3. During the ESP cleanout, three individual samples were collected to prevent overloading of the sample cassettes. The actual TWA for the ESP cleanout operation was determined to be 189 mg/m^3, which corresponded to an 8-hour TWA concentration of 118 mg/m^3. However, the results for this data may be biased due to dust settling, limitations of the size-selector (cyclone), the excessive levels of fly ash present in the confined areas of the ESP, sample location in the ESP, or possible tampering. Two of the sample cassettes used for this consecutive sample (1390 and 239 mg/m^3) were determined to have excessive amounts of dust collected on the filter, which adversely affects the accuracy of the analytical results. These two samples were collected from areas near a lower access port; whereas, the first sample was collected from an access port at the top of the ESP. The respirable dust concentration (11 mg/m^3) obtained from the first of the three consecutive samples may more accurately approximate the worker's minimum exposure during the ESP clean-out because the duration was substantially longer and the concentration was considerably lower than the following two samples. Due to the presence of metals and silica in the fly ash, comparison of these results to the criteria for respirable dust was not appropriate.

Of the ten samples analyzed for respirable silica, two were analyzed as bulk samples due to excessive amounts of dust on the filters, two had trace amounts of quartz between the LOD and the limit of quantitation (LOQ), and only one had quartz present above the analytical LOQ which corresponded to an airborne concentration of 0.073 mg/m^3. The remaining five samples did not have any detectable amounts of quartz, and none of the samples had detectable amounts of cristobalite. The two overloaded samples were collected during the ESP cleanout and analyzed as bulk samples to determine the percent of quartz and cristobalite in the fly ash. The average percent quartz on these two samples was 2.4% (2.3% and 2.5%). The LOD for percent cristobalite was 0.75%. For the other eight samples, the analytical LOD and LOQ for quartz were 0.01 and 0.03 mg, respectively. These equate to a MDC of 0.026 mg/m^3 and a minimum quantifiable concentration (MQC) of 0.079 mg/m^3, assuming an average sampling volume of 378 liters. The analytical LOD for cristobalite was 0.015 mg, which equates to a MDC of 0.040 mg/m^3, assuming a sampling volume of 378 liters. Even though only one sample could be used to determine the silica concentration during the ESP cleanout, the airborne quartz concentration (0.073 mg/m^3), measured as an 8-hour TWA, still exceeded the NIOSH REL for respirable quartz of 0.05 mg/m^3. Although quartz was found on the two overloaded samples also collected during the ESP cleanout, the 8-hour TWA concentration was calculated assuming no further quartz exposure. Therefore, the true quartz concentration encountered during this operation would be expected to be somewhat higher than the one calculated. The ACGIH TLV for respirable quartz is 0.1 mg/m^3. The OSHA PEL for respirable dust containing 2.4% quartz was determined to be 2.3 mg/m^3 using the formula: 10/(%quartz + 2). Therefore, the OSHA PEL was exceeded during the ESP cleanout, assuming that the most accurate approximation of the respirable dust concentration was 11 mg/m^3. The OSHA PEL could not be used to evaluate the other samples because the percent quartz content was only determined for respirable dust from the ESP.

Using the airborne concentrations of the contaminants determined during this investigation, a comparison can be performed to determine if the PAPRs provide adequate protection. NIOSH recognizes a protection factor of 50 for the type of respirators used by the workers performing the cleanout operations. The minimum protection factor required for PPE during these cleaning operations can be determined by dividing the PBZ concentrations of the contaminants by their relevant evaluation criteria. Using the 8-hour TWA concentrations obtained for the PBZ samples, it was determined that the PAPRs may provide adequate protection. However, the individual (shorter duration) PBZ sample results for the ESP cleanout indicated that the concentrations of arsenic, cadmium, and lead exceeded the protection capabilities of the PAPRs (50). Using the most stringent evaluation criterion for these metals, it was determined that the minimum protection factors required would have been 80 for the arsenic concentrations encountered, 73 for cadmium, and 172 for lead. An estimate of the required, minimum protection factor could be determined using area airborne concentrations. Some of the individual area samples for metals collected during the ESP cleanout and the area PCDD/PCDF sample collected during the cleaning of the lower chamber also indicated that the airborne concentrations of aluminum, nickel, and PCDD/PCDF TEQs exceeded the protection factors for these respirators. These data seem to indicate that the PAPRs may not provide adequate protection during the lower chamber and ESP cleanout operations. In addition, 2,3,7,8-TCDD and some of these metals are recognized by NIOSH as potential occupational carcinogens. NIOSH recommends the use of positive pressure, supplied air respirators to prevent potential exposures to carcinogens.

During the course of the cleanout operations, confined space entry procedures implemented by NYDOS were followed by their employees. These procedures included atmospheric monitoring for percent oxygen and explosive gases, a brief inspection of the confined space to be entered, the issue of a permit/checklist before the workers could enter the confined space, and the presence of a stand-by attendant during the ESP cleanout. The monitoring, inspection, and issue of the permit were generally performed by a foreman after the incinerator had cooled and the workers were ready to perform the cleanout procedures.

Even though these procedures were followed during the NIOSH investigation, some perceived limitations in the confined space program were observed by the NIOSH investigators that should warrant further consideration by NYDOS. During the cleanout of the burn chamber, two employees would enter to perform the cleaning operations, while during the cleanout of the upper and lower chambers, one worker would enter the confined space until enough fly ash was removed. At that point, the second employee would also enter the confined space. During these operations, there were periods where there was no communication with a stand-by attendant. In contrast, a stand-by attendant was always present during the ESP cleanout. However, this stand-by attendant may not have had constant communication with the worker entering the space. Workers entering a confined space should always have an effective and constant way to communicate with a stand-by attendant. Other perceived limitations included the potential for falls (from the upper to the lower chamber, into the bottom ash collection hopper, and within the ESP), the need for additional atmospheric monitoring, and the absence of lifting mechanisms for rescue. In addition, the NIOSH investigators did not determine if the current confined space program contained provisions for emergency contingency procedures, worker confined space training programs, or the use of appropriate lockout/tagout procedures. All these items need to be implemented in a comprehensive confined space entry program.

VII. CONCLUSIONS

Based on the results of this evaluation, NIOSH investigators determined that a health hazard exists when workers are involved in cleanout operations at the incinerators. The environmental sampling data collected during this investigation indicate that the airborne PCDD/PCDF concentrations for four of the six area samples exceeded the National Research Council guideline of 10.0 pg/m^3, one sample by a factor of 80. Five of these six area samples were collected during the cleanout operations at Betts Avenue incinerator, and all four of the samples that exceeded the guideline were collected during cleanout operations. One area sample was collected during normal operations at the Greenpoint incinerator. The PBZ and general area samples collected during the investigation indicated that the 8-hour TWA airborne concentrations of aluminum, arsenic, cadmium, lead, manganese, nickel, and respirable silica (as quartz) exceeded the relevant evaluation criteria during the ESP cleanout operations. The airborne concentration of lead during the lower chamber cleanout operations was also found to exceed the OSHA PEL for this metal. The workers performing the cleanouts were wearing PPE which included PAPRs with HEPA filters. However, it was determined that the airborne concentrations for aluminum, arsenic, cadmium, lead, and nickel during some periods of the ESP cleanout and for PCDDs/PCDFs during the cleaning of the lower chamber were high enough to exceed the protection capabilities for these types of respirators. The NIOSH investigators also observed that improper procedures for the donning and doffing of the respirators and other PPE were used, and that the workers performing the fly ash cleaning operations were required to enter confined spaces without a comprehensive confined space safety program.

VIII. RECOMMENDATIONS

Preliminary recommendations based on initial observations were provided during the September 1992 site visit. Given the potential risk for PCDD/PCDF and metal exposures indicated by the environmental sampling results from this investigation and the previous finding of elevated levels of PCDDs/PCDFs in a pooled blood sample from 56 municipal incinerator workers, subsequent recommendations are provided to help improve the health and safety conditions at the Betts Avenue and Greenpoint incinerators.

1. The NYC Department of Sanitation should consider establishing a joint management and union committee to address the environmental results of this investigation and the reported finding of elevated levels of PCDDs/PCDFs in the pooled blood sample of incinerator workers.[1] The committee should address the feasibility of using engineering controls and work practices, such as those included below, to reduce worker exposures. Although there are no established standards or methods for the routine monitoring of workers exposed to PCDDs/PCDFs, the committee should monitor the industrial hygiene and medical literature for future PCDDs/PCDFs developments, including appropriate standards, environmental and biological monitoring methods, surveillance programs, analytical procedures, etc.

2. Worker exposures to lead and other metals in the fly ash should also be reduced through the use of engineering controls and work practices. In the case of lead, the requirements outlined in the OSHA lead standard (29 CFR 1910.1025) should be followed. This standard includes provisions for periodic exposure monitoring, implementation of engineering and work practice controls where overexposures to lead occur, use of respiratory protection while engineering controls are being implemented or when controls are not sufficient to reduce employee exposures to or below the OSHA PEL, provision of clean protective clothing and lunchroom facilities, establishment of a medical surveillance program, and employee notification, education, and training.

3. The NYC Department of Sanitation should implement an effective respiratory protection program, in accordance with the requirements described in 29 CFR 1910.134.[64] Publications developed by NIOSH which should also be referenced when developing an effective respirator program include NIOSH Respirator Decision Logic and the NIOSH Guide to Industrial Respiratory Protection.[56,57] It is recommended that the written program be revised to designate one individual with the responsibility for administering the respiratory protection program. The written respirator program should also contain information on the following topics: (a) the departments/operations which require respiratory protection; (b) the correct respirators required for each job/operation; (c) specifications that only NIOSH/MSHA approved respiratory devices shall be used; and (d) the criteria used for the proper selection, use, storage and maintenance of respirators, including limitations. The respirator program should also reference the requirements contained in the confined space program to assure that employees are adequately protected when working in these areas. A respiratory protection program should include the following elements:

    a. written operating procedures
    b. appropriate respirator selection
    c. employee training
    d. effective cleaning of respirators
    e. proper storage
    f. routine inspection and repair
    g. exposure surveillance
    h. program review
    i. medical approval
    j. use of approved respirators

4. The environmental monitoring results and observations made during the investigation indicated that some elements of the respiratory protection program and the personal protection equipment policy were not adequately addressed. Since the environmental monitoring results indicated that airborne concentrations of some metals may periodically exceed the protection capability of the PAPRs, additional monitoring and a review of the current respiratory

protection use should be conducted. In addition, training for the use of respirators and other forms of PPE should be provided. This training should include the proper use and maintenance of PPE, as well as the proper donning and doffing of PPE.

5. The use of dry methods, such as shoveling for fly ash removal should be minimized where possible and replaced with wet methods. Currently, water is only used to facilitate the transport of the fly ash through the hose connected to the vacuum truck. The fly ash could be partially wetted with a fine spray before shoveling to reduce the generation of airborne fly ash, or a nozzle extension apparatus could be attached to the current vacuum hose to allow workers to manually manipulate the vacuum inside the areas being cleaned, in lieu of manually shoveling the fly ash towards the vacuum hose located near the access port.

6. Smoking and eating in areas where exposure to the fly ash can occur should be eliminated. Workers were observed smoking directly outside areas where the cleaning was being performed. Workers should be required to wash their hands and face prior to eating or smoking.

7. The use of compressed air to clean off clothing should be prohibited. Workers were observed using compressed air to clean dust from their work uniforms after removing the Tyvek® suits. Requiring employees to frequently change dirty work uniforms or the use of a vacuum equipped with a HEPA filter to remove the dust from the uniforms are possible alternatives.

8. The NYC Department of Sanitation should implement a comprehensive confined space entry and safety program to protect workers who must enter these spaces. The confined space management program should be established consistent with the guidelines contained in the NIOSH criteria for a recommended standard, "Working in Confined Spaces," ANSI confined space standard (ANSI Z-117.1), and at a minimum, comply with the legal requirements for General Industry enforced by OSHA.[58,59,61] This program should be applied to company and contractor employees and include the following elements:

    a. written program
    b. labeling and posting of confined spaces
    c. permit application and review
    d. ventilation and purging
    e. isolation of hazardous energy (lock-out/tag-out, pipe blanks, etc.)
    f. atmospheric monitoring
    g. respiratory protection
    h. lifelines and lifting hoists
    i. buddy system and communication
    j. intrinsically safe equipment

k. employee training
l. first aid and emergency contingency plans

IX. REFERENCES

1. Schecter AJ, Malkin R, et al. [1991]. Dioxin levels in blood of municipal incinerator workers. Med Sci Res *19*:331-332.

2. NIOSH [1984]. NIOSH manual of analytical methods. Vol. 3. Cincinnati, OH: National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 84-100.

3. CDC [1988]. NIOSH recommendations for occupational safety and health standards 1988. Centers for Disease Control. Morbidity and Mortality Weekly Report 37, S-7.

4. ACGIH [1993]. Threshold limit values and biological exposure indices for 1993-94. Cincinnati, OH: American Conference of Governmental Industrial Hygienists.

5. OSHA [1989]. OSHA safety and health standards. 29 CFR 1910.1000. Occupational Safety and Health Administration, revised.

6. Goldstein JA [1979]. The structure-activity relationships of halogenated biphenyls as enzyme inducers. Ann NY Acad Sci *320*:164-78.

7. Youshimura H, Youshihara S, Ozawa N, Miki M [1979]. Possible correlation between induction modes of hepatic enzymes by PCBs and their toxicity in rats. Ann NY Acad Sci *320*:179-92.

8. Poland A, Greenlee W, Kende AS [1979]. Studies on the mechanism of action of the chlorinated dibenzo-*p*-dioxins and related compounds. Ann NY Acad Sci *320*:214-30.

9. McConnell EE, Moore JA, Haseman JK, Harris MW [1978]. The comparative toxicity of chlorinated dibenzo-*p*-dioxins in mice and guinea pigs. Toxicity Appl Pharmacol *44*:335-56.

10. Nagayama J, Kuroki H, Masuda Y, Kuratsune M [1983]. A comparative study of polychlorinated dibenzofurans, polychlorinated biphenyls and 2,3,7,8-tetrachlorodibenzo-*p*-dioxin on aryl hydrocarbon hydroxylase inducing potency in rats. Arch Toxicol *53*:177-84.

11. Yoshihara S, Nagata K, Youshimura H, Kuroki H, Masuda Y [1981]. Inductive effect on hepatic enzymes and acute toxicity of individual polychlorinated dibenzofuran congeners in rats. Toxicol Appl Pharmacol *59*:580-8.

12. Moore JA, McConnell EE, Dalgard DW, Harris MW [1979]. Comparative toxicity of three halogenated dibenzofurans in guinea pigs, mice, and rhesus monkeys. Ann NY Acad Sci *320*:151-63.

13. Schwetz BA, Norris JM, Sparschu GL, et al. [1973]. Toxicology of chlorinated dibenzo-*p*-dioxins. Environ Health Perspect *5*:87-99.

14. McConnell EE, Moore JA, Dalgard DW [1978]. Toxicity of 2,3,7,8-tetrachloro-dibenzo-*p*-dioxin in rhesus monkeys (masaca mulatta) following a single oral dose. Toxicol Appl Pharmacol *43*:175-87.

15. Garthoff LH, Cerra FE, Marks EM [1981]. Blood chemistry alterations in rats after single multiple gavage administration of polychlorinated biphenyl. Toxicol appl Pharmacol *60*:33-44.

16. Moore JA, Gupta BN, Vos JG [1976]. Toxicity of 2,3,7,8-tetrachlorodibenzo-furan - preliminary results. In: Proceedings of the National Conference on Polychlorinated Biphenyls. Chicago, IL: Environmental Protection Agency, Office of Toxic Substances, EPA-560/6-75-004, pp. 77-80.

17. NIOSH [1984]. Current intelligence bulletin 40 - 2,3,7,8-tetrachlorodibenzo-*p*-dioxin. Cincinnati, OH: National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 84-104.

18. Hassoun E, d'Argy R. Deneker L [1984]. Teratogenicity of 2,3,7,8-tetrachloro-dibenzofuran in the mouse. J Toxicol Environ Health *14*:337-51.

19. Kociba RJ, Keyes DG, Beyer JE, et al. [1978]. Results of a two-year chronic toxicity and oncogenicity study of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin in rats. Toxicol Appl Pharmacol *46*:279-303.

20. NTP [1982]. Bioassay of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin for possible carcinogenicity (gavage study). Bethesda, MD and Research Triangle Park, NC: National Toxicology Program, DHHS (NIH) Publication No. 82-1765.

21. NTP [1980]. Bioassay of 1,2,3,6,7,8- and 1,2,3,7,8,9-hexachlorodibenzo-*p*-dioxin for possible carcinogenicity (gavage study). Bethesda, MD and Research Triangle Park, North Carolina: National Toxicology Program, DHHS (NIH) Publication No. 80-1758.

22. Ideo G, Bellati G, Bellobuono A, Bissanti L [1985]. Urinary D-glucaric acid excretion in the Seveso area, polluted by tetrachlorodibenzo-*p*-dioxin (TCDD): five years of experience. Environ Health Perspect *60*:151-7.

23. Urabe H, Koda H, Asahi M [1979]. Present state of Yusho patients. Ann NY Acad Sci *320*:273-6.

24. Kuratsune M [1976]. Epidemiologic studies on Yusho. In: Higuchi K, ed. PCB poisoning and pollution. Tokyo, Japan: Kodansha Ltd., pp. 9-23.

25. Hardell L, Sandstrom A [1979]. Case-control study: soft tissue sarcomas and exposure to phenoxyacetic acids or chlorophenols. Br J Cancer *39*:711-7.

26. Hardell L [1979]. Malignant lymphoma of histiocytic type and exposure to phenoxyacetic acids or chlorophenols. Lancet 55-6.

27. NIOSH [1987]. Health hazard evaluation report no. HETA 85-414-1805. Cincinnati, OH: National Institute for Occupational Safety and Health.

28. Eadon G, Aldouos K, Frenkel G, et al. [1982]. Comparisons of chemical and biological data on soot samples from the Binghamton State Office building. Albany, NY: Center for Laboratories and Research, New York State Department of Health.

29. EPA [1987]. Risk Assessment Forum: Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of Chlorinated Dibenzo-p-Dioxins and Dibenzofurans (CDDs and CDFs). Environmental Protection Agency, Washington, D.C. EPA Publication No. 625/3-87/012.

30. EPA [1989]. Risk Assessment Forum: Interim Procedures for Estimating Risks Associated with Exposures to Mixtures of Chlorinated Dibenzo-p-Dioxins and Dibenzofurans (CDDs and CDFs) and 1989 Update. Environmental Protection Agency, Washington, D.C. EPA Publication No. 625/3-89/016.

31. NRC [1988]. Acceptable levels of dioxin contamination in an office building following a transformer fire. National Academy Press. Washington, DC.

32. Proctor NH, Hughes JP, Fischman ML [1988]. Chemical hazards of the workplace, 2nd ed. Philadelphia, PA: J. B. Lippincott.

33. ACGIH [1991]. Notice of intended change: arsenic and its soluble inorganic compounds, including arsine. Applied Occup Environ Hyg 6(12):1049-1056.

34. Reels H, Bucket J, Truc J, et al [1982]. The possible role of direct ingestion on the overall absorption of cadmium or arsenic in workers exposed to Cd or As_2O_3 dust. Am J Ind Med 3:53-65.

35. NIOSH [1992]. NIOSH 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.

36. Dunphy B [1967]. Acute occupational cadmium poisoning: a critical review of the literature. J Occup Med 9:22-26.

37. Louria DB, Joselow MM, Browder AA [1972]. The human toxicity of certain trace elements. Ann Intern Med 76:307-319.

38. IARC [1976]. IARC monographs on the evaluation of the carcinogenic risk of chemicals to man: cadmium, nickel, some epoxides, miscellaneous industrial chemicals, and general considerations on volatile anesthetics. Vol. 11. Lyons, France: World Health Organization, International Agency for Research on Cancer, pp 39-74.

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

40. Franchini I, Magnani F, Mutti A [1983]. Mortality experience among chromeplating workers: initial findings. Scand J Work Environ Health 9:247-252.

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

42. 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 (suppl. 4):156-165.

43. Sorahan T, Burges DCL, Waterhouse JAH [1987]. A mortality study of nickel/chromium platers. Br J Ind Med 44:250-258.

44. Morton WKC, Seaton A [1975]. Occupational lung diseases, 2nd ed. Philadelphia, Pennsylvania: WB Saunders, pp 486-489.

45. Miller CW, Davis MW, Goldman A, Wyatt JP [1953]. Pneumoconiosis in the tungsten-carbide tool industry. AMA Arch Ind Hyg Occup Med 8:453.

46. Coates EO Jr, Watson JHL [1971]. Diffuse interstitial lung disease in tungsten-carbide workers. Ann Intern Med 75:709.

47. Browning E [1969]. Toxicity of industrial metals, 2nd ed. London: Butterworth, pp 132-142.

48. Hernberg S, Dodson WN, Zenz C [1988]. Lead and its compounds. In: Zenz C., Occupational Medicine: 2nd ed. Chicago, IL: Year Book Medical Publishers, pp 547-582.

49. NIOSH [1977]. Occupational diseases: a guide to their recognition. Revised Ed. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 77-181.

50. NIOSH [1990]. NIOSH Pocket Guide to Chemical Hazards, 2nd Printing, 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. 90-117.

51. NIOSH [1986]. Occupational respiratory diseases. 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. 86-102.

52. NIOSH [1974]. Abrasive blasting respiratory protective practices. Washington, DC: U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 74-104, p 106.

53. IARC [1987]. IARC monographs on the evaluation of the carcinogenic risk of chemicals to humans: silica and some silicates. Vol. 42. Lyons, France: World Health Organization, International Agency for Research on Cancer, pp 49, 51, 73-111.

54. NIOSH [1988]. NIOSH testimony to the U.S. Department of Labor: statement of the National Institute for Occupational Safety and Health. Presented at the public hearing on OSHA PELS/Crystalline Silica, July 1988. NIOSH policy statements. Cincinnati, OH: U.S. Department of Health and Human Services, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health.

55. DHHS [1991]. Sixth annual report on carcinogens: summary 1991. Research Triangle Park, NC: U.S. Department of Health and Human Services, Public Health Service, National Institute of Environmental Health Sciences, pp 357-364.

56. NIOSH [1987]. NIOSH respirator decision logic. 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. 87-108.

57. NIOSH [1987]. NIOSH guide to industrial respiratory protection. 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. 87-116.

58. NIOSH [1979]. Criteria for a recommended standard: working in confined spaces. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 80-106.

59. ANSI [1989]. American national standard safety requirements for confined spaces. Des Plaines, IL: American Society of Safety Engineers and American National Standards Institute, Inc. ANSI Z 117.1-1989.

60. API [1984]. Guidelines for confined space work in the petroleum industry. First edition. Washington, DC: American Petroleum Institute. API Publication 2217.

61. Code of Federal Regulations [1993]. 29 CFR 1910.146. Permit-required confined spaces. Washington, DC: Occupational Safety and Health Agency. U.S. Department of Labor. U.S. Government Printing Office. Federal Register, January 14, 1993. 58 FR 4549-4563.

62. NIOSH [1986]. ALERT - Request for assistance in preventing occupational fatalities in confined spaces. 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. 86-110.

63. Code of Federal Regulations [1988]. 29 CFR 1910.147. The control of hazardous energy sources (lock-out/tag-out). Washington, DC: Occupational Safety and Health Agency, U.S. Department of Labor, U.S. Government Printing Office, Federal Register, April 14, 1988. 54 FR 15496.

64. Code of Federal Regulations [1993]. 29 CFR 1910.134. Respiratory protection. Washington, DC: Occupational Safety and Health Agency, U.S. Department of Labor, U.S. Government Printing Office.

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3. New York State Department of Health
4. OSHA, Region II

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 I

Confined Space Entry

Table 1
CONFINED SPACE CLASSIFICATION TABLE
New York City Department of Sanitation
HETA 90-0329

Parameters	Class A	Class B	Class C
Characteristics	Immediately dangerous to life - rescue procedures require the entry of more than one individual fully equipped with life support equipment - maintenance of communication requires an additional standby person stationed within the confined space	Dangerous, but not immediately life threatening - rescue procedures require the entry of no more than one individual fully equipped with life support equipment - indirect visual or auditory communication with workers	Potential hazard - requires no modification of work procedures - standard rescue procedures - direct communication with workers, from outside the confined space
Oxygen	16% or less *(122 mm Hg) or greater than 25% *(190 mm HG)	16.1% to 19.4% *(122 - 147 mm Hg) or 21.5% to 25% (163 - 190 mm Hg)	19.5 % - 21.4% *(148 - 163 mm Hg)
Flammability Characteristics	20% or greater of LFL	10% - 19% LFL	10% LFL or less
Toxicity	**IDLH	greater than contamination level, referenced in 29 CFR Part 1910 Sub Part Z - less than **IDLH	less than contamination level referenced in 29 CFR Part 1910 Sub Part Z

* Based upon a total atmospheric pressure of 760 mm Hg (sea level)

** Immediately Dangerous to Life or Health - as referenced in NIOSH Registry of Toxic and Chemical Substances, Manufacturing Chemists data sheets, industrial hygiene guides or other recognized authorities.

NIOSH [1979]. Criteria for a recommended standard: working in confined spaces. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 80-106.

Table 2
CHECK LIST OF CONSIDERATIONS FOR ENTRY, WORKING IN AND EXITING CONFINED SPACES
New York City Department of Sanitation
HETA 90-0329

ITEM	CLASS A	CLASS B	CLASS C
1. Permit	X	X	X
2. Atmospheric Testing	X	X	X
3. Monitoring	X	0	0
4. Medical Surveillance	X	X	0
5. Training of Personnel	X	X	X
6. Labeling and Posting	X	X	X
7. Preparation			
Isolate/lockout/tag	X	X	0
Purge and ventilate	X	X	0
Cleaning Processes	0	0	0
Requirements for special equipment/tools	X	X	0
8. Procedures			
Initial plan	X	X	X
Standby	X	X	0
Communications/observation	X	X	X
Rescue	X	X	X
Work	X	X	X

9.	**Safety Equipment and Clothing**			
	Head protection	**0**	**0**	**0**
	Hearing protection	**0**	**0**	**0**
	Hand protection	**0**	**0**	**0**
	Foot protection	**0**	**0**	**0**
	Body protection	**0**	**0**	**0**
	Respiratory protection	**0**	**0**	
	Safety belts	**X**	**X**	**X**
	Life lines, harness	**X**	**0**	
10.	**Rescue Equipment**	**X**	**X**	**X**
11.	**Recordkeeping/Exposure**	**X**	**X**	

X = indicates requirement
0 = indicates determination by the qualified person

NIOSH [1979]. Criteria for a recommended standard: working in confined spaces. Cincinnati, OH: U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, National Institute for Occupational Safety and Health, DHEW (NIOSH) Publication No. 80-106.

Elements of a Comprehensive Confined Space Management Program
New York City Department of Sanitation
HETA 90-0329

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

2. **Medical Examinations and Policies** - Preplacement and periodic medical examinations should be provided to all employees included in the confined space management program. Periodic exams should be conducted at least annually, and should include a comprehensive work and medical history with special emphasis on sensory attributes and cardio-pulmonary systems (if respiratory protection is required). Written medical policies should be established which clearly describe specific predisposing conditions that cause the employee to be at higher risk of injury due to confined space entry (or rescue), and the limitations and/or protective measures implemented in such cases.

3. **Employee Education and Training** - All employees included in the confined space management program or emergency contingency procedures should receive periodic training regarding the hazards of confined spaces, entry and exit procedures, lock-out and other energy isolation methods, use of safety equipment including respiratory protection and communication systems, emergency rescue exercises, CPR and first aid procedures, and other precautionary measures of the site specific confined space management program. For training programs to be effective, classroom lectures should be supplemented with "hands-on" exercises, measures to evaluate competency, and "on the job" training of journey level workers under the field supervision of experienced workers. The content of the training program(s) should be tailored to the individual needs of workers who function in different capacities (i.e., confined space entrant, stand-by attendant, rescue personnel, site coordinator or program administrator).

4. **Inventory and Posting** - All equipment which contain hazardous confined spaces and may require work necessitating entry should be identified and a comprehensive inventory should be established which records the equipment identifier, location, function, and preventive maintenance schedule. These confined spaces should be posted in readily visible locations along all of the perimeter entrances. The information on the warning sign should include the potential hazards of the confined space, the required protective gear (and permit procedures) for entry, and the emergency contacts.

5. **Permit Application and Review** - In an effort to prevent unauthorized and improperly protected entry into (or work affecting) confined spaces a written application and permit approval system should be implemented. The application should describe the confined space, location, work tasks to be accomplished including the procedures, and time

schedule. The application must be reviewed by a qualified person who can anticipate potential hazards, select the required precautionary measures (and equipment) necessary for entry, and grant approval via a written permit which contains all of this information. Naturally, strict adherence to the conditions described in the permit is essential for effective control of the potential hazards using a permit system.

6. **Isolation of Energy** - It is critical for all forms of potential energy to be isolated ("de-energized") prior to and for the duration of worker entry in confined spaces. This includes electrical circuits, mechanical components, flow of materials, and may entail lock-out/tag-out procedures of electrical boxes, blanking of pipelines and valves, and disconnecting mechanical drive trains or linkages. The minimum requirements to comply with the General Industry standard for lock-out procedures enforced by OSHA is described in 29 CFR 1910. 147. The underlying premise of an effective lock-out safety program is that for each worker a separate lock is used to isolate the source of energy, with only one key in possession of that worker while present within the confined space (or otherwise exposed to machinery hazards requiring lock-out).

7. **Atmosphere Testing and Monitoring** - In order to determine hazard potential of the atmosphere within a confined space initial testing the environmental conditions is essential ***prior to entry.*** Initial atmospheric tests must include evaluations of oxygen level, flammables/explosives, toxin concentrations, and possibly evaluations of physical agents or explosivity potential of airborne dust. Because of the potential for the atmosphere within a confined space to rapidly change (from the impact the work process or adjacent air spaces may have by generating air contaminants or reducing the oxygen partial pressure) continuous or frequent monitoring is advisable. Acceptable levels of oxygen range from 19.5 to 23.5% oxygen; levels below 19.5% warrant the use of supplied air respiratory protection to protect against the oxygen deficiency and levels above 23.5% expand the flammable limits of combustible and explosive materials requiring special attention to the fire potential. Satisfactory level of flammables is generally regarded as 10% of the lower flammable limit (LFL), however, the oxygen level must determined prior to monitoring the LFL due to the error (lower LFL determinations) possible with many instrument when used in an oxygen deficient atmosphere. The relevant occupational exposure criteria (NIOSH REL, OSHA PEL, or ACGIH TLV) should be applied to evaluate worker exposure to toxic air concentrations. Unknown atmospheres must be treated as containing the most hazardous level since the consequences could be catastrophic, requiring the application of the most protective measures (i.e., use of air supplied respiratory protection with escape provisions if the oxygen level was not determined).

8. **Purge and Ventilate** - In order to reduce air contaminants or increase the oxygen level to acceptable levels, it is often necessary to *purge* the air space by displacement with liquid or vapor (inert gas, water, steam, or cleaning solution) or by forced air ventilation. [If the vessel was displaced with liquid or vapor, it is essential to use forced air following the displacement and ensure adequate oxygen level by atmospheric monitoring.] After the space has been purged (or otherwise determined to contain a safe atmosphere) continuous *ventilation* is required to maintain the safe atmosphere for the duration of the work process

requiring occupancy. Before forced air ventilation is utilized, one must consider the nature of the air contaminants, the size and orientation of the confined space, the work to be performed, as well as the number and location of workers present within the space. Oxygen must never be used in lieu of normal air (which only contains 20.9% oxygen); the use of oxygen can expand the limits of flammability and increase the possibility of fire or explosion and the enhance the severity should one occur.

9. **Respiratory Protection** - Respiratory protection may be required to enter confined spaces depending on the hazard potential of the atmosphere. If respiratory protection is used for normal work procedures or rescue operations, a program must be developed in accordance with the OSHA standards as referenced in 29 CFR 1910.134. Appropriate respiratory protection must be selected on the basis of the air contaminants and exposure concentrations to ensure that the workers exposure does not exceed the protection factor of the respiratory. **Air purifying respirators do not supply oxygen other than that present from the contaminated air, hence *air purifying respirators must not be used in oxygen deficient atmospheres.* Self contained breathing apparatus (SCBA) or an air supplied respirator with an escape air bottle are the only types of respiratory protection approved for confined space entry in an oxygen deficient atmosphere.** The minimum service time for SCBAs should be calculated based on the entry time, plus the maximum work period, and twice the estimated escape time to provide an adequate margin of safety. Accessibility through narrow openings present with many types of confined spaces is an important consideration which may preempt the use of this equipment.

10. **Personal Protective Equipment and Safety Equipment** - Additional safety and personal protective equipment besides respiratory protection may be necessary to adequately protect workers during confined space operations. All of the potential hazardous conditions and respective injury from unprotected exposure must be considered when selecting the appropriate safety equipment which may include hard hats, hearing protection, work gloves, cover-alls, (or chemical impermeable gloves and clothing), eye protection, fall protection, etc. Work being performed in classified flammable atmospheres warrants the use of explosion proof lighting, power tools and any other electrical equipment. Full chest harness fall restraints and retrieval equipment is advised over "safety" belts, but the effectiveness of this equipment for vertical retrieval is questionable without the associated mechanical lifting devices.

11. **Cleaning and Decontamination** - Decontamination of surfaces within confined spaces provides additional worker protection by reducing the inhalation potential (if the contaminated surface contains volatile components) and by eliminating a dermal contact hazard of toxic materials which could be absorbed or otherwise produce irritation/inflammation by direct contact. Obviously, it may be a preventive maintenance task such as cleaning that requires entry into the confined space in the first place; the cleaning procedures by itself can generate hazardous conditions especially if flammable materials are employed which warrants continuous (or frequent) monitoring of the atmosphere.

12. **Stand-by Attendant and Communication System** - No worker should be allowed to work in confined space areas without another person present directly outside the space. A buddy system allows workers to observe fellow workers during their duties for evaluation of confined space procedures, allows early detection and correction of problems, provides surveillance of work progress, and would also provide a quicker response to a confined space incident. The stand-by attendant cannot function as desired without effective communication with the confined space occupant(s); often visual observation of the confined space occupant by the attendant is obstructed necessitating radio contact or another means of effective audible communication.

13. **Contractor Coordination Procedures and Policies** - When work within a confined space is conducted by a hired contractor, the employer who owns and operates the confined space has a responsibility to ensure that appropriate confined space entry precautions are in fact utilized by the contractor. The contractor must be informed that the proposed work is within a confined space, and the potential hazards must be identified along with the minimum precautionary measures and procedures required for acceptable entry. The controlling employer should also coordinate and enforce adherence to the confined space entry procedures, especially when both contractor and host company employees must enter the space concurrently or when multiple contractors are present. The contractors have a legal responsibility to protect the safety of their own employees; as a check method, the contractor must obtain all of the necessary background information from the host company and insist on effective confined space entry procedure even if not required to do so by the host company. The contractor should also inform the host employer of the specific details of the confined space program and work procedures that will be employed including any additional hazards that the contracted work will generate.

14. **Emergency Contingency Procedures** - Well planned contingency procedures should be established in writing and followed during times of a confined space emergency. These procedures should address initial rescue efforts, CPR/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 and periodic practice exercises should be conducted to enhance familiarity with the plan and identify any deficiencies. Everyone involved must memorize their role and responsibilities since response time is critical during a confined space emergency. Multiple fatalities due to confined space accidents is often due to a spontaneous reaction instead of a well planned and executed rescue operation. The importance of properly trained and equipped stand-by and rescue personnel with quick accessibility to the confined space location cannot be overstated. Special consideration must be given to specific design and orientation of each confined space when developing contingency procedures as well as the methods required to withdraw an unconscious or injured worker without producing additional injuries.

15. **Assessment of Program Performance and Surveillance of Confined Space Related Incidents** - In order to identify deficiencies with the confined space 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 confined space accident is also crucial for correcting program deficiencies. Generating and maintaining records pertaining to each confined space operation, the protective measures employed, calibration of equipment, as well as information relative to confined space incidents or near misses are necessary to adequately evaluate the program.

APPENDIX II

PCDD/PCDF Congener Concentrations

Figure 1
Betts Avenue Incinerator
New York City Department of Sanitation
HETA 90-0329

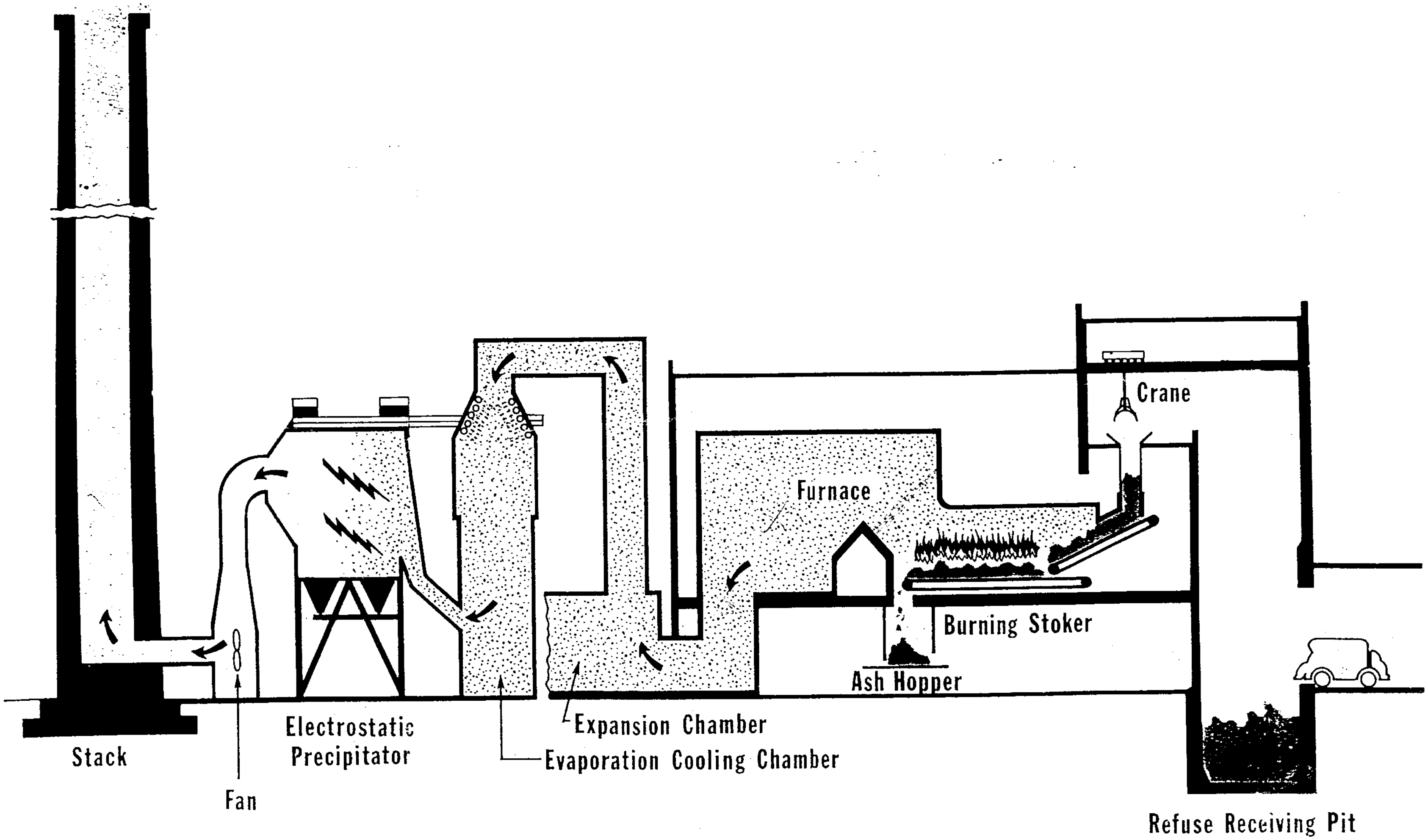

Table III

Evaluation Criteria & Health Effects Summary for Metals

New York City Department of Sanitation
New York, New York
HETA 90-0329
September 15-18,1992

Substance	Evaluation Criteria & Primary Health Effects
Aluminum	Metallic aluminum dust is considered a relatively benign "inert dust."[32] Both the NIOSH REL and ACGIH TLV for aluminum are 10 mg/m^3 TWA, while the OSHA PEL is 15 mg/m^3 TWA.
Arsenic	Exposure to inorganic arsenic can produce dermatitis (skin inflammation), keratoses (horny growths on the skin), peripheral neuropathies (diseases of the nerves of the extremities), peripheral vascular diseases (diseases of the arteries and veins of the extremities), and cancer of the skin, liver, and lungs.[33] Arsenic is absorbed primarily via inhalation and ingestion.[32] Oral ingestion from contaminated hands may result in absorption of toxicologically significant amounts of arsenic.[34] The ACGIH TLV-TWA for arsenic is 0.01mg/m^3 , with the designation of confirmed human carcinogen.[4] The ACGIH has also adopted a Biological Exposure Index (BEI) for arsenic. The BEI is 50 micrograms per gram (µg/g) of creatinine for inorganic arsenic metabolites in urine measured in workers at the end of the workweek.[33] Both NIOSH and OSHA [29 CFR 1910.1018] consider inorganic arsenic to be a potential occupational carcinogen.[5,35] The NIOSH REL (ceiling limit) is 0.02 mg/m^3, and the OSHA PEL-TWA is 0.01 mg/m^3.
Cadmium	Occupational exposure to cadmium can cause pulmonary irritation and is associated with nephrotoxicity. Several inorganic cadmium compounds cause malignant tumors in animals.[32] Most acute intoxications have been caused by inhalation of cadmium oxide fumes that did not provide warning symptoms of irritation and led to fatalities, pneumonitis, and pulmonary edema.[36,37] Cadmium exposure has been implicated to increases in prostate and respiratory tract cancer.[38] NIOSH concluded that cadmium and its compounds are potential carcinogens and recommends reducing occupational exposures to the lowest feasible concentration. The ACGIH TLV and OSHA PEL for cadmium are 0.01 and 0.2 mg/m^3, respectively.
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.[32] 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 indicates carcinogenicity among workers exposed to soluble Cr(VI) compounds.[39-43] Based on this new evidence, NIOSH recommends that all Cr(VI) compounds be considered as potential carcinogens. The NIOSH REL and ACGIH TLV for the divalent, trivalent, and metal forms of chromium are 0.5 mg/m^3, while the OSHA PEL for these forms is 1 mg/m^3. The NIOSH REL for Cr(VI) compounds is 0.001mg/m^3 as a 10-hour TWA. The ACGIH TLVs for Cr(VI) compounds is 0.05 mg/m^3, with a proposed TLV of 0.01 mg/m^3 for insoluble forms on the Notice of Intended Changes. The OSHA PEL for Cr(VI) compounds is 0.1 mg/m^3 as a ceiling concentration.
Cobalt	Occupational exposure to cobalt can cause interstitial fibrosis, interstitial pneumonitis, and sensitization of the respiratory tract and skin.[32] Three types of lung disease have been reported in the tungsten carbide industry and linked to cobalt exposures. These include an interstitial fibrotic process, a hypersensitivity pneumonitis, and an obstructive airways syndrome related to occupational asthma.[44-46] Cobalt and its compounds can also produce an allergic dermatitis that usually occurs in skin areas subjected to friction, such as the ankle, elbow flexures, and sides of the neck.[47] The NIOSH REL and the current ACGIH TLV are 0.05 mg/m^3 , while the OSHA PEL is 0.1 mg/m^3. The ACGIH has proposed a TLV of 0.02 mg/m^3 and an animal carcinogen classification on the Notice of Intended Changes.
Lead	Chronic lead exposure has resulted in nephropathy (kidney damage), gastrointestinal disturbances, anemia, and neurologic effects.[32] These effects may be felt as weakness, fatigue, irritability, high blood pressure, mental deficiency, or slowed reaction times. Exposure also has been associated with infertility in both sexes and fetal damage.[48] The OSHA PEL for lead is 0.05 mg/m^3, while the current ACGIH TLV is 0.15 mg/m^3. The ACGIH has proposed a TLV of 0.05 mg/m^3 and an animal carcinogen classification on the Notice of Intended Changes.
Manganese	Manganese fume exposure has been associated with chemical pneumonitis and central nervous system effects.[32,49] The NIOSH REL for manganese is 1 mg/m^3 TWA with a STEL of 3 mg/m^3, the current ACGIH TLV is 5 mg/m^3 TWA, and the OSHA PEL is 5 mg/m^3 as a ceiling limit. The ACGIH has proposed a TLV of 0.2 mg/m^3 on its Notice of Intended Changes.
Nickel	Metallic nickel compounds can cause sensitization dermatitis.[32] NIOSH considers nickel a potential carcinogen, as nickel refining has been associated with an increased risk of nasal and lung cancer.[50] The NIOSH REL for nickel is 0.015 mg/m^3, while both the current ACGIH TLV and OSHA PEL are 1 mg/m^3. The ACGIH has proposed a TLV of 0.2 mg/m^3 with a classification as a confirmed human carcinogen.

TABLE I

LIMITS OF DETECTION
(Micrograms per Filter)

New York City Department of Sanitation
New York, New York
HETA 90-0329
September 15-18,1992

Analyte	LOD (µg/filter)	Analyte	LOD (µg/filter)
Aluminum	3	Lead	1
Arsenic	5	Phosphorous	5
Barium	0.5	Platinum	10
Beryllium	0.5	Selenium	5
Calcium	3	Silver	0.5
Cadmium	0.5	Sodium	10
Cobalt	0.5	Tin	5
Chromium	0.5	Tellurium	5
Copper	0.5	Thallium	10
Iron	1	Titanium	0.5
Lithium	1	Tungsten	10
Magnesium	3	Vanadium	0.5
Manganese	0.5	Yttrium	0.5
Molybdenum	1	Zinc	0.5
Nickel	1	Zirconium	0.5

NOTE: The Minimum Detectable Concentration (MDC), in milligrams per cubic meters (mg/m^3), can be determined by dividing the LOD by the sample volume in liters.

Table II

2,3,7,8-TCDD
TOXICITY EQUIVALENCY FACTORS

New York City Department of Sanitation
New York, New York
HETA 90-0329
September 15-18,1992

Compound	**EPA-TEFs/87**	**I-TEFs/89**
Mono-,Di-, and TriCDDs	0	0
2,3,7,8-TCDD	1	1
Other TCDDs	0.01	0
2,3,7,8-PeCDD	0.5	0.5
Other PeCDDs	0.005	0
2,3,7,8-HxCDDs	0.04	0.1
Other HxCDDs	0.0004	0
2,3,7,8-HpCDDs	0.001	0.01
Other HpCDDs	0.00001	0
OCDD	0	0.001
Mono-,Di-, and TriCDFs	0	0
2,3,7,8-TCDF	0.1	0.1
Other TCDFs	0.001	0
1,2,3,7,8-PeCDF	0.1	0.05
2,3,4,7,8-PeCDF	0.1	0.5
Other PeCDFs	0.001	0
2,3,7,8-HxCDFs	0.01	0.1
Other HxCDFs	0.0001	0
2,3,7,8-HpCDFs	0.001	0.01
Other HpCDFs	0.00001	0
OCDF	0	0.001

TCDD-tetra chlorinated dibenzo-*p*-dioxin
CDD-chlorinated dibenzo-*p*-dioxin
CDF-chlorinated dibenzofurans
Pe-penta
Hx-hexa
Hp-hepta
O-octa

Table IV

Concentrations of 2,3,7,8-TCDD Equivalents (TEQ)

New York City Department of Sanitation
New York, New York
HETA 90-0329
September 15-18,1992

Airborne Concentrations

Sample Description	Sample Duration (min)	Sample Volume (liters)	TEQ Results using 1987 EPA-TEFs (pg/m^3)	TEQ Results using 1989 I-TEFs (pg/m^3)
Slagging of Burn Chamber	486	9700	4.3	9.0
Cleaning of Lower Chamber	476	9500	430	800
Cleaning of Upper and Lower Chambers	655	12900	12	25
Exterior; During Cleaning of Chambers	480	9600	126	263
Cleaning of Electrostatic Precipitator	383	6000	22	90
Normal Operations at Greenpoint Plant	480	9600	2.7	4.6
Evaluation Criteria: National Research Council			**10.0 pg/m^3**	

Concentrations in Bulk Samples

Sample Description	TEQ Results using 1987 EPA-TEFs (ppt)	TEQ Results using 1989 I-TEFs (ppt)
Burn Chamber	1.7	3.2
Upper Chamber	1.5	3.0
Lower Chamber	4.4	6.8
Electrostatic Precipitator	290	880
Greenpoint - Composite of Upper & Lower	17	46

TCDD-tetra chlorinated dibenzo-*p*-dioxin
pg/m^3-picograms per cubic meter
min-minutes
TEFs-toxicity equivalency factors
ppt-parts per trillion

Table V

Airborne Concentrations of Metals
Personal Breathing Zone Samples (mg/m^3)

New York City Department of Sanitation
New York, New York
HETA 90-0329
September 15-18,1992

Sample Description	Time *(military time)* **(min)**	Volume (L)	Aluminum	Arsenic	Cadmium	Chromium	Cobalt	Lead	Manganese	Nickel
Slag Scraping	*0745-0945*	*240*	*6.2*	*ND*	*0.002*	*0.054*	*0.003*	*0.071*	*0.046*	*0.004*
Slag Scraping\Lower Chamber Cleanout	*0945-1350**	*340*	*1.1*	*ND*	*ND*	*0.013*	*ND*	*0.015*	*0.010*	*ND*
Actual TWA	**290**	**580**	**3.2**	**ND**	**0.001**	**0.030**	**0.001**	**0.038**	**0.025**	**0.002**
8-hour TWA			**1.9**	**ND**	**0.001**	**0.018**	**0.001**	**0.023**	**0.015**	**0.001**
Lower Chamber Cleanout	*0814-1202*	*456*	*5.3*	*ND*	*0.002*	*0.044*	*0.002*	*0.061*	*0.035*	*0.004*
"	*1202-1353*	*222*	*3.3*	*ND*	*ND*	*0.038*	*ND*	*0.036*	*0.028*	*ND*
Actual TWA	**339**	**678**	**4.6**	**ND**	**0.001**	**0.042**	**0.001**	**0.053**	**0.033**	**0.003**
8-hour TWA			**3.2**	**ND**	**0.001**	**0.030**	**0.001**	**0.037**	**0.023**	**0.002**
Precipitator Cleanout	*0812-0922*	*140*	*24*	*0.079*	*0.33*	*0.16*	*0.016*	*4.7*	*0.27*	*0.043*
"	*0922-1235*	*386*	*1.5*	*ND*	*0.044*	*0.026*	*ND*	*0.60*	*0.021*	*0.005*
"	*1235-1257*	*44*	*48*	*0.16*	*0.73*	*0.52*	*0.032*	*8.6*	*0.70*	*0.091*
"	*1257-1350*	*106*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*
Actual TWA	**338**	**676**	**8.8**	**0.027**	**0.14**	**0.081**	**0.006**	**1.9**	**0.11**	**0.018**
8-hour TWA			**6.2**	**0.019**	**0.099**	**0.057**	**0.004**	**1.3**	**0.077**	**0.013**
EVALUATION CRITERIA**	NIOSH RELs		10	0.002 C	LFC	0.5	0.05	<0.1	1	0.015
	ACGIH TLVs		10	0.01	0.01	0.5	0.05 *(0.02)*	0.15 *(0.05)*	5 *(0.2)*	1 *(0.05)*
	OSHA PELs		15	0.01	0.2	1	0.1	0.05	5 C	1

*employee wearing this sample left premises, sampling was stopped from 1048-1203.
**evaluation criteria are listed for 8-hour time weighted averages, unless otherwise noted.

mg/m^3- milligrams per cubic meter; min- total sampling time in minutes; L- liters; ND- not detected, below limit of detection (Table I); Actual TWA- time weighted average of sequential personal breathing zone samples collected from one employee; 8-hour TWA- time weighted average for 8 hour workday using the actual TWA and assuming no further exposures; C- ceiling limit for a 15-minute sample; LFC- lowest feasible concentration; *( )*- proposed TLV on the ACGIH Notice of Intended Changes.

Table VI

Airborne Concentrations of Metals
Area Samples (mg/m^3)

New York City Department of Sanitation
New York, New York
HETA 90-0329
September 15-18,1992

Sample Description	Time *(military time)* **(min)**	Volume (L)	Aluminum	Arsenic	Cadmium	Chromium	Cobalt	Lead	Manganese	Nickel
Slag Scraping	*0747-1034*	*334*	*0.54*	*ND*	*ND*	*0.008*	*ND*	*0.006*	*0.010*	*ND*
8-hour TWA			**0.19**	**ND**	**ND**	**0.003**	**ND**	**0.002**	**0.003**	**ND**
Upper Chamber Cleanout-Outside	*0732-1452*	*880*	*0.024*	*ND*	*ND*	*0.001*	*ND*	*ND*	*ND*	*ND*
8-hour TWA			**0.022**	**ND**	**ND**	**0.001**	**ND**	**ND**	**ND**	**ND**
Lower Chamber Cleanout	*0959-1332*	*426*	*1.0*	*ND*	*ND*	*0.011*	*ND*	*0.012*	*0.008*	*ND*
8-hour TWA			**0.44**	**ND**	**ND**	**0.005**	**ND**	**0.005**	**0.004**	**ND**
Lower\Upper Chamber Cleanout-Outside	*0808-1428*	*760*	*0.18*	*ND*	*ND*	*0.002*	*ND*	*0.016*	*0.002*	*ND*
8-hour TWA			**0.14**	**ND**	**ND**	**0.002**	**ND**	**0.013**	**0.002**	**ND**
Lower Chamber Cleanout-Outside	*0800-Fault*	*274*	*5.8*	*ND*	*0.005*	*0.40*	*0.003*	*0.18*	*0.055*	*0.011*
"	*1300-1428*	*176*	*0.057*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*	*ND*
Actual TWA	**225**	**450**	**3.6**	**ND**	**0.003**	**0.24**	**0.002**	**0.11**	**0.033**	**0.007**
8-hour TWA			**1.7**	**ND**	**0.001**	**0.11**	**0.001**	**0.052**	**0.015**	**0.003**
Precipitator Cleanout	*0858-1235*	*434*	*19*	*0.042*	*0.28*	*0.12*	*0.010*	*1.4*	*0.28*	*0.035*
"	*1235-1302*	*54*	*570*	*1.2*	*9.4*	*6.1*	*0.24*	*110*	*7.0*	*1.3*
"	*1302-1359*	*114*	*0.32*	*ND*	*ND*	*0.007*	*ND*	*0.053*	*0.008*	*ND*
Actual TWA	**301**	**602**	**65**	**0.14**	**1.0**	**0.63**	**0.029**	**10**	**0.83**	**0.14**
8-hour TWA			**41**	**0.088**	**0.63**	**0.40**	**0.018**	**6.3**	**0.52**	**0.088**
EVALUATION CRITERIA**	NIOSH RELs		10	0.002 C	LFC	0.5	0.05	<0.1	1	0.015
	ACGIH TLVs		10	0.01	0.01	0.5	0.05 *(0.02)*	0.15 *(0.05)*	5 *(0.2)*	1 *(0.05)*

Fault- sampling pumps failed, total sample time was estimated to be approximately 137 minutes using the pump timers.
**evaluation criteria are listed for 8-hour time weighted averages, unless otherwise noted.

mg/m^3- milligrams per cubic meter; min- total sampling time in minutes; L- liters; ND- not detected, below limit of detection (Table I); Actual TWA- time weighted average of sequential general area samples collected from one area; 8-hour TWA- time weighted average for 8 hour workday using the actual TWA and assuming no further exposures; C- ceiling limit for a 15-minute sample; LFC- lowest feasible concentration; *( )*- proposed TLV on the ACGIH Notice of Intended Changes.

Table VII

Airborne Concentrations of Respirable Dust and Silica

New York City Department of Sanitation
New York, New York
HETA 90-0329
September 15-18,1992

Respirable Dust

Sample Description	Date	Time *military time* (min)	Volume (L)	Concentration (mg/m^3)	8-hour TWA (mg/m^3)
PBZ - Slag Scraping	9/17	*0750-1324** (200)	340	2.3	0.96
Slag Scraping	9/17	*0747-1325* (338)	575	0.38	0.27
Upper Chamber Cleanout - Outside	9/16	*0732-1452* (440)	748	0.23	0.21
PBZ - Lower Chamber Cleanout	9/16	*0820-1356** (332)	564	0.83	0.57
Lower Chamber Cleanout	9/17	*0959-1332* (213)	362	1.4	0.62
Lower Chamber Cleanout - Outside	9/16	*0800-1428** (244)	415	4.7	2.4
Upper\Lower Chamber Cleanout - Outside	9/16	*0808-1428** (231)	393	0.13	0.063
Precipitator Cleanout @	9/17	*0858-1236* (218)	371	11	
"	"	*1236-1306* (30)	51	1390†	
"	"	*1306-1359* (53)	90	239†	
Actual TWA	**"**	***0858-1359* (301)**	**512**	**189†**	**118†**
EVALUATION CRITERIA:				NIOSH\OSHA	5

*indicates that sampling pumps faulted during collection, actual sample times were estimated using pump timers.
†Results are suspect due to limitations of the size-selector (cyclone) in a confined and extremely burdened environment (see Results and Discussion section of report).

Silica (as Quartz)

Sample Description	Concentration (mg/m^3)	8-hour TWA (mg/m^3)
PBZ - Slag Scraping	trace	trace
Lower Chamber Cleanout - Outside	trace	trace
Precipitator Cleanout @	0.16	0.073
EVALUATION CRITERIA:	NIOSH ACGIH OSHA**	0.05 0.1 **

trace - detected value was between the minimum detectable concentration (MDC) and minimum quantifiable concentration (MQC) of 0.026 and 0.079 mg/m^3, respectively, based on a sample volume of 378 liters.
**percent quartz was determined to be 2.4%; therefore, the PEL for respirable dust containing 2.4% quartz calculated by using OSHA formula: 10/(2.4+2) was 2.3 mg/m^3. This PEL can only be used to evaluate respirable dust concentrations from the ESP (see Results and Discussion section of report).

PBZ- personal breathing zone sample; all others are general area samples.
Actual TWA- time weighted average of sequential collected during precipitator cleanout.
8-hour TWA- time weighted average for 8 hour workday using the actual TWA and assuming no further exposures.
@-indicates corresponding precipitator cleanout sample.

min- miutes; L- liters; mg/m^3- milligrams per cubic meter

PCDD/PCDF Congener Concentrations
Bulk Samples
(ppt)

New York City Department of Sanitation
New York, New York
HETA 90-0329
September 15-18,1992

Analyte	Burn Chamber	Upper Chamber	Lower Chamber	Electrostatic Precipitator	Greenpoint - Composite of Upper & Lower
2,3,7,8-TCDD	0.4	ND	ND	ND	ND
Total TCDD	0.57	10.63	75.46	428.88	60.99
1,2,3,7,8-PeCDD	1.27	0.73	2.01	123.39	8.63
Total PeCDD	1.66	4.82	24.01	1968.34	145.92
1,2,3,4,7,8-HxCDD	0.9	1.06	1.4	272.99	15.23
1,2,3,6,7,8-HxCDD	0.85	1.82	3.19	460.06	32.56
1,2,3,7,8,9-HxCDD	1.62	ND	2.79	667.7	39.78
Total HxCDD	3.72	24.09	40.51	5905.75	402.78
1,2,3,4,6,7,8-HpCDD	14.03	13.16	14.79	5699.32	357.56
Total HpCDD	23.19	22.69	27.63	10000	628.68
OCDD	101.95	52.22	55.27	14094.17	1066.25
2,3,7,8-TCDF	2.88	5.31	12.84	503.71	28.73
Total TCDF	2.95	11.23	61.98	2437.81	45.95
1,2,3,7,8-PeCDF	0.5	0.78	2.69	127.62	7.23
2,3,4,7,8-PeCDF	0.7	2.13	4.72	430.26	21.82
Total PeCDF	0.6	7.89	34.06	4158.6	195.93
1,2,3,4,7,8-HxCDF	3.51	2.21	5.11	1353.14	52.71
1,2,3,6,7,8-HxCDF	1.02	1.11	2.5	544.75	22.73
2,3,4,6,7,8-HxCDF	2.49	1.58	2.53	888.96	43.09
1,2,3,7,8,9-HxCDF	0.27	ND	ND	19.49	1.61
Total HxCDF	7.3	7.45	17.66	5813.68	239.84
1,2,3,4,6,7,8-HpCDF	10.16	5.47	8.38	4595.18	155.56
1,2,3,4,7,8,9-HpCDF	1.41	ND	ND	330.28	21.36
Total HpCDF	11.57	7.99	11.71	7052.73	264.33
OCDF	32.42	26.08	25.42	2730.66	135.43

PCDD - Polychlorinated dibenzo-*p*-dioxins; PCDF - Polychlorinated dibenzofurans; ppt - parts per trillion

T - tetra; Pe - penta; Hx - hexa; Hp - hepta; O - octa

PCDD/PCDF Congener Concentrations
Area Air Samples
(pg/sample)

New York City Department of Sanitation
New York, New York
HETA 90-0329
September 15-18,1992

Analyte	Slagging of Burn Chamber	Cleaning of Lower Chamber	Cleaning of Upper & Lower Chamber	Exterior; During Cleaning of Chambers	Cleaning of Electrostatic Precipitator	Normal Operations at Greenpoint Plant
2,3,7,8-TCDD	4.86	199.92	15.47	57.60	10.42	4.22
Total TCDD	123.44	31255.11	607.07	8784.10	246.96	143.90
1,2,3,7,8-PeCDD	19.44	2007.77	72.18	576.00	34.32	9.41
Total PeCDD	390.74	70499.41	1607.26	16669.44	454.08	156.96
1,2,3,4,7,8-HxCDD	26.24	2910.26	87.65	864.96	94.98	10.08
1,2,3,6,7,8-HxCDD	47.63	8775.54	179.16	2138.88	171.58	18.34
1,2,3,7,8,9-HxCDD	59.29	8603.22	246.18	2489.28	218.16	24.29
Total HxCDD	657.07	128444.79	2781.45	35081.28	1713.39	243.94
1,2,3,4,6,7,8-HpCDD	388.80	54933.26	1257.97	15700.80	3603.88	128.35
Total HpCDD	712.48	102780.78	2353.53	30609.60	6300.20	232.80
OCDD	836.89	91116.87	2559.76	32986.56	29203.60	295.78
2,3,7,8-TCDF	86.51	6166.10	320.94	2057.28	258.60	72.48
Total TCDF	451.01	7689.30	1452.59	7774.08	1274.62	540.77
1,2,3,7,8-PeCDF	19.44	1340.42	77.33	393.60	55.76	11.23
2,3,4,7,8-PeCDF	47.63	3216.81	179.16	1203.84	108.47	24.77
Total PeCDF	175.93	26676.94	1600.81	10846.08	2005.69	250.27
1,2,3,4,7,8-HxCDF	86.51	6484.07	293.87	2666.88	1074.24	32.16
1,2,3,6,7,8-HxCDF	41.80	2690.35	145.65	989.76	322.33	16.61
2,3,4,6,7,8-HxCDF	61.24	3891.78	213.96	1541.76	913.07	21.98
1,2,3,7,8,9-HxCDF	4.86	152.32	10.31	45.12	14.09	3.74
Total HxCDF	352.84	27358.58	1363.66	11076.48	4135.17	145.34
1,2,3,4,6,7,8-HpCDF	170.10	13389.88	583.87	8309.76	7210.82	62.59
1,2,3,4,7,8,9-HpCDF	25.27	1683.14	88.93	513.60	360.33	11.62
Total HpCDF	298.40	23762.87	1116.19	12157.44	10466.01	110.21
OCDF	126.36	5342.62	465.29	2398.08	5369.35	52.61

PCDD - Polychlorinated dibenzo-*p*-dioxins; PCDF - Polychlorinated dibenzofurans; pg/sample - picograms per sample

T - tetra; Pe - penta; Hx - hexa; Hp - hepta; O - octa