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ABSTRACT

The objective of this study was to characterize the resource recovery industry with regard to current or potential occupational health problems. Safety issues were specifically excluded from the scope of the investigation. The assessment described herein was based on in-depth industrial hygiene surveys at seven resource recovery facilities selected to represent the major large-scale technologies in the industry. Included were four facilities that produced a refuse derived fuel (RDF) for use off-site, two mass-burn incineration plants, and one RDF production plant which had on-site combustion.

The study findings indicate that only noise and nuisance dusts are common, excessive exposures in these facilities and, therefore, should be recognized as the most significant worker health hazards. The present nature of the industry population (its small size and short work history) precludes any retrospective epidemiological studies at this time, but the need for prospective studies may be warranted based on the microbial sampling results. Medical surveillance information, however, varies from plant to plant, with audiometry and spirometry data especially lacking. Since few of the documented exposures are of a magnitude for concern, there does not appear to be a need to develop a criteria document specifically for this industry. Furthermore, several facilities have demonstrated that current control technology is capable of maintaining worker exposures within acceptable limits. The prudent use of good industrial hygiene practices, coupled with these control methods, should ensure the continued health of the resource recovery industry work force.

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SECTION 1

INTRODUCTION

In the late 1960's and early 70's many urban communities began to realize the serious shortcomings in their solid waste disposal plans. Adequate landfill space was becoming increasingly scarce, and the feasibility of transporting refuse farther and farther from the points of collection was decreasing due to costs (1). Cities facing these problems began to consider alternative means of disposal, such as bioconversion, incineration for volume reduction, or material recycling to extract marketable components before disposal. Interest in these approaches, especially when coupled with energy recovery, received a substantial boost as fossil fuel costs began escalating rapidly in 1973. About 70 to 80% of the mass of typical municipal solid waste (MSW) is combustible, thus enabling it to be burned directly for energy recovery or to be processed into a fuel (2,3).

Today, faced with energy costs that continue to rise and concerned with the environmental effects associated with dump sites, many communities have constructed, or are planning to construct, some type of large-scale resource recovery energy system to help ease their critical disposal needs.

In early 1981, approximately 25 resource recovery plants were in operation, and design or feasibility studies for at least another 25 facilities were under way(4). The growth of this new industry that promotes the conservation of resources has a drawback, however. Namely, a growing number of workers will experience increased exposure to the potential hazards associated with the processing of large volumes of solid waste. Therefore, the National Institute for Occupational Safety and Health (NIOSH), under its mandate from Congress, has commissioned this study of the resource recovery industry in the early phases of its development.

The characterization of the resource recovery industry presented in this report is based on comprehensive industrial hygiene investigations at seven facilities representative of the three major technological approaches used for large-scale waste-to-energy systems in the United States. These are: (a) the production of a refuse-derived fuel (RDF) for combustion at an off-site boiler; (b) direct incineration of unprocessed MSW for energy recovery; and (c) production of RDF with on-site combustion (integrated system). This study included four RDF production facilities, two direct incineration sites, and one integrated facility. The characterization study included a review of the current literature on the safety and health aspects of the industry, detailed occupational health assessments to document the extent of worker exposures to occupational hazards, investigation of the data base for assessing the feasibility of epidemiological studies, evaluation of

medical surveillance programs (or the need thereof), assessment of the need for a NIOSH criteria document, and evaluation of present and developing control technologies of benefit in reducing worker exposures to hazardous conditions. Fire and explosion hazards, as well as other safety issues, were not included in the scope of this study.

For most of the facilities, this study was the first comprehensive evaluation of the occupational health aspects of their plant. This fact, coupled with MRI's use of advanced survey techniques, especially in the case of the microbiological aerosols, makes it difficult to use the limited historical evidence available to validate these findings. The compilation of data for this NIOSH characterization effort was limited somewhat by fluctuating operating schedules (mechanical breakdowns) at most of the plant sites, constraints by some plant managers on personnel sampling, and by inherent variations in the material being processed. Although the study plan attempted to reduce day-to-day and site-to-site variations, the major source of contamination--the refuse--can be extremely variable with respect to particular components. For example, although no hazardous levels of airborne asbestos were found during the surveys, it is still possible that the illegal disposal of large quantities of asbestos-containing wastes in a resource recovery facility could result in worker exposure to airborne fibers.

This report is divided into 7 sections. The introduction is followed by the study design used for this research effort; a short summary of the recent literature on the health and safety aspects of the resource recovery industry; an evaluation of control technology use; and a discussion of the feasibility of future morbidity and mortality studies. These sections are followed by the study conclusions and recommendations that are addressed separately to the resource recovery industry and to NIOSH.

Because of the volume and detail of the survey results for each plant visit, these data are presented in the appendix to this report. Also included in the appendices are descriptions of each plant's health and safety program, descriptions of each plant's employment and recordkeeping practices, and a summary of the microbiological sampling and analytical methods used by MRI and its subcontractors.

SECTION 2

STUDY DESIGN

The following subsections describe the basic study design for the "Industrial Hygiene Characterization of Resource Recovery Systems." The first subsection presents the rationale for the selection of the plant sites, the second subsection details the survey protocols, the third subsection describes the sampling and monitoring strategies, the fourth subsection gives the contaminant sampling and agent monitoring methods, the fifth subsection explains the protocol for health and safety program evaluations in each plant, the sixth subsection describes the evaluation of control technology, and the last subsection gives the assessment of retrospective cohort mortality and cross-sectional morbidity studies.

SITE SELECTION

The selection of the resource recovery facilities for in-depth industrial hygiene characterization was based on: (a) the types of processing operations within each facility; (b) the end product of the plant (refuse derived fuel (RDF), steam, or electricity); (c) the consistency of normal operations at the facility; (d) the willingness of the plant operators to participate in the study; and (e) the commercial viability of the plant process. A list of 15 representative plants was developed which met the above criteria. From this list, two waterwall incineration plants, four processing (RDF) plants, and one combined process (RDF to steam) plant were selected. Geographically these seven plants were made up of three from the East Coast, three from the Midwest, and one from the North Central region.

SURVEY PROTOCOLS

The surveys were conducted generally over a 4-day period at each facility. The plant survey was conducted as follows:

DAY 1: Information collection/walk-through survey

Information Collection

- Met with plant management to discuss plans for conducting the survey. Addressed employee participation.
- Obtained general operating information, equipment layout diagrams, and production data.
- Collected employee data (number of workers, sex, job description, length of employment, etc.).

- Obtained information on present industrial hygiene and safety programs, medical services, safety training, etc.
- Ascertained availability of employee records (accident, worker's compensation, illness, medical, insurance, etc.).
- Collected information on general maintenance, housekeeping procedures, etc.

Walk-Through Survey

- Observed equipment and workers in normal work mode.
- Recorded observations of exposure control measures (dust, vapor, noise, etc.), including personal protective devices.
- Determined sampling locations, workers to be monitored, and other survey variables.

DAY 2: Set up equipment and conducted sampling program

DAY 3: Conducted sampling program

DAY 4: Concluded any remaining sampling, packed equipment, and returned to MRI Kansas City.

Microbiological samples collected for analysis were air shipped on the day of collection. The schedule was modified at plants with special operations on second or third shifts and at plants with mechanical shutdowns or special production schedules to allow for representative sampling.

SAMPLING AND MONITORING STRATEGIES

The sampling protocols were designed to provide sufficient data to produce a reasonable estimate of the concentrations of the suspected agents to which workers may be exposed in resource recovery operations. Where applicable, 8-hr time weighted average (TWA) and peak concentrations were established. Personnel breathing zone and area sampling were conducted for agents such as physical hazards, particulates, and chemical vapors. Microbiological agents were surveyed by area techniques.

A summary of the survey sampling plan is presented in Table 1. For each agent or monitoring parameter listed, the measurement or collection method, analytical method, and sampling site or criteria are shown. As indicated, not every type of hazard assessment was performed at each plant site. Several airborne chemical agents possessed a very limited hazard potential since they were not likely to be present at above minimal concentrations. When these agents were not detected in the initial plant surveys, they were eliminated from further consideration. Also, site-specific conditions resulted in one or more hazardous agents being present in one plant environment and not in another. Thus, the full sampling plan shown in Table 1 was tailored for each individual survey.

TABLE 1. SUMMARY OF THE SITE SURVEY PLANT FOR SAMPLING

Hazard category	Subcategory, instrumentation, or collection method	Analytical method (all analyses by accredited/ licensed labs)	Sampling sites
Particulates			
1. General particulate			
a. Total concentration	a. Personnel sampler with glass fiber filter	a. NIOSH 29.02 (gravimetric)	a. All plants, most samples from the process area
b. Morphology	b. 47 mm, 0.1 µm Nuclepore filter	b. Scanning electron microscopy (SEM) (McCrone Associates, Inc.)	b. Selected plants
c. Size distribution	c. Accu-vol samplers with Sierra impactor heads	c. Gravimetric	c. All plants
2. Respirable	Personnel sampling with cyclone and filter (cassette)	Gravimetric	All plants; receiving and process areas only
3. Asbestos	Personnel sampler with MCE 0.8 µm filter	P&CAM 239/Asbestos: phase contract microscopy; SEM if required	Process areas
4. Silica	Personnel sampler with 5.0 µm PVC filter	P&CAM 109/Crystalline Silica: x-ray diffraction	Process areas
5. Welding fume	Personnel sampler with 0.8 µm filter	Gravimetric; atomic absorption if indicated	All plants, if welding during survey
6. Metals (Be, Cd, Cr, Pb, Zn)	Personnel sampler with 0.8 µm filter	P&CAM 173/Trace Metals: atomic absorption	All plants based on results from first two plants; in receiving and process areas; ash handling areas of incinerator plants
7. Oil mist	Personnel sampler with filter	P&CAM 272/Oil Mist: fluorometric spectrophotometry	All plants where appropriate (i.e., compressor area, etc.)

TABLE 1. (continued)

Hazard category	Subcategory, instrumentation, or collection method	Analytical method (all analyses by accredited/ licensed labs)	Sampling sites
Chemical			
1. Organics - general	a. By portable IR and GC	a. Direct reading, select wavelengths/columns	a. Based on results from the first two plants, receiving and process areas
	b. Solid sorbent sampling for ventilation	b. P&CAM 127/Organic Solvents: GC	b. Based on above
2. PCBs	Personnel sampler with Florisil tube	P&CAM 244/PCB: gas-liquid chromatography with EC detector	Process areas
3. PNAs	Personnel sampler with glass fiber/silver membrane filters followed by porous polymer tube	HPLC and GC/MS (NIOSH recommended method)	Process areas
4. Carbon monoxide	Direct by Interscan monitor	Direct reading	All plants, all areas where internal combustion and other CO emitting equipment are used
5. Pesticides - limited to organophosphate and carbamates	a. Impinger with water	a. By enzyme assay (cholinesterase inhibition)	a. All plants, receiving/process areas
	b. Impinger with ethylene glycol	b. Validation by GLC	b. Where necessary, based on assay
6. Ozone	Impinger	Direct reading	As indicated
7. Hydrogen chloride	Impinger	Modified NIOSH S246/HCl: automated ferricyanide colorimetric	Incinerator plants
8. Hydrogen cyanide	Impinger	Modified P&CAM 116/HCN: pyridine-barbituric acid colorimetric	Incinerator plants
Microbiological			
1. Indicators (Total bacteria count, fecal coliforms)	AGI-30 impinger train, LVAS	MPN, pour plate (includes confirmatory)	All plants

TABLE 1. (concluded)

Hazard category	Subcategory, instrumentation, or collection method	Analytical method (all analyses by accredited/ licensed labs)	Sampling sites
2. Potentially Pathogenic bacteria (<u>Staph. aureus</u> , <u>Klebsiella sp.</u> , <u>Shigella sp.</u> , <u>Salmonella sp.</u> , <u>Mycobacterium sp.</u> , <u>Mocardia sp.</u> , <u>Streptomyces sp.</u>)	AGI-30 impinger train, LVAS	Selective media, spread plate counts, and confirmatory testing	All plants
3. Potentially pathogenic fungi (<u>Aspergillus flavus</u> , <u>Aspergillus fumigatus</u>)	AGI-30 impinger train, LVAS	Spread plate, confirmatory testing	All plants
4. <u>Legionella pneumophila</u>	LVAS	Immunofluorescent microscopy; guinea pigs (by CDC)	3 plants
Viral	LVAS	--	4 plants
Noise	a. General Radio Model 1981 SLH, NIOSH Type I; 1988 SLH b. B&K Noise Dosimeters, Model 4425; Metrosonics 301	a. As per ASNI S1.13 and NIOSH published methods b. Where exposure is estimated to exceed OSHA limits	All plant areas by zones > 80 dBA or where impulse hazard exists; octave band analysis on zones > 85 dBA
Nonionizing radiation	a. Illumination - General Electric Light Meter b. Ultraviolet (welding) c. Thermal	a. Direct reading b. By survey c. WBGT	Only those plants where indicated. Heat stress or cold stress dependent on the season and plant conditions
Ventilation	a. General survey b. Ventilation studies - by hot wire anemometer (Thermal Systems No. 1650), pitot tube, and pressure by gauge and manometer	a. Location/performance data b. As per ACGIH, Industrial Ventilation Manual (16th Ed.)	All plants; all exhaust ventilation, makeup air, heating/cooling (general ventilation)

CONTAMINANT SAMPLING AND AGENT MONITORING METHODS

Particulates

Particulate contamination of the plant ambient air was evaluated to determine seven characteristics of the airborne dust. These were:

1. Total mass concentration;
2. Respirable mass concentration;
3. Particle size distribution;
4. General particle morphology;
5. Asbestos content;
6. Free silica content; and
7. Trace metal composition.

In addition, monitoring for welding fumes and oil mist was conducted where warranted.

Total and respirable mass concentrations were determined through personnel and area sampling on a full-shift basis. Particle size distribution was determined using Sierra impactor heads mounted on high-volume (Accu-vol) samplers. The general morphology of airborne particulates was defined by collecting short-term area samples on special filters for analysis by scanning electron microscopy (SEM) at McCrone Associates, Inc., in Chicago. Sampling for workroom asbestos and silica levels was done by filter collection on an area basis. The trace metal content of the airborne particulate was determined by atomic absorption analysis of filter samples collected on an area basis. Oil mist sampling was conducted only at those sites where an obvious exposure situation existed.

Chemical Agents

The determination of a profile of airborne organic contaminants inside a resource recovery plant was difficult due to the variations in the composition of refuse being processed. The MRI survey team attempted to estimate the significance of organic contamination by monitoring for a selected list of chemical agents. These were chosen on the bases of being suspected products of refuse processing and also having importance as health hazards.

An initial screening for organic contaminants (plus ammonia) was done using gas chromatographic (GC) and infrared (IR) monitoring techniques via portable instrumentation. Again, the screening process included only selected chemicals using the criteria described above. The list of organic contaminants screened for is shown below.

<u>Organic Contaminant</u>	<u>Analytical Method</u>	<u>Wavelength (IR only)</u>
Benzene	IR/GC	3.3
Turpentine	IR	3.4
Ammonia (inorganic)	IR	10.4
Methyl ethyl ketone	IR	8.5
Methylene chloride	IR	13.3
Toluene	IR	13.7
Trichloroethylene	IR	11.8
Methane	GC	-
Total hydrocarbons	GC	-

When levels of any of these contaminants were indicative of a potential health hazard, solid sorbent sampling was conducted to establish the TWA concentration of that contaminant. It also served to validate the direct reading instrument data.

Polychlorinated Biphenyls (PCB) and Polynuclear Aromatic Hydrocarbons (PNAH)--Sampling for PCBs and PNAHs was conducted at appropriate locations in selected resource recovery plants.

Carbon Monoxide--

Carbon monoxide sampling was conducted by direct reading instrumentation (Interscan COtector with strip chart recorder). All areas where potential CO exposure existed were surveyed by this method.

Pesticides--

Pesticide monitoring was limited to the processing areas of all resource recovery plants surveyed. Initial screening was conducted using an enzyme inhibition methodology with validation by gas-liquid chromatography (GLC). Monitoring was limited to organophosphorus and carbamate pesticides, as these two classes are the most widely used and should be representative of general pesticide contamination.

Hydrogen Chloride (HCl) and Hydrogen Cyanide (HCN)--

Levels of HCl and HCN were monitored only in the mass-burn resource recovery plants since the production of HCl and HCN is normally associated with the combustion of products containing chlorine.

Microbiological Agents

A comprehensive survey of airborne microbiological hazards was conducted at six facilities. Agents for microbiological analysis included several pathogenic bacteria and fungi. The survey plan included two indexing systems, total bacteria count and fecal coliforms.

Microbiological Sampling Methods--

Two types of microbiological samples were taken at each survey site. Grab samples of solid waste were taken for microbiological counts of the source materials. Samples of airborne microbiological agents were collected at each site by two methods, the AGI-30 impinger* fitted with a preimpinger† and the Litton or Sci-Med large-volume air sampler (LVAS).‡

The AGI-30 impinger has been recommended as a standard reference aerosol sampling device (5,6). However, the AGI-30 has a low sampling rate (12.5 L/min) which may not be sufficient to detect epidemiologically significant levels of microorganisms. For detecting low levels of microorganisms, pathogens in particular, it is necessary to sample a significantly large volume of air. Therefore, a cluster of AGI-30 impingers, used simultaneously and in series, was employed to increase the amount of air sampled. The impinger and preimpinger menstrooms were composited to reduce analysis costs.

The LVAS is designed specifically to detect low concentrations of microorganisms. It is capable of sampling air at a rate of from 400 to 1,200 L/min. Its ability to collect low levels of microorganisms at epidemiologically significant levels has been established (7,8).

Two types of collection menstrooms were used. Gelatin-milk solution (9) was used with the AGI-30 impinger and preimpinger. A suitable tissue culture medium with 10% (v/v) inactivated fetal calf serum was used with the LVAS.

Microbiological air samples were taken at each facility three times per day on each of 2 consecutive days by the two sampling methods. At selected facilities, two additional samples per day were taken with the LVAS for Legionella analysis at the Center for Disease Control (CDC). The samplers were placed at an elevation 5 ft (1.5 m) above the floor at a single sampling site which was selected in the facility's dusty area.

Once collected, the samples were appropriately labeled and stored in ice. Positive and negative control samples were submitted to the lab along with each day's collected specimens. Specimens were shipped daily by express air freight to Kansas City, and analysis was begun the following morning.

Microbiological sampling controls were used in the field to assess experimentally the loss of microbial viability during the sampling periods for each sampling device. This was accomplished by including samples which had selected viable microorganisms introduced into the collection menstruum. The sampling device was then operated for the specified period of time.

* Ace Glass Company, Vineland, New Jersey, Catalog No. 7540-10.

† Ace Glass Company, Catalog No. I-1033.

‡ U.S. Army, Dugway Proving Grounds, Utah, and Sci-Med Environmental Systems, Inc., Eden Prairie, Minnesota.

Microbiological Sample Analysis--

Microbiological samples from all the selected survey sites were analyzed for both indicator and pathogenic species (see Table 2). All microbiological assays (with the exception of Legionella pneumophila assay by CDC) were conducted at the University of Kansas Medical Center Microbiological Laboratories in Kansas City, Kansas.

The microbiological assays were conducted according to the following methods. Total bacteria count was determined by either spread or pour plate method using tryptic soy agar plus 50 units/ml mycostatin (10). Confirmed fecal coliform assays were conducted using the most probable number method (11).

Staphylococcus aureus was enumerated by direct spread plate assessment on Baird-Parker agar (12). Presumptive S. aureus isolates were confirmed by gram stain and coagulase tests.

Klebsiella sp. were enumerated by spread plate assessment on MacConkey-Inositol-Carbenicillin agar (13). Presumptive Klebsiella isolates were confirmed and speciated according to standard University of Kansas Medical Center procedures.

Shigella sp. were assayed by both spread plate and enrichment techniques. XLD agar was used as the plating medium and Hajna GN broth was used for enrichment. Presumptive Shigella isolates were verified and speciated using biochemical and serological tests.

Salmonella was assayed by spread plate and enrichment techniques. Bismuth sulfite and Hektoen agar served as the solid media. Selenite cystine broth incubated at 42°C served as the enrichment medium (14). Presumptive Salmonella isolates were verified and speciated using biochemical and serological tests.

Samples for Mycobacterium sp. analysis were decontaminated with NaOH, concentrated by centrifugation, and inoculated in several media. Solid media included Lowenstein Jensen medium, Lowenstein Jensen Graft, and 7H11 agar. In addition, Dubos broth was used for enrichment. Cultures were incubated for a period of 8 weeks at 35°C in 8 to 10% CO₂. Enumeration and verification of presumptive M. tuberculosis isolates was conducted in accordance with CDC recommendations (15).

Quantification of a Nocardia sp. was attempted with the spread plate technique on a Lowenstein Jensen and BHI agar media with added antibiotics, e.g., carbenicillin and amphotericin B. Verifications were conducted according to Haley (16).

Starch casein salt agar plus antibiotic was used in conjunction with the spread plate method to assess Streptomyces population (17). The plates were incubated at 28°C for 10 days. Streptomyces suspects were confirmed by spore morphology and lysozyme resistance.

TABLE 2. LISTING OF MICROBIOLOGICAL AND VIRAL ASSAYS CONDUCTED AT
RESOURCE RECOVERY PLANTS

Testing laboratory	Microbial/viral assay	Resource recovery plant
Clinical Laboratories Section ^a University of Kansas Medical Center Kansas City, Kansas	Total bacteria count Fecal coliforms <u>Staphylococcus aureus</u> <u>Klebsiella sp.</u> <u>Shigella sp.</u> <u>Salmonella sp.</u> <u>Mycobacterium sp.</u> <u>Nocardia sp.</u> <u>Streptomyces sp.</u> <u>Aspergillus fumigatus</u> <u>Aspergillus flavus</u> Total mold count	B, C, D, E, F, G
Analytical Bacteriology Branch ^b Center for Disease Control Atlanta, Georgia	Legionnaire's disease bacteria (<u>Legionella</u> and <u>Legionella-like</u> <u>organisms</u>)	B, C, F
Department of Pathology and Oncology ^c University of Kansas Medical Center Kansas City, Kansas	Adenovirus Rhinovirus Herpesvirus Poliovirus Coxsackievirus A and B Echovirus Influenza virus Parainfluenza virus Rotavirus Calici and Calici-like viruses Norwalk and Norwalk-like viruses	C, D, E, F

^a Under the direction of Dr. Norma Jack Lindsey, Head, Microbiology Section.

^b Under the direction of Dr. W. B. Cherry, Research Microbiologist.

^c Under the direction of Dr. A. M. Behbehani, Professor of Pathology.

The CDC agreed to analyze samples for Legionella pneumophila, the causative agent of Legionnaire's disease. Initially, the samples were screened by using a direct immunofluorescent stain. If sufficient presumptive organisms were observed, the samples were tested by inoculation into guinea pigs (18).

Aspergillus fumigatus levels were determined using the spread plate technique. The assay medium was 2% malt extract agar containing gentamicin and chloramphenicol (19,20,21). The plates were incubated at 42°C for 48 to 72 hr. Presumptive A. fumigatus isolates were enumerated and verified on the basis of colony texture, color, rate of growth, and conidiophore morphology.

Aspergillus differential medium containing gentamicin and chloramphenicol were used with the spread plate method to assess Aspergillus flavus levels (19,22,23). The plates were incubated at 28°C for 72 hr. Verification of isolates was conducted as for A. fumigatus.

Viral Agents

A survey for viral agents was conducted in conjunction with the microbiology assay at four facilities.

Viral Sampling Methods--

Two types of samples were taken at each survey site for virological analysis. Grab samples of solid waste were taken for viral titers of the source materials. Aerosol samples were taken at each site by two biological sampling devices, the all-glass impinger (AGI-30) fitted with a preimpinger and the Litton LVAS.

One solid waste grab sample was taken per day with sterile gloves and placed in sterile Whirl-Pak bags for transport. The solid waste samples were refrigerated at approximately 4°C following collection.

The AGI-30 impinger was included in the aerosol sampling protocol as a reference sampling device. To compensate for the AGI-30's low sampling rate (12.5 L/min), a cluster of four AGI-30 impingers fitted with preimpingers was operated simultaneously to increase the amount of air sampled.

Preimpingers were included with the AGI-30's for two purposes. First, the preimpinger removed particulates greater than 5 µm in size. The large particulate cutoff prevented clogging of the AGI-30 orifice. Second, the preimpinger which operated with 5 ml of collection menstruum allowed more gradual rehydration of the particles collected by the AGI-30. The preimpinger and impinger menstruums were composited to reduce analysis costs.

The LVAS was operated at 1,000 L/min and had an electrical potential of 14 kV. Fluid throughput rate was operated near each instrument's maximum capacity (~ 8 to 12 ml/min) because of the dusty conditions within resource recovery facilities.

Two types of collection menstrooms were used during the study. Gelatin-milk solution (9) was used with the AGI-30 impinger and preimpinger. Eagle's basal medium (BME) with Hank's salts and 10% heat inactivated bovine serum was used with the LVAS.

Microbiological air samples were collected at each facility three times per day on each of 2 consecutive days by the two sampling methods. The samplers were placed at an elevation 5 ft (1.5 m) above the floor at a single sampling site which was selected in one of the facility's worst case areas.

After collection, the aerosol samples had the following antibiotics added: 200 to 400 units/ml penicillin; 100 to 200 µg/ml streptomycin; and 5 to 10 µg/ml fungizone. The samples were then frozen, stored, and shipped on dry ice. All samples were shipped daily by air to MRI in Kansas City for analysis.

Viral Sample Analysis--

All virus analyses were conducted at the University of Kansas Medical Center (UKMC) Virology Laboratories. The UKMC laboratories are American Society of Certified Pathologists (ASCP-) and CDC-certified.

Solid waste and liquid aerosol samples were analyzed for human virus content. The frozen samples were thawed quickly and processed immediately after receipt at the analytical labs.

The solid waste sample was homogenized in 10% beef extract at pH 7.0 (24) or by some other suitable procedure. The homogenate was centrifuged at low speed to remove the large particulate fractions. The supernatant was saved and processed according to procedures used with the liquid aerosol samples.

All samples were concentrated approximately 25-fold by ultracentrifugation prior to virus analysis. Each sample was shaken, homogenized, and centrifuged at low speed to remove the large particulate fraction. The sample was ultracentrifuged, and the precipitate was reconstituted to 5 to 10 ml for analysis.

The concentrated samples were quantitatively screened by inoculating aliquots of 0.2 ml into five roller tubes each of the following cell lines; human embryonic lung (HEL) fibroblasts; heteroploid monkey kidney cells (LLC-MK₂) (25); and Madin Darby canine kidney cells (MDCK) (26,27). The tubes were rolled at 37°C for a minimum of 7 days and observed daily for viral cytopathic effects (CPE). Tubes showing CPE, hemadsorption, or hemagglutination were purified and further tested to determine the group of the isolated virus.

The target virus sensitivity of each cell line is depicted in Table 3.

Two litters of suckling mice (~ 8 to 12 mice per litter) were inoculated with a second portion of concentrated sample for isolation of coxsackievirus type A. The mice were observed for paralysis, and those exhibiting symptoms were treated by histopathologic methods for the detection of coxsackievirus type A.

TABLE 3. TISSUE CULTURE CELL LINE SUSCEPTIBILITIES^a

Cell line	Viral susceptibility
Primary monkey kidney (Cynomolgus)	Coxsackie B viruses Echoviruses Polioviruses Influenza viruses Parainfluenza viruses
Human embryonic lung (HEL)	Adenoviruses Rhinoviruses Herpesviruses
Madin Darby canine kidney (MDCK)	Influenza viruses Parainfluenza viruses

^a Each cell line may exhibit broader susceptibilities to viruses other than those presented and cross susceptibilities may occur.

The third portion of the concentrated specimen was tested by electron microscopy (28) for the detection of rotaviruses (29,24), Norwalk (30), or Norwalk-like viruses (31), and caliciviruses (32). These viral agents, while not recoverable in cell culture, have become increasingly associated with diarrhea and vomiting outbreaks.

Positive specimens during the qualitative tests were quantified by diluting 10^{-1} to 10^{-5} and inoculating these dilutions into either of the above three assay methods.

Noise

General Survey--

The sampling strategy for measuring noise levels was evaluation of exposure zones rather than surveys of specific equipment. This technique minimized the number of measurements while optimizing their significance in terms of worker exposure. The noise survey consisted of the following components:

1. Determine areas with sound levels at or above 80 dBA using a precision sound level meter-slow response.
2. Monitor areas containing peak or impact noise.
3. Conduct octave band analysis of noise from equipment above 90 dBA.

General area sound levels were determined during walk-through surveys using a General Radio 1982 or 1988 precision sound level meter. These readings were identified on plant layout diagrams.

On the second day, these same areas were further defined and checked for variation from the previous day. Levels were again identified on the plant layout maps. The same procedure was used to record impact noise zones.

On the second or third day, octave band measurements were taken to characterize the plant's major noise sources.

Personnel Monitoring--

Data collected during the zone designations were used to select employees for noise dosimetry measurements. Only those employees with exposure potentials greater than 85 dBA/8 hr were selected to wear dosimeters. Personnel exposure noise measurements utilizing a B&K Model 4425 (set at 90 dBA) or Metrosonics Model 301 dosimeters were taken during the second and third day of the survey.

Equipment Calibration Procedures

All instrumentation used in this study was calibrated according to the manufacturers' specifications or according to NIOSH specifications. Calibration procedures and results were noted on the industrial hygiene monitoring data sheets. Sampling pumps were field-calibrated with primary standards before and after their use. Direct reading instruments were calibrated using known gas concentrations or standards or via an absorbent filter zeroing protocol (as was done for the MIRAN-1A IR analyzer).

HEALTH AND SAFETY PROGRAM EVALUATION

Health and safety programs at each facility were documented. This was based on formal and informal documentation of monitoring and sampling programs, work practice procedures, personal protective equipment, inspections, accident and injury reports, safety and health committee reports, training records, etc., from the management at each plant.

EVALUATION OF CONTROL TECHNOLOGY

Concurrently with the comprehensive industrial hygiene survey of resource recovery facilities, MRI assessed the current state of control technology used to minimize worker exposures. Although control technology was defined to include engineering controls, process and area monitoring systems, work practices, and personal protective equipment, the emphasis in this portion of the study was on the first two methods. Work practices and personal protective device usage were evaluated under other areas of the survey.

The objectives of the control technology evaluation, within the constraints of normal plant operations, were to:

1. Document the extent and design of currently used control technology;
2. Evaluate the effectiveness of the control methods found;
3. Identify the needs for new or improved technology; and

4. Recommend programs for control technology research and development.

Information was gathered from discussions with plant personnel and from direct observation regarding design specifications, operating modes, reliability and maintenance, and impact on process operation. To the extent possible, actual performance parameters were determined by taking field measurements of flow rates, velocities, temperatures, etc. These determinations overlapped with the general ventilation assessment task.

Control system effectiveness was determined through a combination of: (a) observations by the control technology engineer; (b) engineering evaluation of the performance parameters; and (c) results of the industrial hygiene air monitoring program.

ASSESSMENT FOR RETROSPECTIVE COHORT MORTALITY AND CROSS-SECTIONAL MORBIDITY STUDIES

The assessment for retrospective cohort mortality and cross-sectional morbidity studies for the resource recovery industry was conducted with the assistance of Dr. John Neuberger, an environmental epidemiologist at the University of Kansas Medical Center. The assessment was based on the availability and validity of employee data, availability of a suitable control population, and the results of the industrial hygiene assessments (i.e., the type and degree of occupational hazard identified).

SECTION 3

SUMMARY OF LITERATURE REVIEW

To obtain background information for the subject program and to supplement the results of this study, MRI conducted a review of the published literature. This search focused on the following areas:

1. Previous occupational health and safety studies of the working environments in resource recovery plants or related facilities.
2. Epidemiological evaluations of workers in the resource recovery industry or related areas.
3. Information pertaining to the use of industrial hygiene control technology in the industry.
4. Information about operational facilities, such as process descriptions, workforce descriptions, health and safety programs, and recordkeeping procedures.
5. Sampling and analytical techniques for use in the industrial hygiene surveys.

Both manual and computer literature search methods were used. The computerized data bases or sources included in the review were: NTISearch, Enviroline, Medline, Chemical Abstracts Search, Pollution Abstracts, and Toxline, in addition to internal computer searches conducted by the NIOSH project officer. The manual search consisted of reviewing current issues of periodicals which would not be included in a computer data base, as well as consulting published bibliographies and reference lists prepared by other researchers.

The results of the search showed that, as expected, only a limited amount of published information pertains directly to occupational health and safety issues (fewer than 20 references). The majority of the literature concerned with the resource recovery industry is directed toward the economic, technical, and social aspects of the processing systems. The published literature indicated that occupational health studies have been conducted previously at five refuse processing facilities. Four of these were pilot plants or test facilities (NCRR in Washington, D.C., Richmond, California, St. Louis, and Warren Spring Laboratory in England), while only one was a full-scale operating plant (Ames). The reported studies undertaken at the Richmond Field Station (33), the St. Louis Refuse Processing Plant (34-36), and the Ames Solid Waste Recovery Plant (37-39) were fairly broad. Each monitored

for dusts and their physical/chemical characteristics, noise, and microbiological aerosols. The evaluation conducted at NCRR (40) did not include noise measurements, and only microbiological agents were investigated at the Warren Spring Laboratory (41). An earlier microbiological study of the environment within a solid waste incinerator was performed by researchers at the University of Michigan (42).

It is quite likely that some of the presently operating resource recovery facilities have conducted their own industrial hygiene evaluations, but the results of this work have been kept confidential.

Overviews or summaries of the occupational health problems facing the resource recovery industry have been presented by Duckett (43,44) and Zerwas et al. (45,46). Both concluded that serious work-related hazards were not evident, but that further, more definitive studies were needed to answer questions regarding exposure hazards such as asbestos, noise, and microbiological organisms. The earlier plant studies have done much to improve the base of knowledge in these areas, but were usually not comprehensive or detailed enough to satisfy the more subtle areas of concern. It was for these reasons that NIOSH commissioned the subject program to provide the needed information.

There have been no rigorous epidemiological studies of resource recovery workers and there are very few data on their adverse health experiences. This lack of data may be attributed to the fact that no serious health problems have been evident among the employees of these facilities and that the industry is still in a developmental stage.

Several epidemiologic studies of municipal sanitation workers, however, have been published. One of the most recent of these, done by Cimino (47), reviewed the injury and disease statistics compiled by the New York City Department of Sanitation (NYCSD). He concluded that the incidence of acute respiratory conditions for NYCSD workers does not exceed that of the general population. Cimino also found a slightly higher rate of arthritis compared to other industry categories and higher overall injury rates, but no skin disease or hepatitis problems. The most disturbing finding was that of increased coronary heart disease in the cohort examined. The reasons for the high incidence rate were not known.

Managers of the facility at Ames, Iowa have published the findings of an internal study which showed that workers at their resource recovery plant did not lose more time due to accident or illness than did their counterparts in other city departments (48). Nor did they exhibit a higher turnover rate. From these observations, the authors concluded that the plant workers were not being subjected to any extraordinary hazards and were just as safe in their jobs as other city workers.

Information about the use of industrial hygiene control technology is also generally lacking. One study (39) noted a significant reduction in the in-plant levels of airborne bacteria after a dust control system was retrofitted at the plant. Another study (49) at the same facility measured dust concentrations before and after the control system installation and found

consequent reductions ranging from 29 to 95% at various locations. No other discussions of control technology applications were found during the literature review other than the acknowledgment of the presence or absence of control technology at the facility in question.

Considerable material pertaining to the plants and their design and methods of operation was compiled from the search. Several of the facilities have had numerous articles written about them for presentation at technical conferences. However, these publications rarely contained information about the personnel at the plants or the health and safety programs used.

The literature search did not yield much useful advice for the planned survey sampling and analytical methods. MRI had already done considerable research in the area of microbiological sampling, and the investigators did not uncover any new information to supplement that data base. The other air sampling and analytical methods employed were standard NIOSH procedures and did not require further development.

SECTION 4

EVALUATION OF CONTROL TECHNOLOGY IMPLEMENTATION

At each of the resource recovery facilities surveyed for this study, MRI conducted an assessment of the use of control technology to minimize worker exposures. The objectives of this evaluation were to:

1. Document the types and extent of controls currently in use;
2. Evaluate the observed effectiveness of the control method;
3. Identify the need for new or improved control technology, or better use of current technology; and
4. If needed, recommend a program for control technology research and development.

Information was gathered during the plant surveys through discussions with plant personnel pertaining to design specifications, operating modes, reliability and maintenance, and the impact on process operation of the engineering controls employed in the facilities. Actual performance data were collected by measurement, as well by observation, and physical inspection while conducting each plant survey. Similar methods were used to collect information regarding personal protective equipment usage and work practice/administrative controls. The following sections summarize the study findings for each type of exposure control method according to facility category (i.e., RDF production, incineration, and combined).

ENGINEERING CONTROLS FOR AIRBORNE CONTAMINANTS

RDF Production

Of the four resource recovery facilities surveyed by MRI that were engaged solely in RDF production, three utilized engineering controls (i.e., exhaust ventilation) to limit fugitive dust emissions from their processing equipment. The fourth facility (Plant C) had a ventilation system originally in place, but it has been disconnected and was no longer in use when the MRI survey was conducted. Plants A, B and E have included local exhaust ventilation systems as an essential component of their operations. Both B and E are newer facilities which have incorporated these control systems into their plant's original design. Plant A, however, was one of the first established resource recovery facilities and its dust collection system was retrofitted after three years of operation.

Plant A--

The dust collection system at Plant A consists of two separate operations:

1. Routing of the ADS exhaust air through a fabric filter (baghouse) to remove particulates.
2. A local exhaust system with six dust collection hoods located over equipment in the processing area. The dust laden air is routed to the same baghouse used to control the ADS exhaust air emissions.

The decision to retrofit was based on the following needs:

1. Reduce the fire hazard;
2. Reduce plant clean-up costs;
3. Reduce electric motor and electric equipment repair and maintenance; and
4. Reduce plant downtime due to equipment failure.

Industrial hygiene concerns were not a part of the retrofit decision, but were acknowledged as a secondary benefit.

Dust collection hoods are located over each of the shredder discharge conveyors, over each disc screen, and over the bucket elevator discharges onto the conveyors leading to the reject storage bins. A duct manifold system connects these hoods to a 37.3 kW (50 hp) fan which discharges into the baghouse.

The baghouse consists of four sections or banks, three of which can be operated at one time to handle the air flow while the fourth is taken off-line for cleaning. Once every 18 min, each of the four sections is bypassed and the filter bags mechanically shaken for 2 min.

Dust collected by the baghouse drops into a metering air lock feeder (one for each section) and is pneumatically removed by a fan powered by a 7.4 kW (10 hp) electric motor. Collected dusts are readded to the fuel. This fan discharges into a cyclone separator. The cyclone separator and its air lock feeder are connected to the surge bin feeding the ADS system, and air discharged from the cyclone is returned to the baghouse system. Filtered air from the baghouse discharges into the processing area near the plant roof (positive pressure-type baghouse). Table 4 is a schedule of air flows for the processing plant dust collection system.

Plant B--

The original design of the plant included a dual dust control system for each of the processing lines. The dual system includes a two-unit baghouse to remove particulates from the exhaust of each air classifier. Also, a two-unit baghouse and dust collection system are used to control fugitive dust from the refuse processing operations.

TABLE 4. DUST COLLECTION SYSTEM AIRFLOW AT PLANT A

Measurement location	Air velocity m/s (fpm)	Duct diameter cm (in.)	Air flow m ³ /s (cfm)
A. First shredder discharge	25.9 (5,098)	27.9 (11)	1.59 (3,369)
B. First disc screen discharge	25.9 (5,098)	27.9 (11)	1.59 (3,369)
C. Second disc screen discharge-east duct	23.6 (4,646)	20.3 (8)	0.77 (1,632)
D. Second disc screen discharge-west duct	22.4 (4,409)	20.3 (8)	0.72 (1,526)
E. Second shredder discharge	12.2 (2,402)	35.6 (14)	1.21 (2,564)
F. <u>Conveyor to reject bins</u>	14.7 (2,894)	22.9 (9)	<u>0.60 (1,271)</u>
<u>Total-dust pick up hoods</u>			<u>6.48 (13,730)</u>
G. Baghouse dust transport	18.8 (3,701)	40.6 (16)	2.44 (5,170)
H. Total system, main duct to baghouse	26.0 (5,118)	66.0 (26)	8.92 (18,900)

The dust collection hoods are located at all major points of dust emission. These major points are:

- At the picking area over the drag conveyor feeding the primary shredder.
- Inside the shredder area.
- Discharge of the heavy fractions from the air classifier.
- Discharge of the light fraction from the deentrainment cyclone.
- Discharge of heavy fraction disc screen.
- Discharge of light fraction disc screen.
- Over the trommel area.
- Side pick up from the Dings magnetic ferrous removal discharge.

Additional pickup points are located wherever material is transferred from one device to another. There are a total of 21 exhaust hoods for each processing line. Airflows were measured at 7 of the 21 pickup points and before the baghouse on the No. 1 processing line. These are shown in Table 5. The other 14 exhaust ducts were inaccessible or inoperative.

Plant E--

An extensive dust control system has been incorporated into the design of the Plant E facility. Collection points (hoods) are located throughout the processing areas. All captured dust is subsequently ducted to one of four fabric filters located on the roof of the plant. Three of the four collectors are used to control dust from equipment associated with the plant's initial and middle processing step. The dust collected by these three units is eventually discarded. Dust collected from the final processing steps, however, is sent to the fourth fabric filter and the material thus captured is routed back to the process and becomes part of the final product.

Emissions from equipment in process line 100 are collected by Filter F-401, which is rated at 30,500 cfm. This section of the dust collection system utilizes 15 collection points. Filter F-402, rated at 28,700 cfm, controls emissions from process line 200 using 14 collection points. The line 100 flail mill has two dust collection points with a combined exhaust rate of 10,000 cfm and the line 200 shredder also has two collection points with a total of 14,000 cfm of exhaust. These two portions of the system, along with 12,000 cfm of exhaust from the ferrous metal scrubber operation, are ducted to Filter F-801.

The collection system which controls emissions from the final fuel processing step (i.e., output end of both secondary trommels, the two ball heaters and the ball storage units) has 14 collection points and a total airflow of 16,650 cfm.

TABLE 5. LOCAL EXHAUST VENTILATION SYSTEM PARAMETERS AT PLANT B

Location	Velocity ^a 1	Velocity ^a 2	Velocity ^a 3	Average	Duct Dia	CFM
Baghouse West	1,700	1,750	1,400	1,620	22"	4,268
Baghouse East	2,200	3,200	3,000	2,800	22"	7,391
1	NM				9"	
2	NM				6"	
3	NM				6"	
4	NM				6"	
5	NM				6"	
6	NM				6"	
7	NM				6"	
8	NM				6"	
9	NM				16"	
10	NM				16"	
11	90	100	90	93	6"	18
12	Not Operating					
13	4,700	4,800	4,800	4,767	6"	936
14	3,700	3,800	3,700	3,733	6"	733
15	NM				6"	
16	300	280	280	287	6"	56
17	5,000	5,000	5,000	5,000	6"	982
18	2,500	2,500	3,000	2,667	6"	524
19	2,100	2,400	4,000	2,833	6"	556
20	NM					
21	NM					

^a Velocity in feet per minute.

NM - Not measured.

Table 6 contains a listing of each exhaust hood or collection point in the system and its design flow rate. Measurements taken during the MRI survey at several locations are shown in Table 7.

The dust control systems at Plants B and E are similar in that they are comprehensive networks with collection hoods at all major points of dust generation. Also, each plant has dual processing lines which have separate exhaust ventilation systems so that they can be operated independently. At both facilities, fabric filters are used to de-entrain the collected dust particles. One difference between the two systems is in the ductwork designs. All duct branches lead to a single main duct and then to a single baghouse at Plant B (for each half of the plant), while at Plant E, there are five fabric filters which serve the entire system. Thus, at Plant E, if one of the baghouses is temporarily out of service, only a portion of the dust control system is nonfunctional, whereas at Plant B, the dust control system for one-half of the processing equipment would be shut down should one of the baghouses become inoperative.

Plant C--

The dust control system at Plant C was incorporated into the original plant design. It consists of dust collection hoods at the major dust generating points and a baghouse for particulate removal. A schematic diagram of this system is shown in Figure 1. The dust collection points include the north and south shredders, the center compactor, the glass and aluminum recovery units, and the air classifier system.

Each collection hood is equipped with a means to control the airflow. The shredders have hydraulically operated slide valves, while all of the other valves are manually operated dampers. Air is pulled through the system by an 85,000 cfm I.D. fan located on the clear air side of the baghouse.

At the time of the MRI survey, the dust collection system was not operating, but the I.D. fan was being used to provide air for the air classifier system and the secondary shredder. In this mode, excessive dust produced by the two unit operations is collected by the baghouse, thus preventing its release into the plant.

Other ducts in the original system are now closed off. In the R&D area, the glass and aluminum recovery units are not in operation. Therefore, the exhaust ducts to these units are blocked. The duct to the south shredder was disconnected when a modification was made to the infeed conveyor, and the slide valve is kept closed. The north shredder duct is still connected to the infeed hood, but its slide valve is also kept closed. Similarly, the valve in the duct leading to the center compactor hood is kept closed. This hood has been modified to include the south compactor.

The dust collection scheme at each shredder includes a cyclone separator just after the pickup point. These collectors are intended to remove large particles from the airstream and thereby reduce the burden on the I.D. fan, which is at the opposite end of the dust collection system.

TABLE 6. DUST COLLECTION SYSTEM EXHAUST POINTS AND FLOW RATES AT PLANT E

Filter No.	Fan No.	Equipment served	Rated airflow (cfm)
F-401	B-401 30,500 cfm at 11.5 in. s.p.	Primary Trommel R-101	2,000 (3)
		Primary Trommel over output conv C-103	2,000
		Primary Trommel over output conv C-104	1,900
		Primary Trommel under output conv C-108	3,200
		Magnetic Separator R-103	1,000 (2)
		Magnetic Separator Non-Fe output conv C-109	4,000
		Magnetic Separator Fe output conv C-111	750
		Magnetic Separator Fe output conv C-112	750
		Magnetic Separator Fe output conv C-801	750
		Magnetic Separator Non-Fe output conv C-109 at entrance to ADS R-104	1,400
		Secondary Trommel R-105	2,250 (2)
F-402	B-402 28,700 cfm at 12 in. s.p.	Primary Trommel R-201	2,000 (3)
		Primary Trommel under output conv C-208	2,400
		Primary Trommel over output conv C-203	2,000
		Primary Trommel over output conv C-204	1,900
		Magnetic Separator R-203	1,000 (2)
		Magnetic Separator Non-Fe output conv C-209	4,000
		Magnetic Separator Non-Fe output conv at ADS	1,400
		Magnetic Separator Fe output conv C-801	750
		Magnetic Separator Fe output conv C-801 at densifier	1,100
		Secondary Trommel R-205	2,250 (2)
F-801	B-201 14,000 cfm at 12 in. s.p. B-302 11,000 cfm at 10.5 in. s.p.	Shredder R-202 output	12,000
		Shredder R-202 output conv C-208	2,000
		Metal Scrubber R-301	11,000
F-801	B-101 10,000 cfm at 12 in. s.p.	Flail mill R-102 output	7,300
		Flail mill R-102 output conv C-102	2,700

TABLE 6. (concluded)

Filter No.	Fan No.	Equipment served	Rated airflow (cfm)
F-410	B-410 16,650 cfm at 11.5 in. s.p.	Secondary Trommel R-205 over output	1,500
		Secondary Trommel R-205 over output conv C-215	2,500
		Secondary Trommel R-205 under output conv C-911	750
		Secondary Trommel R-105 over output	1,500
		Secondary Trommel R-105 over output conv C-115	2,500
		Secondary Trommel R-105 under output conv C-911	750
		Ball Heater R-207 conv C-220	1,200
		Ball Heater R-107 conv C-120	1,200
		Storage R-702 conv C-705	350
		Storage R-702 conv C-702	350
		Storage R-701 conv C-701	350
		Storage R-701 conv C-706	350
		Storage R-701 conv C-708	350

TABLE 7. MEASURED AIRFLOWS IN DUST COLLECTION SYSTEM AT PLANT E

Test location	Air velocity (ft/min)	Air temp. (°F)	Measured airflow (cfm)	Airflow specified (cfm)	Duct diameter (in.)
Conveyor No. C-109 at input	480	80	167	1,400	8
Conveyor No. C-108 at input end	560	80	440	3,200	12
Conveyor No. C-203 at input end	>6,000	75	3,290	2,000	10
Conveyor No. at ADS input	1,700	105	593	1,400	8
Magnetic separator output conveyor No. 801	4,400	80	855	750	6
Trommel Line 100 Trommel Line 200	Each trommel has 3 ducts for dust collection. The valves in these 6 ducts were fully closed with the air bleed down stream of each valve open fully.				

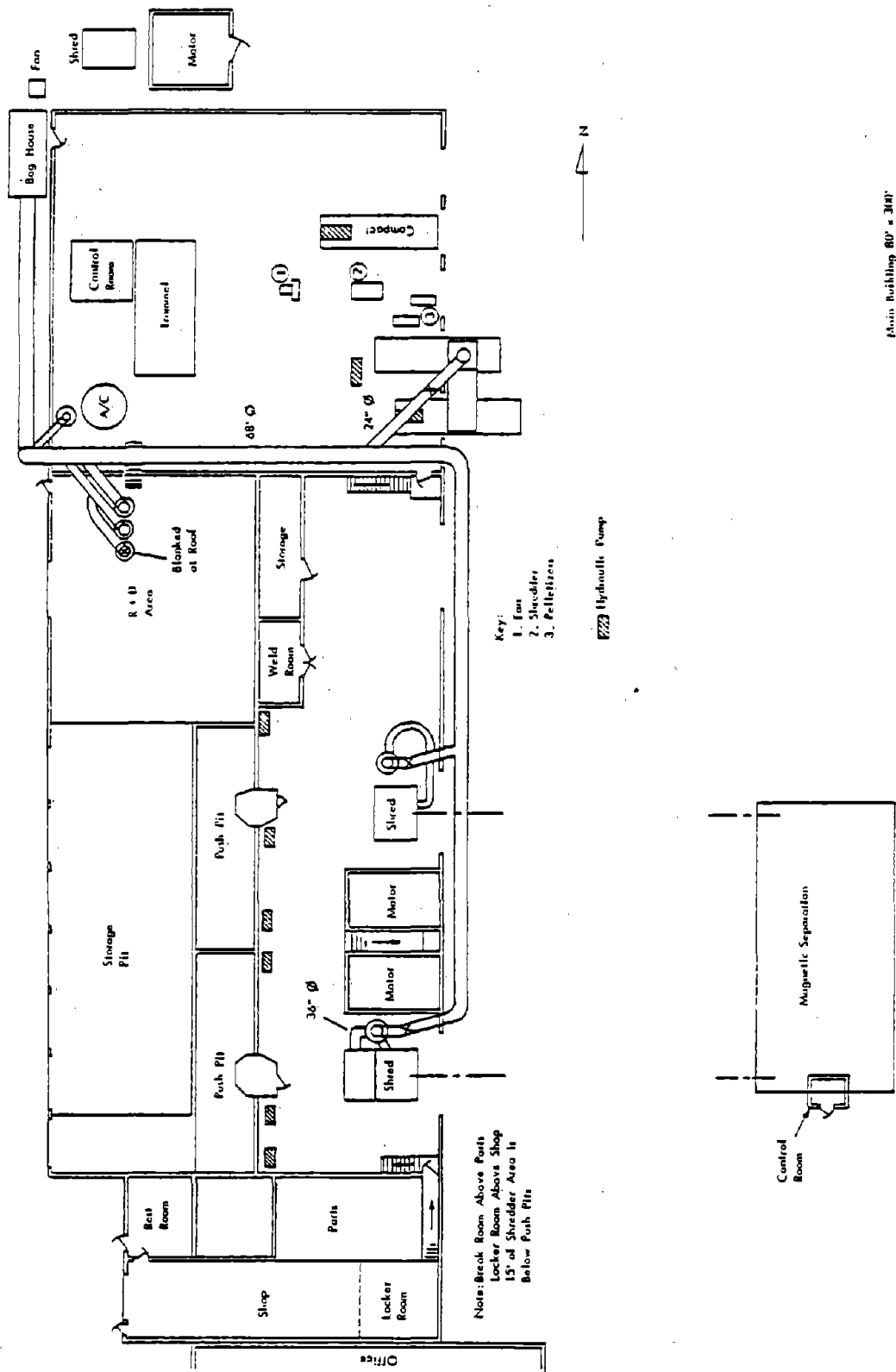


Figure 1. Plan view of the dust collection system at Plant C.

MRI's evaluation of the effectiveness of the dust control system at a particular RDF processing plant was primarily based on observation of its operation and air sampling results. Time restraints, along with the physical inhibitions (inaccessability and hazards) of making detailed measurements, precluded a thorough engineering analysis of each system. Likewise, air sampling conducted with and without operation of the control system being evaluated would have provided valuable information, but could not be done under the program constraints. A previous study at Plant A, however, indicated a significant reduction in airborne dust concentrations after the dust control system had been installed (48). The average decrease was reported to be approximately 80%.

Of the three operating dust control systems at RDF production facilities surveyed for this study, two were judged to be only fairly effective and one appeared to provide good dust control. In all three cases the designs were sound, but problems existed with system imbalances and inadequate airflows. For example, Plant E appeared to have a well-designed, comprehensive exhaust ventilation system when viewed on the blueprints. However, airflow measurements made in ducts leading from several conveyor hoods showed severely decreased volumetric flowrates compared to the design specifications. These air velocities were insufficient to collect and transport particulate material through the system. At other points, the airflows were much higher than specified. Similar deficiencies were found when the system at Plant A was evaluated.

Relatively effective dust control was provided by the exhaust ventilation system at Plant B. No areas of excessive dust emissions were observed and the highest airborne dust concentration measured by MRI was 1.5 mg/m^3 , even though only one-half of the dual-section control system was operative at the time of the survey. Plant operation was normal, although somewhat reduced from full capacity.

The findings from MRI's evaluation of engineering controls employed at RDF production facilities can be stated as follows:

- Local exhaust ventilation can be used in an effective manner to reduce fugitive dust emissions from refuse processing equipment.
- The most serious problem appears to be one of operation and maintenance, i.e., keeping the system balanced and maintaining sufficiently high flowrates in each branch to transport the collected material.
- Although some minor redesign would be beneficial to the control systems evaluated in this study, it can be concluded that conventional ventilation methods and equipment are adequate to reduce dust levels within RDF processing facilities.

Incineration

Two of the resource recovery facilities surveyed by MRI (Plants D and G) had no "front-end" processing of the solid waste received. All the material was incinerated directly with some separation of the residual components after the combustion stage. This kind of resource recovery facility is similar to a utility power plant in that the major operating portion consists of the boilers and their auxiliary equipment. These areas are relatively clean, for the most part, and do not require engineering control systems. Both of the plants surveyed also included wet quench systems at the boiler ash discharge points, thus virtually eliminating the potential of dust exposures in those plant areas.

The solid waste handling portion of each facility, however, can be a dusty environment requiring some type of ventilation control. This area typically includes a tipping floor, a refuse storage pit and furnace charging hoppers on an elevated level. It is also completely segregated from the boiler areas of the plant. Both of the facilities surveyed by MRI used only general ventilation methods to provide a measure of ambient dust level control in the MSW handling areas. Engineering controls, such as local exhaust ventilation, are not adaptable to these areas because of the large room volumes (high ceilings) involved, the large area of dust generation (not a small, defined source), and the activities of the overhead cranes above the refuse pit (cannot obstruct craneways). Therefore, any dust control must be effected through the use of roof ventilators or by natural air movements. Both Plants D and G also had placed their boiler combustion air intakes near the feed hoppers on the charging decks. By doing this, some of the dust-laden air rising from the storage pit below or generated from the cranes dropping refuse into the hoppers is removed from the area and is drawn into the boilers. The amount of air required by the boilers in each facility (even when operating at full capacity), however, is not sufficient to serve as the sole method of dust control for the whole charging floor-storage pit-tipping floor area.

In addition, the MSW handling portions of incineration facilities are generally low exposure areas. Crane operators are enclosed in air-filtered, air-conditioned cabs and front loader operators on the tipping floor may have similar protection. The only other workers exposed are usually associated with managing vehicle traffic on the tipping floor or are maintenance personnel. None of these categories of employees were found to be overexposed, based on the MRI surveys.

Another dust control method is commonly available to resource recovery plants of this type and was found at both of the incineration sites surveyed. Water spray nozzles are located in the back wall of the storage pit for use on pit fires. These water sprays can also be used to control dust arising from the pit and to dampen the stored refuse there, but according to the plant personnel, are rarely used for this purpose.

In summary, engineering controls are not used for airborne dust abatement at mass-burn incineration facilities. The combustion equipment segment of such plants does not require dust control, while the MSW handling areas are

ventilated by a combination of general mechanical methods (roof fans and combustion air intakes and natural air movement through open doorways).

RDF Production with On-Site Incineration

One survey site included in the study consisted of the production of an RDF followed by direct, on-site incineration for the production of steam (Plant F). This facility is unique in its design, possessing different equipment layouts and unit operations designs than were commonly seen at the other six survey sites. Most important, the plant design did not include provisions for either a localized dust collection system or a general exhaust ventilation plan. Louvers and open doorways provide the only work area ventilation. The MRI survey showed this to be insufficient in several areas of high dust concentration, primarily in the boiler ash handling areas. An exhaust ventilation system tailored to these specific locations would likely reduce dust exposures to a very low level and result in much cleaner floors and equipment surfaces.

Fan intakes in two portions of the plant help to produce an inflow of outside air through doorways and louvers. The blowers for the two air classifiers draw air across the tipping floor, down through the storage pits (beneath the tipping floor), and past the shredders (a distance of about 250 ft). The three, forced-draft boiler combustion fans draw their air from the outside through louvers in nearby walls and through truck entrances on the floor below. These fans produce a moderate amount of air movement when they are in operation, but cannot be considered as engineering controls. They tend to spread any dust contamination within the plant, rather than confine it.

Engineering Control Strategies

A great deal of information has been collected as a result of this study concerning the generation of dusts and fumes within resource recovery facilities. This section addresses the engineering control options available to reduce employee exposures in specific areas of the plant or when working near certain unit operations.

MSW Receiving Area (Tipping Floor)--

The air contaminants generated in this area are result of both movement of the refuse (dumped from a truck, dropped from a crane bucket or pushed along and piled by a front-end loader) and vehicle exhaust. It is because of the mobility of the vehicles and overhead cranes, and the room they require to operate, that engineering controls are impractical in these areas. General ventilation reduces the accumulation of contaminants, and therefore the extent of worker exposures somewhat, but is not adequate to prevent significant exposures at the floor level. It also may create a potential environmental (and odor) problem outside the plant because pollution controls are not normally associated with ventilators.

Another control option to consider is the use of water sprays directed into receiving pits or at points on the tipping floor where refuse is dumped. However, this added moisture would likely result in mechanical handling and

processing problems in RDF production plants and would lower the fuel value of the refuse for incineration facilities. None of the plants surveyed by MRI employed this option.

It appears that personal protection is the only feasible control method for workers in MSW receiving areas. It should be pointed out that very few people are assigned to continuous work in these areas. Also, crane operators are generally enclosed in air-filtered, air-conditioned cabs, and are thus isolated from the contaminated environment while they are operating the cranes. Generally, it was found that dust exposures on the tipping floors were not excessive according to current standards, but could reach moderately high levels for short periods during intensive vehicle and crane activity. Carbon monoxide did not appear to present a problem. Therefore, the use of simple dust masks during periods of elevated dust concentrations would seem to be an effective method of providing a margin of safety for workers stationed in MSW receiving areas.

Shredder Areas--Since most of a shredder is enclosed, the only dust generating points are where the refuse enters and leaves the unit. These points can be successfully controlled by local exhaust ventilation and enclosing the transfer point as much as possible. But great care must be taken to integrate the ventilation design with the explosion venting characteristics of the particular shredder unit. The addition of a ventilation hood should not inhibit the venting paths at either opening.

One of the facilities surveyed for this study had enclosed their two shredders in a separate, concrete block room within the plant. Since this area was off-limits to employees during operation, it effectively isolated workers from exposure to any dusts or fumes emitted from the shredders.

Conveyors and Material Transfer Points--The control technology evaluations at Plants A, B, and E have shown that dusts generated by material handling, particularly at transfer points, can be adequately controlled using standard local exhaust ventilation techniques. Such systems, however, require regular maintenance to insure the proper flowrates in all branches for consistent dust capture. Some problems still remain with spillage from overhead conveyors. For the most part, the falling particles from such conveyors are quite large and do not represent a respirable exposure hazard, but smaller ones do contribute to airborne dust levels with the plant. Better conveyor design will likely reduce such spillage problems in the future. Conveyor enclosures are not practical control measures in many cases because of the interferences with maintenance and the need for plant operators to visually inspect the material at various points in the process.

Other Specific Operations--

Several other special operations were observed at some of the survey sites which appeared to require engineering controls. These included welding sheds or small rooms devoted exclusively to welding, a manual ash removing operation at one of the facilities with boilers, and an RDF storage area unique to one plant. Each of these sites generally needed a hooded enclosure at the area of contaminant generation, along with an amount of exhaust

ventilation sufficient to contain and capture the emissions. This arrangement would drastically reduce worker exposures, while preventing the spread of the contaminants involved to adjacent portions of the facility.

CONTROL OF NOISE EXPOSURE

The generation of high levels of noise by processing equipment has been a recognized problem in the resource recovery industry. To compound this problem, the processing facilities are generally built within bare concrete walls. Also, the equipment (conveyor lines, shredders, separators, etc.) usually spans multiple working levels within the same vertical plane and hence the resultant noise levels are additive. The single most significant factor in mitigating the effects of this noise generation on the employees is their mobility. Typically, the employees in the processing areas are either maintenance personnel, assigned to repair the equipment, or are in a utility classification with duties of cleaning the area. Hence, their TLV exposures are reduced by quieter periods in other segments of the plant.

The configuration of the equipment, coupled with the absence of any isolation options (for background measurements), made this segment of our survey very difficult to implement as originally planned.

The major noise generating equipment produced sound levels generally in the lower (i.e., 500-2,000 Hz) frequency ranges, indicating control potential through damping and isolation techniques. However, because of the nature of the process equipment, the compact physical configurations and the reverberant concrete containment walls, it would appear that most common control techniques might not be cost effective. An in-plant isolation booth or designated quiet area for the exposed workers and implementation of a hearing conservation program may present the best short-term solution.

PERSONAL PROTECTIVE EQUIPMENT

Personal protective equipment normally would include respiratory protection devices, hearing protection devices, and protective clothing such as hardhats, glasses, gloves, shoes, suits, etc. Generally, personal protective equipment should not be used as a permanent solution to a hazardous condition, but rather as a temporary measure until permanent controls can be instituted (i.e., engineering controls). In addition, under present Federal standards a respiratory protection program is mandated when respiratory protection is required; and a hearing conservation program, when noise exposures warrant protection devices. These programs include a number of provisions to insure that effective protection is being provided.

The personal protective equipment issued to an employee at a resource recovery facility would normally include a hardhat, safety shoes, safety glasses, ear plugs or muffs, gloves, coveralls, and a dust respirator. All seven plants surveyed for this study made these items available to their employees or, in the case of safety shoes, provided full or partial reimbursement. Four of the facilities also had at least one Scott® Air-Pak on hand for emergency situations. In addition, several of the plants had

other special protective items such as full face shields, welding masks, rubber gloves and aprons, and half-mask cartridge respirators for use as needed.

Although the necessary personal protective equipment was commonly available to the workers at these seven sites, the equipment was not consistently used at the majority of the plants. Safety policies varied widely, from mandatory use of hard hats, safety shoes, safety glasses and hearing protection within production areas, to facilities where no policy was evident and workers were not using personal protective equipment. A major problem appeared to be enforcement of stated company policies. At some sites where plant representatives stated that all employees were required to wear safety glasses in production areas or to wear hearing protection in restricted, high noise locations, it was apparent from casual observation that these policies were not always enforced. The most common infractions noted were inadequate hearing protection in noisy areas and workers not wearing dust respirators when in dusty locations. There were, nonetheless, a significant number of workers who seemed to be aware of the potential hazards in their work environment and who were very conscientious about using the proper protective equipment. These employees were in the minority, however. In addition, formal programs on hearing conservation and respiratory protection programs were not in evidence at any of the seven facilities surveyed.

Commonly used personal protective devices such as the ones discussed above are adequate to protect the production employee of a typical resource recovery facility from nearly all hazards encountered there. Only under unusual circumstances would more sophisticated equipment be required. It is the responsibility of each plant operator, however, to ensure that the employees consistently use the necessary protective devices.

ADMINISTRATIVE OR WORK PRACTICE CONTROLS

Written work practice controls can be a very effective aid to the employee in recognizing the health hazards attendant to a particular job. Work practice controls provide the employee with a basis for performing the job in the most effective, cost efficient, and safe manner. None of the seven facilities surveyed by MRI utilized written work practices that included the health aspects of the employee's duties.

Administrative controls include posting and restricting hazardous areas, rotating workers to reduce individual exposures (not a recommended technique) and instituting other programs or policies that reduce or eliminate hazards from the employee's work environment. Many of the surveyed facilities used administrative controls; however, the controls were generally based on achieving optimum production or relieving personnel of tedious assignments. Many of the plants restricted access to the shredders, primarily because of the explosion hazard. Few plants restricted access to areas because of noise, but the use of such restrictions should be considered. Lockout programs at the facilities surveyed were generally good. However, not all plants have such a program (see Appendix E, Plant Health and Safety Programs).

SECTION 5

FEASIBILITY OF MORBIDITY AND MORTALITY STUDIES

As part of MRI's overall characterization of the resource recovery industry, the feasibility of retrospective cohort mortality and cross-sectional morbidity studies was evaluated on the basis of the availability and validity of employee data and the results of the industrial hygiene surveys.

EMPLOYEE DATA

As discussed in the preceding section (Employment and Medical Recordkeeping Practices), the quality and extent of employee data recordkeeping practices vary from facility to facility. For example, medical records may contain apparently detailed clinical and physiometric baseline data, or they may be completely absent. In addition, some facilities require periodic medical examinations, but most do not. Therefore, there may be little information available regarding potential shifts in clinical values (i.e., spirometry, audiometry, blood chemistry, etc.) related to the work environment.

The employee turnover rate in the job classifications of highest potential risk (unskilled maintenance, utility, sweeper, etc.) is large enough to confound retrospective study attempts. Observations made at the facilities would indicate that these unskilled labor classifications are generally staffed by relatively young individuals; hence, their job mobility might further diffuse attempts to relate any specific workplace exposures to later pathology. Also, the relative youth of the industry generally (the majority of plants have been operating less than 5 years) would preclude findings of any latent diseases.

INDUSTRIAL HYGIENE SURVEY RESULTS

Results of industrial hygiene surveys at the seven selected facilities have shown several cases of overexposures to dusts, noise, and perhaps welding fumes. Although the significance of the findings are not clear due to the lack of standards for exposures, microbial aerosols may also be a potential hazard.

Because of these findings NIOSH should consider evaluating the presently available medical records from the industry as a pilot study prior to considering an in-depth prospective cross-sectional morbidity study. Indications from these records of industrial bronchitis or other pneumoconioses, permanent threshold shifts or other forms of hearing disability, or patterns of bacterial or viral illness may provide the needed rationale to conduct a complete prospective morbidity study. If the presently available medical

data are not adequate, NIOSH could consider recording the medical histories, conducting clinical tests (to possibly include blood titers as an indication of bacterial exposures), and gathering other information as deemed necessary.

FUTURE RECORDKEEPING PRACTICES

The American Society for Testing and Materials (ASTM) Subcommittee E38.07 on health and safety aspects of resource recovery has developed a draft standard on a recommended practice for maintaining health and safety records. Within the drafted standard are recommendations for the industry to collect and maintain detailed occupational and medical data which, if adopted, would greatly aid future investigators in any epidemiological studies to be conducted for this industry.

SECTION 6

CONCLUSIONS

This section presents the conclusions drawn from the characterization study. They are based on the survey results of the seven sites which were chosen as representative of the industry as a whole. The conclusions are discussed according to the following categories: air contaminants, microbiological aerosols, noise exposures, plant health and safety programs, control technology use, employment and recordkeeping practices, feasibility of morbidity and mortality studies, and the need for the development of a NIOSH criteria document.

AIR CONTAMINANTS

The majority of the sampling conducted was on an area rather than a personal basis. Few personal samples indicated overexposures based on the limits listed in Appendix H. A number of area samples indicated high dust concentrations in certain areas that are normally not staffed (e.g., secondary shredder area below conveyor C-6 at Plant A). Therefore, from the total and respirable dust measurements in the facilities surveyed, there does not appear to be a health hazard to most employees, based on present standards or recommendations for nuisance particulates. However, since the composition of the dust is highly heterogeneous and dependent on the refuse being processed, and because of the consequent potential hazards from microbial, chemical, and mineral contamination, it would be a prudent administrative practice to restrict and post the dustier areas of processing sections of a plant as respiratory protection areas.

Trace metals such as lead, zinc, cadmium, chromium, and beryllium did not appear to present any airborne health hazard in the facilities surveyed. These metals were either not detectable or were detected only at negligible concentrations. These particular metals were selected as being representative of the most potentially significant trace metal hazards to be found in resource recovery facilities. Therefore, it is assumed that other trace metals can also be discounted as potential airborne health hazards.

Welding fume exposures to welders in the facilities surveyed were generally a problem. At most facilities welding is done both by contractors and by plant employees involved in maintenance and in new construction. While contractors were not monitored, their practices were similar to those of the plant employees; namely, welding without adequate exhaust ventilation and without welding screens for the protection of onlookers. Specific recommendations were made in the individual survey reports that were sent to each

plant. However, as a general practice at all plants with employees conducting routine maintenance welding (e.g., retipping shredder hammers), localized exhaust ventilation and a shielded area should be provided.

Airborne silica was found at a significant level in only one facility. Obviously, the hazard from silica will depend on the refuse being processed. As a general conclusion, silica would not appear to present a health hazard to most employees in this industry.

Sampling results did not indicate an airborne hazard to employees from asbestos during our surveys. However, MSW receiving area personnel should be cautioned to be alert to the potential for an unknowing person to deliver asbestos as refuse to their plant.

No airborne levels of organophosphorus or carbamate pesticides were detected. The majority of our surveys were conducted in the cooler months; however, when insect pests (and hence pesticide usage) are not a widespread problem and the amount of yard wastes collected was low.

PCBs were not found above typical ambient levels. The potential for contamination of airborne dusts would depend on each plant's policy for the acceptance of waste oil and discarded electrical equipment. (Generally, large metal objects are not processed by the plants.)

General organics monitoring did not indicate any significant health hazard to the employees of the facilities surveyed. There were several sporadic episodes of an apparent evolution of waste paint solvents, but these were infrequent and of short duration.

PNAH results did not appear to indicate any significant health hazard to employees. One sampling result at Plant B was at the threshold limit value, but it was based on total benzene solubility and not on the detection of one of the five specific polycyclic species of interest. Carbon monoxide, while present in all of the facilities surveyed, was not detected at hazardous levels. Running vehicles in the tipping floor or receiving areas of the plant without adequate ventilation could pose a problem in some instances. However, this did not occur during MRI's surveys.

No HCN or HCl production from incineration was found in the workplace at facilities D, G, or F. No oil mist conditions were observed that would have warranted this type of monitoring.

MICROBIOLOGICAL AEROSOLS

The various plants surveyed were not significantly different from each other in terms of the microorganisms isolated or their respective concentrations. Minor differences occurred but, within the constraints of our study protocols, could not be explained by the type of operation, seasonal differences, or the geographic site.

Average total bacteria counts from the dust and solid waste ranged from 10^7 to 10^8 bacteria/g. Total bacteria aerosols ranged from 10^5 organisms/ m^3 taken with the AGI to 10^6 organisms/ m^3 taken with the IVAS.

The average fecal coliform content of the solids was approximately 10^4 organisms/g, while the aerosols ranged from 10^2 organisms/ m^3 to 10^3 organisms/ m^3 .

Average Staphylococcus aureus content of the solids was approximately 10^4 organisms/g, whereas in aerosols it was 10^2 colonies/ m^3 .

Average Klebsiella pneumoniae and K. oxytoca results were similar, with approximately 10^4 organisms/g to 10^5 organisms/g in the solids and 10^3 organisms/ m^3 in aerosols.

Salmonella enteritidis serotypes were evaluated by enrichment procedures from solid and aerosol samples collected at several plants.

Shigella and Legionella microorganisms were not isolated at any of the resource recovery plants tested.

Several mycobacterial species, but not tuberculosis, were recovered in both solid and aerosol samples collected at several plants. At Plant C, Mycobacterium fortuitum and M. terrae complex were found in solid waste and dust samples at 20 cells/g to 40 cells/g. In the aerosol samples, M. szulgai was recovered by enrichment at < 200 cells/ m^3 . Mycobacterium scrofulaceum was recovered at < 200 to 600 cells/ m^3 . Mycobacterium gordonae was recovered at 200 cells/ m^3 , and M. terrae was found at 15 cells/ m^3 .

Streptomyces content of the solids averaged 10^5 /g to 10^6 /g. Streptomyces aerosols were 10^3 / m^3 to 10^4 / m^3 .

Nocardia species other than asteroides and brasiliensis were found intermittently with concentrations that averaged 10^3 cfu/g to 10^3 cfu/g in solids and 10^2 cfu/g to 10^3 cfu/ m^3 in aerosols.

Aspergillus fumigatus was found more frequently in settled dust (average 10^4 cfu/g) than in solid waste (average 10^3 cfu/g). The aerosol concentration ranges from an average of 10^3 cfu/ m^3 to 10^4 cfu/ m^3 .

Aspergillus flavus was not found in any solid waste samples and was found in only two dust samples (average 10^3 cfu/g). Yet A. flavus was found in 50% of the aerosol samples at an average of 10^3 cfu/ m^3 .

Aerosols of human pathogenic viruses were not detected in any resource recovery plant tested, which indicates a low hazard potential for workers. Poliovirus type 3 was isolated from a solid waste grab sample at Plant F at a concentration too low to quantitate. This suggests that pathogenic viruses may be present in wastes delivered to resource recovery facilities.

Since no exposure standards for airborne microbial organisms presently exist, it is difficult to discuss the sampling results presented above in

terms of the health risks to resource recovery employees. Certainly, no significant worker health problems are known to have arisen thus far within the industry from the daily exposures to large volumes of solid wastes. It is also of little value to compare these study results with those from other aerobiology studies at other types of solid waste treatment facilities unless those studies can shed some light on infective dosages. The primary conclusion is that a number of specific microorganisms were isolated at discernable concentrations in air samples collected at the seven sites. Several known pathogens, such as Shigella, Legionella, and Nocardia asteroides and brasiliensis, were not detected in any of the samples and should therefore be no cause for concern.

In the absence of personal exposure limits, observance of personal hygiene measures such as routine respirator use, showering before leaving the premises, washing before eating, and prompt attention to cuts should be encouraged.

NOISE EXPOSURES

Noise is a potential hazard to employees in the resource recovery industry. It is more pronounced in the RDF production facilities than in the incineration facilities because there are more conveyors and large processing equipment used. Generally, all plants had areas that might often exceed 90 dBA. However, because of worker mobility, few workers were actually overexposed (> 90 dBA) during our survey. The implementation of a hearing conservation program is recommended.

PLANT HEALTH AND SAFETY PROGRAMS

In general, the plant health and safety programs were not as extensive as might be found in a model program, but some facilities such as Plant B appeared to have all of the elements of a successful program. Developing periodic employee monitoring programs, where indicated, should be considered by the industry. In addition, a more rigid enforcement policy for personnel protective equipment use by many of the plants should be implemented.

CONTROL TECHNOLOGY USE

The use of local exhaust ventilation systems appears now to be a standard practice when designing a new resource recovery facility. Older plants have retrofitted control systems after encountering mechanical equipment maintenance problems from excessive dust fallout in their facilities. The traditional ventilation system designs have been shown to significantly reduce the levels of airborne particulates in the working environment, but only when properly maintained. The upkeep of these systems in resource recovery facilities is too often overlooked when other plant operational problems take precedence, and loss of collection efficiency results.

The use of noise control technology, other than isolation, is very limited in the industry. This is due to the large size of most of the offending pieces of processing equipment, as well as the complex physical arrangements

of the machinery (e.g., criss-crossing conveyors and multilevel duct work). Better equipment designs as the industry matures may reduce noise generation levels somewhat, but the use of hearing protection is likely to remain the most effective method of reducing employee exposures.

Personal protective equipment is generally being used by workers at every plant, but there is considerable variation in management policy regarding its use. Most facilities make a variety of devices available to their employees, but apparently either the workers are not well trained in their proper use, or management does not enforce the use in required areas. The incidence of in-plant injuries observed in this study, although not excessive, would indicate that policies such as the mandatory wearing of safety glasses by all employees in the industry should be adopted.

EMPLOYMENT AND RECORDKEEPING PRACTICES

Employment and recordkeeping practices vary extensively from facility to facility. The major impacts of this diversity of data completeness are on the feasibility of morbidity and mortality studies being conducted at the facilities or for the industry in total. Recommendations to standardize the collection and documentation of health and safety data have been developed as a draft standard by the American Society for Testing and Materials (ASTM) subcommittee E38.07.

FEASIBILITY OF MORBIDITY AND MORTALITY STUDIES

The feasibility of morbidity and mortality studies is addressed in detail in Section 10. However, the study conclusion is that retrospective studies would be extremely difficult and probably of little value at this point. Cross-sectional morbidity studies may be feasible and of value depending on the need as demonstrated by presently available medical records of resource recovery employees.

THE NEED FOR THE DEVELOPMENT OF A NIOSH CRITERIA DOCUMENT FOR THE RESOURCE RECOVERY INDUSTRY

There does not appear to be a need to develop a criteria document specifically for this industry other than ensuring that this report is made available.

SECTION 7

RECOMMENDATIONS

MRI's recommendations are separately addressed to NIOSH and the recovery industry. Suggestions for industry managers to maintain the health of their work force are as follows:

- Consider providing respiratory protection for workers in particularly dusty areas when airborne dust concentrations exceed one-half of the recommended exposure limit (10 mg/m^3). Consider posting and restricting these locations as respiratory protection areas. Conduct routine monitoring to establish representative dust levels, determine the need for permanent engineering controls, or to ascertain the need to continue respiratory protection.
- Provide appropriate exhaust ventilation and welding screens for all welding operations. It is particularly important to ventilate the interior of a shredder when welding is taking place inside (such as hammer retipping), thereby providing fresh air and directing fumes away from the worker.
- Emphasize personal hygiene measures for employees. Specifically, workers should wash before eating, eat only in designated areas (i.e., lunchroom), have dual locker facilities to prevent contamination of street clothes (or have daily uniform change), and shower before leaving the plant at the shift's end. Prompt medical attention should be paid to cuts and abrasions to prevent infection.
- Provide a hearing conservation program for all employees exposed to noise levels greater than 90 dBA. Enforce the use of hearing protective devices in high noise areas. The Federal hearing conservation program requirements are outlined in 24 CFR 1910.95, as amended by the Federal Register, Vol. 46, No. 162, August 21, 1981.
- If not already doing so, consider implementing a medical surveillance program which includes preemployment and periodic medical examinations. This program should include a review of work and medical history, respiratory evaluation with spirometry, audiometric testing, blood chemistry analysis, and other diagnostic tests recommended by the company physician.

The following recommendations are offered to NIOSH for evaluating occupational health conditions in the resource recovery industry:

- Consider additional studies to determine the relationship between concentrations of airborne microbiological agents and adverse health effects for workers in the resource recovery industry. Although no problems with infectious illnesses were reported at the facilities surveyed, the levels of pathogenic bacteria measured by MRI were sufficiently high to be of concern.
- Consider an in-depth study of safety hazards in the industry. It is apparent that the most serious hazards to resource recovery workers stem from explosions and moving conveyors.
- Consider a cross-sectional morbidity study to determine whether working in resource recovery facilities poses more of a health risk than comparable types of industrial work. Employee medical data maintained by plants within the industry are not uniform, however, and a morbidity study may yield only marginal results.
- Ensure the availability of this report to all segments of the industry, municipalities involved in resource recovery operations, and interested labor unions.

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APPENDIX A

REFUSE DERIVED FUEL PRODUCTION FACILITIES

The following sections detail the general scheme of plant operations, personnel descriptions, and survey results. The survey results are divided into sections on general air contaminants, microbiological aerosols, and noise exposures at plants designated as A, B, C, and E.

DESCRIPTION OF PLANT OPERATIONS AND PERSONNEL

Plant A Facilities

The Plant A solid waste recovery system is a continuously operating system that processes municipal solid waste (MSW) for use as a supplemental fuel in the existing steam generators at the municipal power plant of the city in which the plant is located. The total system consists of a nominal 150-ton/day (136-Mg/day) processing plant, a 500-ton (454-Mg) Atlas storage bin, pneumatic transport systems, and the existing municipal power plant. The processing plant incorporates two stages of shredding, ferrous and non-ferrous metal recovery, and an air density separator (ADS).

The first MSW was fed through the processing plant on August 30, 1975. This was followed by a 4-month start-up period, and the plant was considered fully operational for evaluation purposes by January 1, 1976.

Figure A-1 is a block flow diagram of the processing plant. MSW is delivered to the tipping floor (shown in Figure A-2) which is 48 m by 32 m and has two entrances and exits. One is for commercial trucks and the other for private automobiles and pickup trucks. Commercial trucks are weighed on a truck scale and private vehicles are simply counted. A front-end loader is used to push the MSW onto the infeed conveyor (denoted C-1 in the figures).

Raw refuse first enters the plant processing system via infeed conveyor C-1 into the first stage shredder, then via conveyor C-3 through the second stage shredder. A magnetic belt separator removes ferrous metal from the material flow stream between the first and second stage shredder. Conveyor C-6 transports the material from the second stage shredder into the air density separation (ADS) subsystem. Light material which rises up through the ADS system becomes the refuse derived fuel (RDF) product and is ultimately transported via a pneumatic conveying system to the outdoor storage bin (Atlas bin) prior to entering the electric power generating plant. The heavy (reject) material drops out of the ADS onto conveyor belts where it is transported to a storage bin. Material in the reject bin is periodically removed and trucked to a

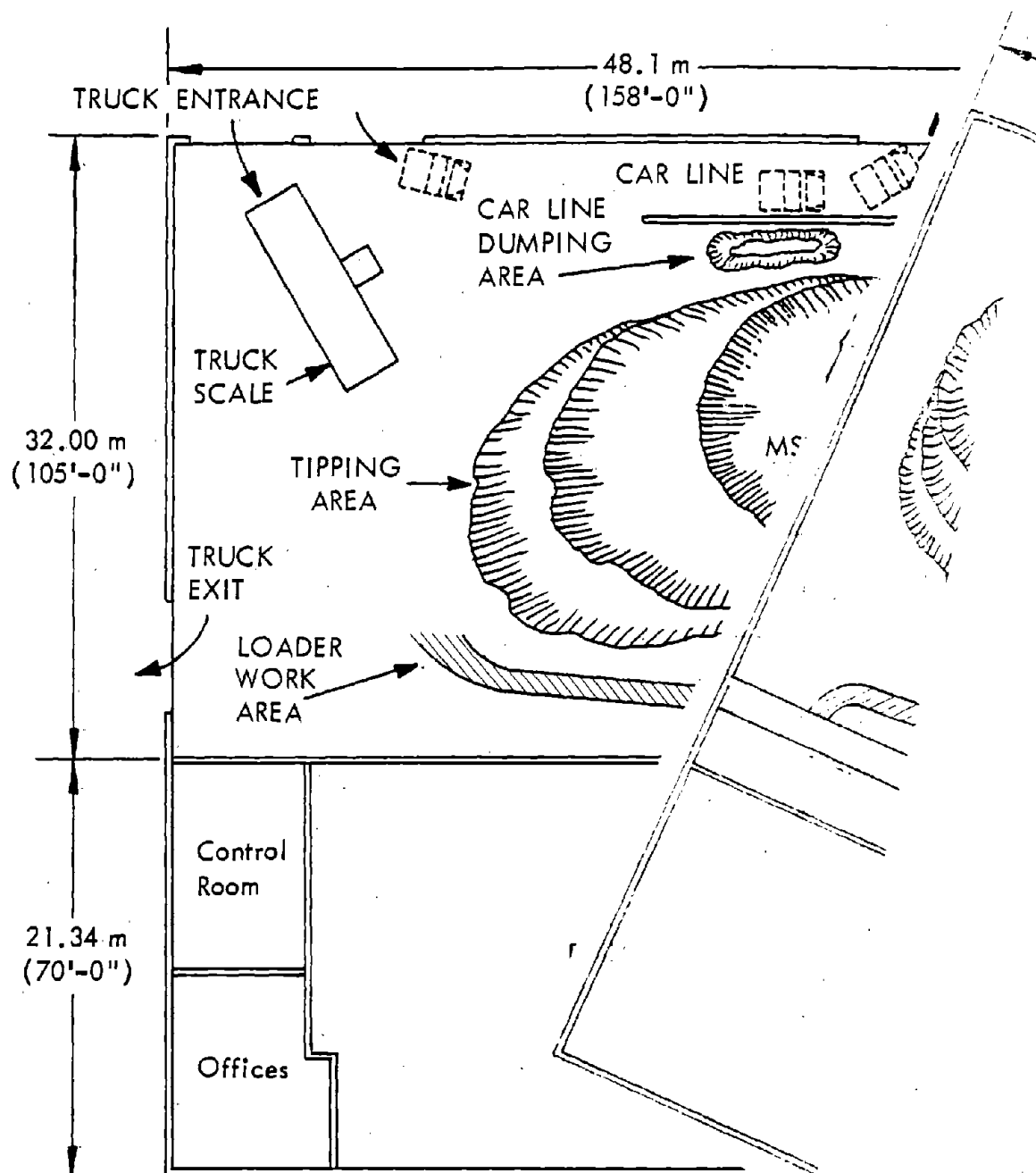


Figure A-2. Tipping floor layout, Plant A.

landfill. Additional ferrous metal recovery is achieved from the ADS heavy material by magnetic head and tail pulleys. This ferrous metal is added to the ferrous metal recovered by the primary magnetic separator.

An aluminum separation system (Almag) composed of a trommel screen and an electrical eddy current separator was originally installed at the plant but this system is now inoperative. It is shown by dotted lines in Figure A-1.

For engineering evaluation purposes, the facility can be divided into the following subsystems:

- Tipping floor
- Shredder system
- ADS system
- Rejects handling system
- Ferrous metal separation system
- Aluminum separation system

The plant is arranged so that the tipping floor area is separated from the processing area by a concrete wall. The approximate dimensions of these two areas are shown in Figure A-2. The second segment or processing area is a complex and interwoven array of machinery and conveyors. Access to the equipment is provided by a series of catwalks and grate areas at varying levels. Thus, the processing area of the plant is basically a large, open configuration that allows a relatively free interchange of air and contaminants throughout the area.

A third distinct segment of the facility is comprised of an office area, control room, lunchroom, and an employee locker room. They are located at the west end of the plant and are separated from the processing area. The control room is situated so that the operator has an elevated view of both the tipping floor and the processing area from the control panel, in addition to closed-circuit television surveillance.

Monthly solid waste processing rates for 1977 and 1978 are shown in Table A-1. As indicated by the data, monthly refuse throughput totals are not consistent and are governed by the amounts of waste received at the plant, as well as by equipment downtime. Daily plant operation is likewise a function of daily equipment performance. During the MRI survey, for example, the flow of material through the system was interrupted numerous times for varying time periods due to pluggages at transfer points or other equipment malfunctions. Therefore, it is difficult to estimate an hourly or daily material processing rate. Figure A-3 presents a graphic comparison of the 1977 and 1978 production data and gives an indication of seasonal variation at the plant. Although monthly production figures such as those shown in Table A-1 are not yet available, the plant supervisor has indicated that approximately 28,338 tons (27,708 Mg) of raw refuse were processed during 1979.

TABLE A-1. MONTHLY PRODUCTION - REFUSE PROCESSING PLANT A

Month	Raw refuse processed	Paper	Rejects to landfill	Weight (Mg)			RDF (by difference) ^a
				Fe-metal	Non Fe-metal	Woodchips	
<u>1977</u>							
January	2,352.90	0.00	243.33	95.56	1.98	0.00	2,011.83
February	2,956.16	13.60	225.65	187.85	0.00	6.15	2,522.91
March	3,791.23	0.00	305.67	285.83	0.33	15.06	3,184.34
April	3,761.82	0.00	239.87	275.06	0.00	15.61	3,231.28
May	3,921.94	0.00	332.09	240.05	0.00	3.00	3,346.80
June	2,657.20	15.78 ^b	217.61	178.12	0.00	0.00	2,245.69
July	3,520.13	0.00	370.85	217.85	0.00	5.71	2,925.72
August	4,733.73	12.93	621.50	313.61	6.20 ^c	10.61	3,768.88
September	4,523.12	5.46	580.62	315.41	0.00	0.00	3,621.61
October	4,467.67	13.61 ^d	351.62	264.38	0.00	0.00	3,838.06
November	3,825.92	0.00	182.47	244.14	0.00	0.00	3,399.31
December	<u>3,300.00</u>	<u>7.29</u>	<u>221.49</u>	<u>111.46</u>	<u>0.00</u>	<u>0.00</u>	<u>2,959.76</u>
Total	43,811.82	68.67	3,892.97	2,729.37	8.51	36.14	37,056.16
<u>1978</u>							
January	3,414.20	0.00	226.42	201.69	0.00	0.00	2,986.09
February	2,776.41	3.46	157.38	180.61	0.00	0.00	2,434.96
March	3,766.58	0.00	286.26	288.26	0.00	3.08	3,188.98
April	4,027.51	0.00	403.69	257.65	0.00	8.25	3,357.92
May	3,015.05	0.00	272.57	213.30	0.00	0.00	2,529.18
June	4,600.02	0.00	402.75	261.90	5.94	0.00	3,929.43
July	3,912.57	0.00	397.61	194.69	4.78	0.00	3,315.49
August	4,590.84	0.00	412.97	103.41	50.36	0.00	4,024.10
September	3,852.99	0.00	287.38	204.57	0.00	0.00	3,361.04
October	1,999.16	0.00	195.73	106.68	0.00	0.00	1,696.75
November	0.00 ^e	0.00	0.00	0.00	0.00	0.00	0.00 ^e
December	<u>2,021.89</u>	<u>0.00</u>	<u>169.14</u>	<u>85.07</u>	<u>0.00</u>	<u>0.00</u>	<u>1,767.68</u>
Total	37,977.22	3.46	3,211.90	2,097.83	61.08	11.33	32,591.62

a RDF by difference is incoming raw refuse less paper, rejects, Fe-metal, non Fe-metal, and woodchips. Therefore, the RDF by difference also includes any plant material losses.

b Includes 9.25-Mg cardboard.

c Aluminum.

d All cardboard.

e Plant shut down for equipment installation.

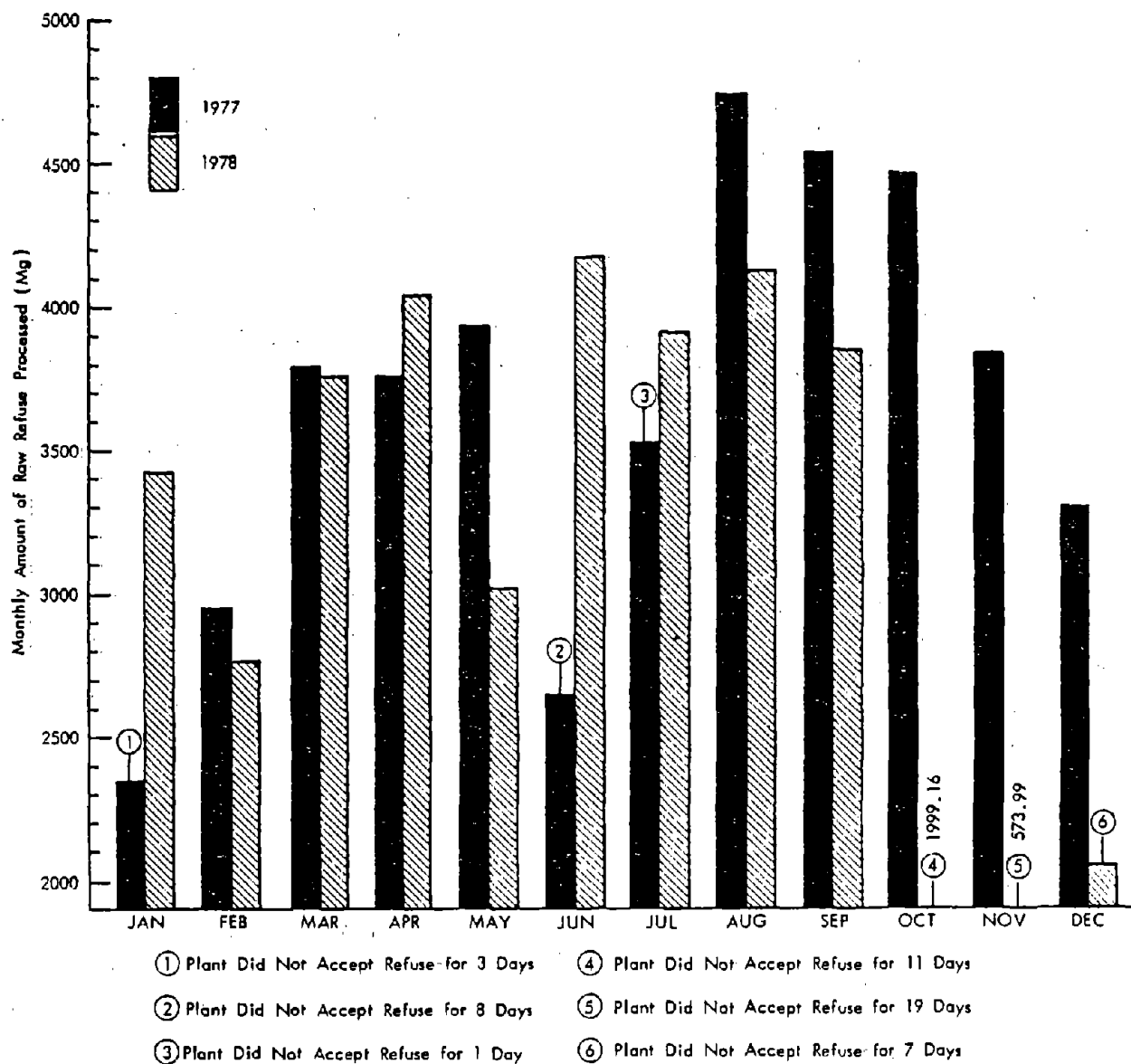


Figure A-3. Monthly amount of raw refuse received, comparing 1978 to 1977.

Refuse is accepted and processed at the plant during only one work shift (7:00 AM to 4:30 PM). The second and third shifts are reserved for cleanup and maintenance activities.

Plant A Personnel

The City's Department of Public Works--Solid Waste Division has 14 employee positions allotted for its solid waste plant. These are listed in Table A-2.

TABLE A-2. PUBLIC WORKS--SOLID WASTE DIVISION
1979-80 ADOPTED POSITIONS

Position classification	Approved Number
Resource recovery superintendent	1
Plant operations supervisor	1
Senior maintenance worker/electrical	1
Senior maintenance worker	2
Maintenance worker	2
Truck driver	1
Senior heavy equipment operator	1
Laborer	4
Clerk	0.5
Utility engineer	0.5
Total approved positions	14

Twelve persons are normally employed on the first shift. However, during the MRI survey, one laborer position was vacant. One senior maintenance worker and one other maintenance worker are employed on the night shift (10:30 PM to 6:30 AM) for general equipment maintenance work, while four laborers conduct a general cleanup and blowdown of the processing area twice each week between 4:00 and 8:00 PM.

The resource recovery superintendent and the plant operations supervisor normally remain in the office or control room area. Occasionally, they enter the processing area to assist, but it is estimated that this may account for only about 10% of their time. The clerk is part-time and essentially remains in the office or lobby area of the plant.

The heavy equipment operator and one laborer work in the tipping floor area. The equipment operator is responsible for moving the incoming refuse onto the storage pile and also onto the feed conveyor for the primary shredder by operating the front-end loader. The laborer operates the weigh scale for incoming refuse trucks and examines the deposited material for bulky or

dangerous objects which cannot be shredded. He also maintains the floor area by sweeping material missed by the front-end loader.

The remaining seven employees on the day shift work in various sections of the processing area. Duties of the senior maintenance worker include supervision of the day shift crew and general production and maintenance activities as needed; there is no specific work area assignment. Similarly, the senior maintenance electrical worker and the regular maintenance worker are not assigned to any single area but must deal with any production or equipment problems which arise. The truck driver operates the dump truck used to haul reject material from the plant to a landfill operation and spends approximately half the time in the rejects loading area and the remaining time in driving between the solid waste plant and the landfill. Two laborers are assigned to general cleanup duties during the day shift. They appear to spend the majority of their time sweeping on the bottom floor level of the plant.

Finally, the utility engineer's time is divided equally between the solid waste plant and the municipal power plant. He acts as a liaison between the two facilities and appears to spend very little time in the processing or tipping floor areas.

Training of new employees takes place on-the-job under the supervision of a senior employee. The employees at Plant A are represented by the International Union of Operating Engineers. The senior person on the plant "floor" is the union steward.

Plant B Facilities

When Facility B began operation in 1977, it became the largest privately funded, municipally oriented resource recovery program in the United States. The plant contracted to dispose of all the city-collected solid waste and to provide an RDF for sale to a nearby electric power company generating station. The plant was designed to process up to 1,500 tons/day (1,361 Mg) of solid waste, which gives it an annual capacity of 400,000 tons (362,880 Mg) as compared to the city's present estimated total waste generation of approximately 300,000 tons (272,160 Mg). However, Plant B's production schedule is directly tied to the power company's fuel consumption requirements. At the time of MRI's survey, production had been reduced from a two-shift, 5-day schedule to a one-shift, 3-day work week because of boiler problems at the power station. Thus, only a portion of the city's MSW is now delivered to the plant, and any refuse not processed by Plant B is directly landfilled.

The processing plant consists of tandem equipment trains, each capable of handling about 60 tons/hr (196 Mg/ks) of MSW. As shown in Figure A-4, each train incorporates primary shredding, air classification, ferrous metal separation, and secondary shredding unit operations. The plant also has capabilities for glass and aluminum separation, but these operations are not currently in use. Figure A-5 is a block diagram of the material flow scheme.

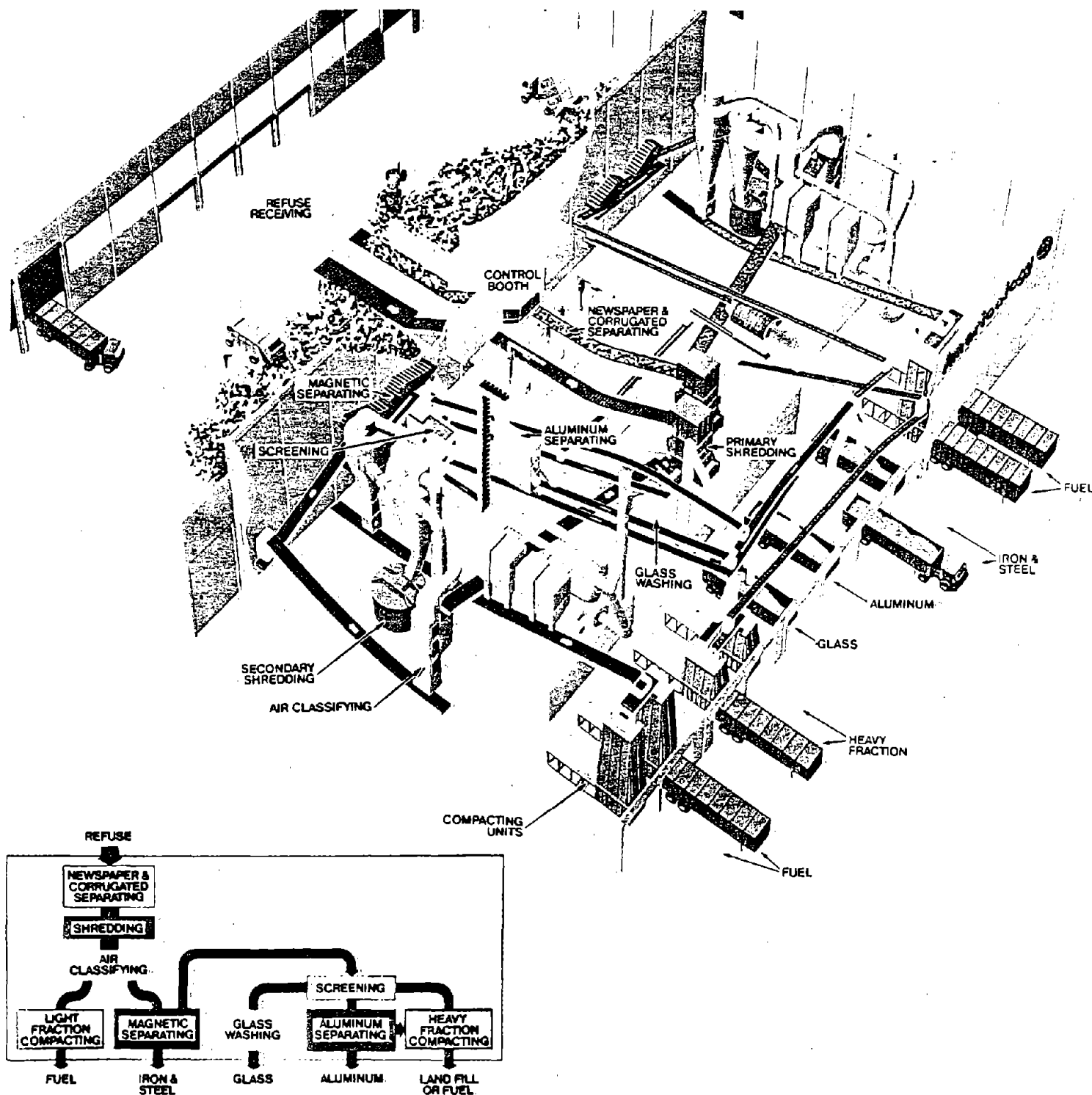


Figure A-4. Perspective, cutaway view of Plant B equipment layout.
(Reproduced from a Plant B publication)

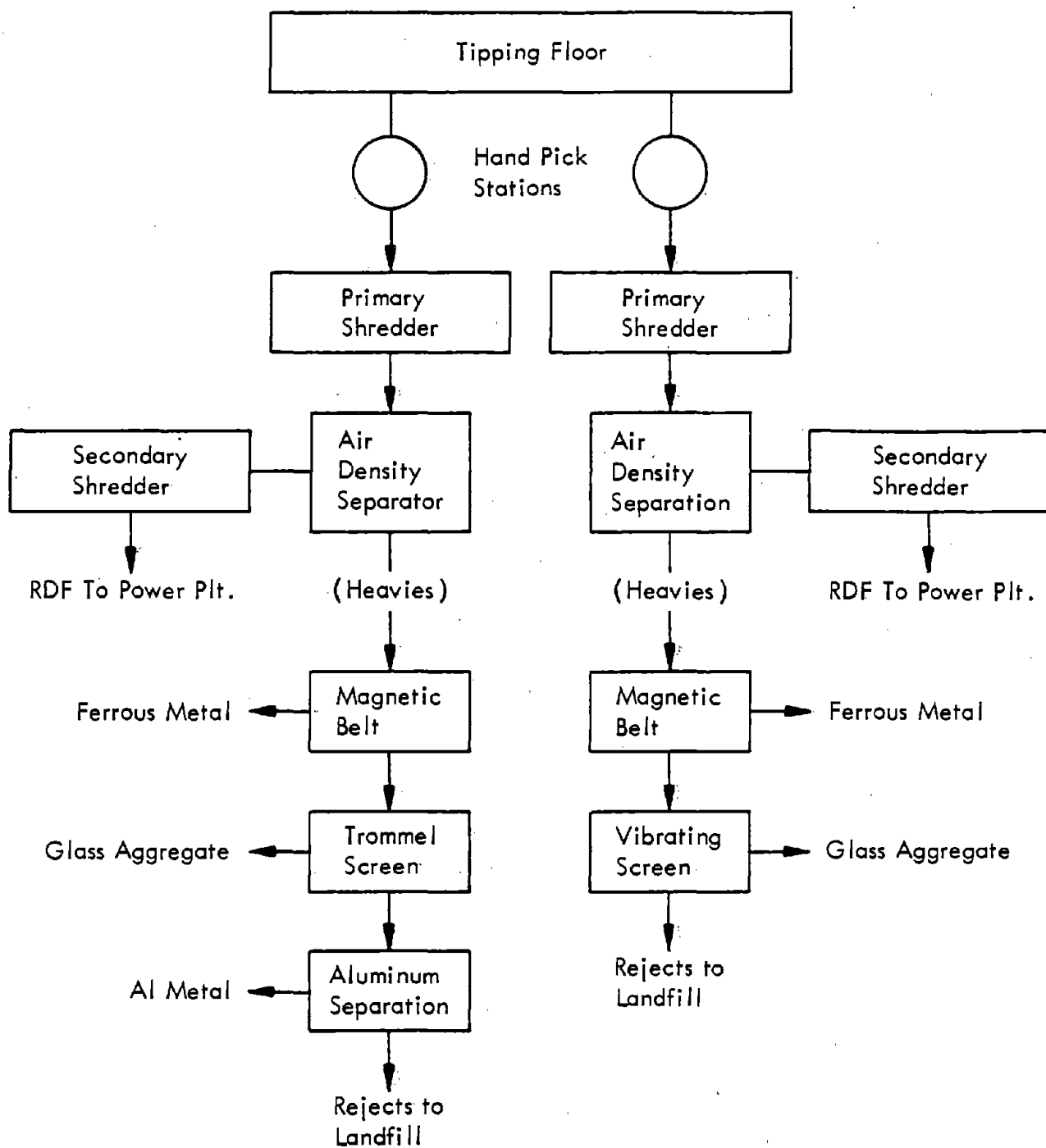


Figure A-5. Block flow diagram of Plant B process.

MSW is delivered to Plant B by municipal collection vehicles and packer trucks (from transfer stations) and deposited on the tipping floor. A front-end loader piles the material and then evenly distributes it onto the two pit conveyors in the center of the floor (one for each processing train). As the conveyed refuse enters the processing room, it passes a picking station where workers continually scan the MSW stream and manually remove hazardous items (e.g., bulky metal objects, flammable or explosive items, and rope or hose) which could damage the shredder. After the picking station, the MSW enters a Williams horizontal-shaft hammermill for primary size reduction.

The shredded refuse is then conveyed to a zigzag-type air classifier for density separation. Light material (mainly paper and plastics) is carried up through the classifier and into a cyclone which separates the solid material from the air stream. It is then further reduced in size by a Heil vertical-shaft secondary shredder and conveyed to the packer truck station at the rear of the plant.

Heavy material dropping out of the air classifier is sent to a two-stage magnetic separation operation for recovery of ferrous metals. Remaining material is conveyed to the "heavy fraction" packer truck station for transport to a landfill.

The plant configuration is such that the tipping floor is segregated from the processing area by a concrete wall. As can be seen in Figure A-4, vehicle entry and exit doors are located at opposite ends of the facility (one for refuse delivery trucks and the other for hauling of recovered materials). The delivered MSW is piled opposite the receiving doors on either side of the feed conveyors and pushed toward the center of the floor. The plant's control booth is located in the center of the wall which separates the tipping floor from the processing area. Thus, the operator has a clear view of the tipping floor activity, the feed conveyors to the shredders, and a good portion of the processing area.

The two primary shredders are positioned in the center of the processing area. They are surrounded by an enclosure consisting of a short concrete wall with wire rope mesh curtains above for explosion control. The wire mesh sections have canvas panels covered with metal foil on the interior side for fire or explosion containment. The top of the shredder enclosure consists of a thick metal bar grid to contain flying objects in the event of an explosion.

The remainder of the process area is in an open configuration consisting of equipment at many different levels, reaching up about three stories. Stairways and catwalks primarily provide access to specific pieces of equipment. Therefore, very few walkways interconnect or are at the same level.

A maintenance shop, maintenance personnel offices, employee washroom and locker room, lunchroom, and a quality control lab are located on three levels at the northeast corner of the processing area. This area is enclosed by concrete block walls to separate it from the rest of the processing area.

Plant B Personnel

The Plant B staff currently consists of 31 full-time employees. They are organized into four categories: utility, production, maintenance, and management, as shown in Table A-3. All of the workers listed in Table A-3 are normally employed on the day shift (7:00 AM to 3:30 PM) but were only working a Monday-Wednesday-Friday schedule due to a reduced demand for the plant's fuel product at the time of the survey. Tuesdays and Thursdays were reserved strictly for maintenance activities. The crew on these maintenance days consists of eight mechanics, two electricians, and one welder.

TABLE A-3. PLANT B JOB CATEGORIES

Category	Job classification	Number of employees
Utility	Picker	4
	Relief picker	2
	Forklift operator	1
	Office janitor	1
Production	Spotter	1
	Compactor operator	2
	Front-end loader operator	2
Maintenance	Mechanics	6
	Maintenance trainees	2
	Electrician	2
	Welder	1
	Stockroom attendant	1
Management	Control room supervisor	1
	Floor foreman	1
	Maintenance supervisor	1
	Maintenance superintendent	1
	Quality control supervisor	1
	Operations manager	1
Total		31

The refuse pickers work along the shredder feed conveyors at a location just beneath the control room where the feed conveyors enter the processing area from the tipping floor. Two pickers are positioned at each conveyor, one on either side of the line. They remove hazardous items from the refuse stream with long-handled, claw tools. Pickers are relieved at approximately 4-hr intervals and are rotated between the picking station and general clean-up operations. The forklift operator moves and replaces bins located throughout the plant, such as the ones located beneath the picking stations,

and assists in maintenance operations when heavy equipment movement is involved. The forklift operator sometimes relieves the pickers during their shorter break periods. Thus, this position's work is not confined to a particular area of the plant.

The spotter and compactor operators are responsible for maintaining the compactor truck stations in the load-out area. The compactor units frequently become jammed or must be stopped and started when a truck becomes full and an empty unit is brought in to replace it. It is the duty of the operators to sequence the load-out activities as required. The spotter is the truck driver responsible for removing the fully packed trucks and replacing them with empty ones. In addition, the spotter moves the open-top trucks used for hauling recovered ferrous metal.

All maintenance personnel are based in the maintenance shop area, but they work throughout the plant as problems arise. The welder is also assigned the duty of periodically retipping hammers for the shredder, which is done inside a welding shed located at the south end of the processing area. The welder may spend several consecutive hours retipping hammers and the remaining time on other maintenance welding.

With the exception of the control room supervisor, who always remains in the control room, the supervisory staff divide their time between desk duties in the maintenance and quality control offices and various required activities throughout the facility. The majority of the operations manager's working hours are spent in the office or otherwise outside of the processing area.

Nonmanagement employees are represented by the Iron and Steel Workers of America.

Plant C Facilities

Plant C processes MSW at a rate of about 100 tons/hr (326 Mg/ks) when running at design capacity. It produces an RDF while recovering ferrous metal and also has a component to potentially recover aluminum and glass. However, this segment of the system was not operating at the time of the MRI survey. A schematic diagram of the overall system is shown in Figure A-6.

Primary unit operations in Plant C consist of a storage pit, two push pits, two shredders, two magnetic separators, two air classifiers, two cyclones, a trommel screen, and a pelletizer. These areas are shown in the plan view of the plant presented in Figure A-7. Raw MSW is dumped from trucks into the storage pit or one of the two push pits. Material in the storage pit is later transferred to the push pits by metal pan conveyors and then up into the shredders. The shredding operation and subsequent ferrous recovery steps are accomplished before air classification. Horizontal-shaft hammermills driven by 1,000-hp motors are used for shredding the MSW, and belt-type magnetic separators are used for ferrous recovery.

Rubber-troughed conveyors are used to carry the shredded material to the ferrous separators, and the recovered ferrous metal from both separators is

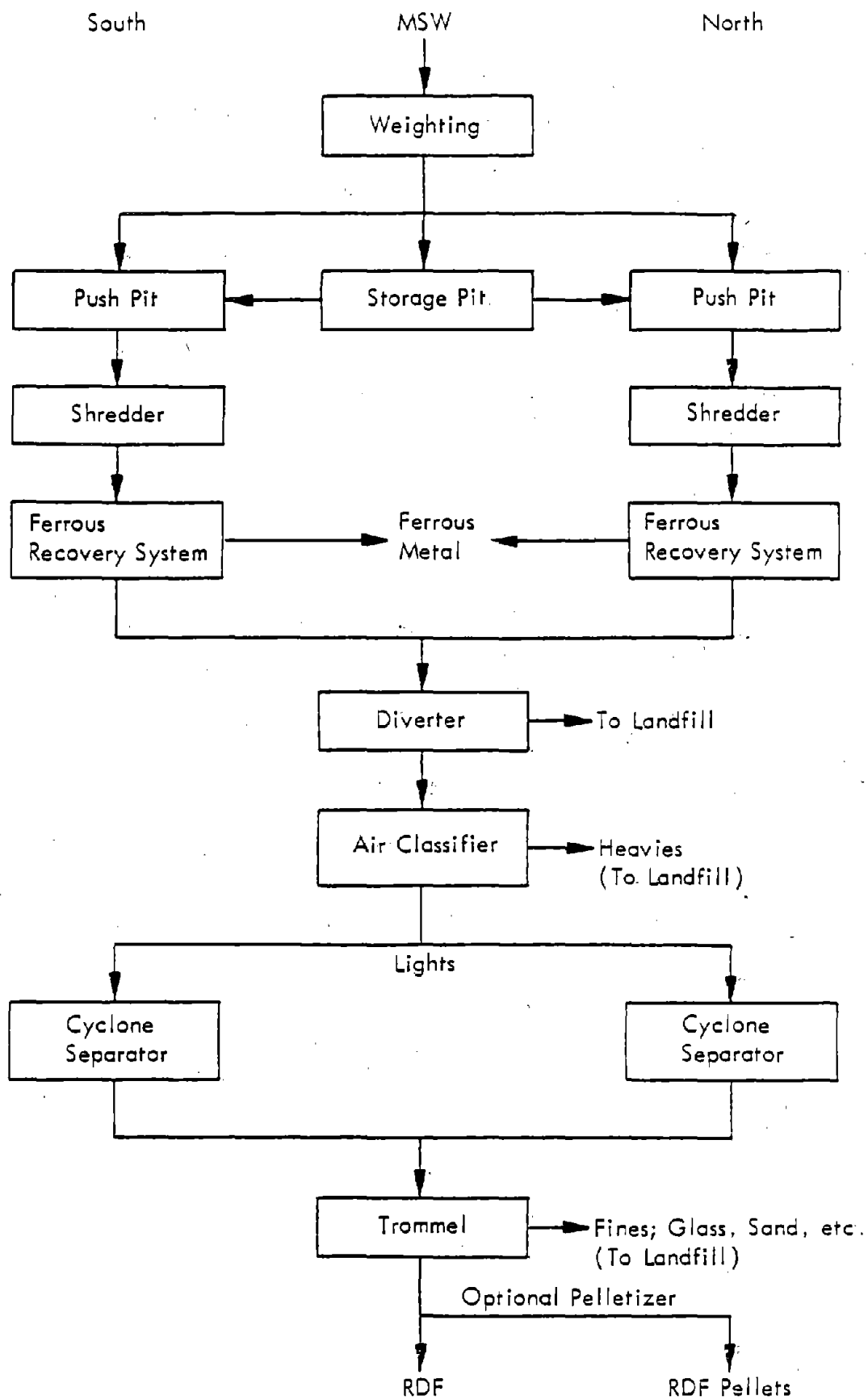


Figure A-6. Schematic of material flow at Plant C.

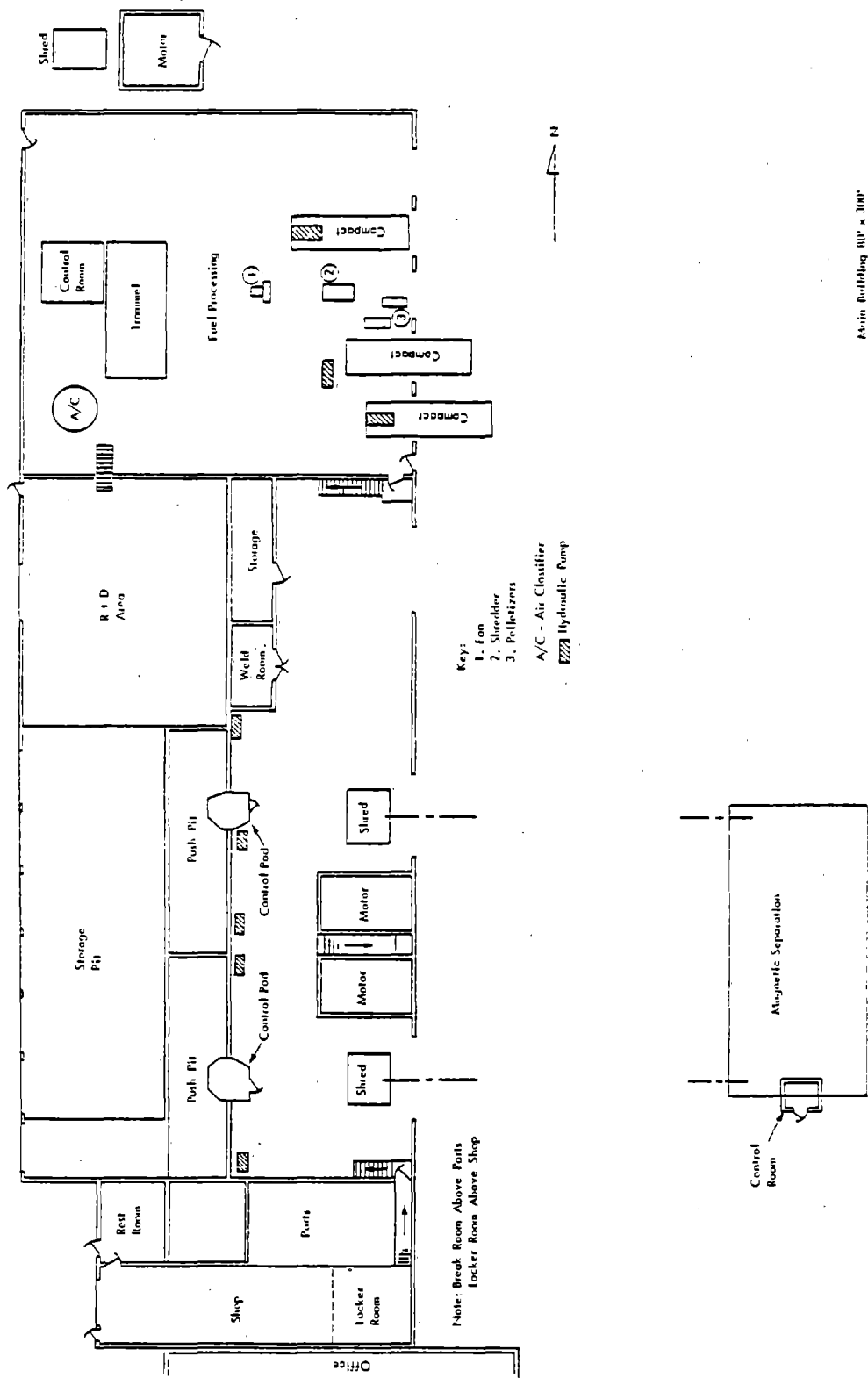


Figure A-7. Plan view of Plant C facilities and equipment.

conveyed into an open-top trailer for shipment to a steel mill. The non-ferrous material leaving the magnetic separator system is conveyed to a compactor for shipment to a landfill. Part of the flow to the compactor can be diverted to the air classifier by using a sliding diverter blade arrangement. After the ferrous separation step, a portion of the total material throughput is thus diverted to a vertical cylinder air classifier unit.

Heavy materials that enter the air classifier drop out from the bottom and are conveyed to compactors for landfilling, and the light fraction is entrained in the air stream and carried out the top. A cyclone separates this material from the air stream. The light fraction then enters a trommel screen where glass and grit are removed and later taken to a landfill. Oversize material passing through the trommel is conveyed to an optional pelletizer which densifies it into pellet form for shipment to the fuel user. If not pelletized, the material is shipped as is.

The front half of the plant, which includes the shredders and magnetic separators, operates independently of the back half. The back half includes the air classifier, trommel, and pelletizer. The control room for the back half is shown in Figure A-7. The shredders and magnetic separation system are controlled from a separate location beneath the tower structure which houses the ferrous separators.

For engineering evaluation purposes, the Plant C facility can be divided into the following subareas (refer to Figure A-7):

- Shop and personnel area
- Storage pits and R&D area
- Shredder room
- Shredder control pods
- Processing building
- Magnetic separator area

The shop and personnel areas (restrooms, locker room, and break room) are separated from the storage pits by a built-up partition. The common wall with the shredder room is poured, reinforced concrete.

The storage pits and R&D area are in the same room. The R&D area is located where the third shredder pits will eventually be, if plant volume requires the expansion. The R&D area is not partitioned off from the active storage pits. The north wall of this area is common with the processing building and is constructed of concrete blocks. The east wall joins the shredder room and is constructed of a fabricated metal.

The lower half of the shredder room is below grade, with foundation walls of poured concrete. The lower half of the west wall is formed by the steel sides of the push pits and, above that, of fabricated metal.

The shredder control pods are located high in the wall separating the storage pits from the shredder room. The pods are just above the shredder room roof and provide visibility into the storage pits through the west wall and to the shredder infeed conveyors through the floor. Access to these pods is through a trap door in the floor which leads to the back wall of the push pits and also by a door leading to a catwalk on the shredder room roof.

The processing building is not a separate building, but it is partitioned off from the storage area and shredder room by a concrete block wall.

The magnetic separator area is an open, elevated structure located east of the main building. Inclined conveyors carry the materials to and from the main building. The base of the equipment level is 14 ft (4.3 m) above ground. This area is partly protected from the weather by a roof, but the sides of the structure are open.

All conveyors and work areas are protected by an automatic sprinkler system.

Plant C Personnel

The work force at Plant C is currently comprised of 64 employees in a variety of job categories. Table A-4 lists these workers according to job description for each work shift. The first shift crew works from 7:00 AM to 5:30 PM, 4 days per week, while the second and third shifts work 5 days per week, from 5:00 PM to 1:30 AM and 1:00 AM to 8:00 AM, respectively.

Each of the line operators at Plant C has control over one of the three operational segments of the facility (i.e., push pits/input conveyors/shredders; air classification/RDF conveyors; and secondary materials separation). Their duties are mainly to maintain the flow of material through their particular segment of the system and to manage its control center.

Staging and loading operators either control truck traffic and operations at the unloading docks (holding pit and push pits), or they control the operation of the output conveyor system and the stationary compactor/RDF loading stations. They may also direct truck traffic involved in the loading of various recovered resources and perform other related tasks in their areas.

Utility personnel are basically assigned to cleanup duties, but they also assist mechanics, electricians, and the various operators in correcting equipment malfunctions when required.

Homeowner collection pit operators supervise the area near the plant entrance where City residents are allowed to drive up in their own vehicles and deposit refuse in open-top trailers. The operators are also responsible for directing traffic and maintaining the appearance of the area.

TABLE A-4. PLANT C EMPLOYEES CATEGORIZED
BY JOB DESCRIPTION

Shift	Number of employees	Job description
1st	2	Supervisors
	9	Line operators
	9	Staging and loading operators
	6	Drivers
	2	Homeowner pit operators
	1	Crane operator
	1	Utility worker
	1	Transport clerk
	1	Tool room clerk
	2	Electricians
	1	Mechanic
	<u>34</u>	
2nd	1	Supervisor
	5	Utility worker
	1	Electrician
	1	Tool room clerk
	9	Mechanics
	1	Oiler/greaser
	<u>18</u>	
3rd	1	Supervisor
	5	Staging and loading operators
	4	Line operators
	1	Driver
	<u>11</u>	

Plant E Facilities

The Plant E resource recovery facility began operation in 1979 but still remains essentially in the start-up phase due to a number of equipment and material flow problems. The facility is designed to process a maximum of 1,800 tons (1,633 Mg) of solid waste per day using two production lines. Each line is rated at 75 tons/hr (245 Mg/ks) but only one of them has been put into operation thus far at a reduced processing rate of 25 tons/hr (81.7 Mg/ks). Furthermore, this line runs only for intermittent periods because of inherent mechanical problems. A schematic diagram of the processing system is shown in Figure A-8.

KEY

1. Primary Trommel
2. Primary Shredder
3. Magnetic Separator
4. Air Density Separator
5. Secondary Trommel
6. Ball Mill
7. Ball Heater
8. Screen
9. Process Heater
10. Glass & Aluminum Plant
11. Pre-Processing

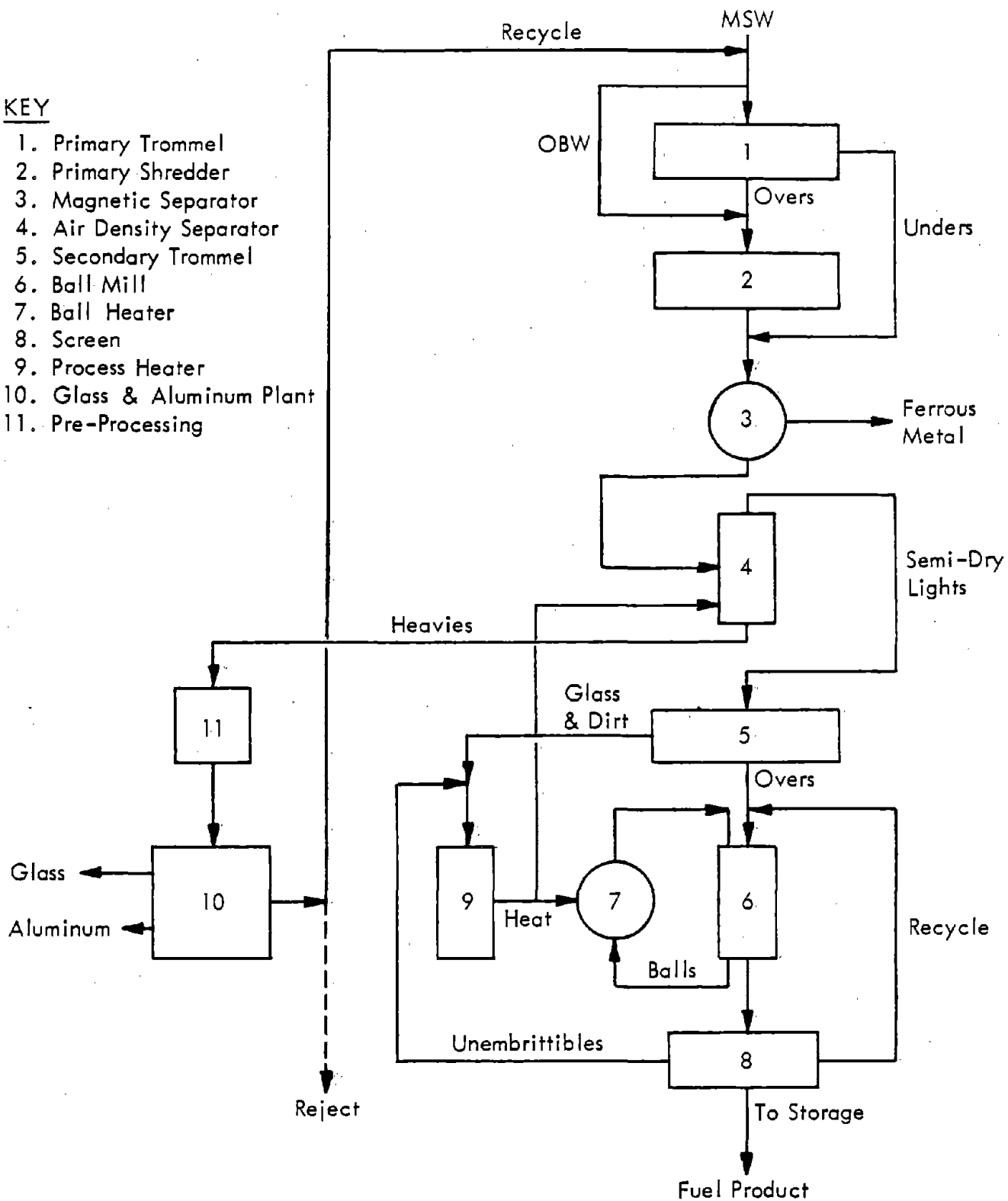


Figure A-8. Schematic diagram of the Plant E resource recovery process.

Refuse collection trucks unload their material at Plant E from a balcony level overlooking the tipping floor. Two payloaders then move the piles of solid waste into two pushwall corners located opposite the truck balcony. From the material stacked in these corners, the payloaders scoop out portions and spread them out on open areas of the tipping floor. Workers then manually sort through the refuse to remove any oversized bulk items or hazardous materials. Once the refuse has been inspected in this manner, it is pushed onto one of two infeed conveyors located in the center of the tipping floor.

The refuse material is conveyed through a concrete dividing wall and into the processing area where it first enters a primary trommel. The trommel screens allow material smaller than about 5 in. (12.7 cm) to drop through its openings. Oversized material is discharged from the lower end of the rotating trommel and sent to a hammermill where it is substantially reduced in size. This shredded refuse is combined with the undersized material from the trommel and conveyed to a magnetic separation system.

In the magnetic separator, ferrous metals are picked up from the moving conveyor by a rotating drum and transferred to a cleaning device. The cleaner further separates any light material debris from the heavy ferrous fraction and returns it to the mainstream for further processing. The ferrous metal is collected and sold as a by-product.

All nonferrous material goes to an air density separator. Heavy components such as glass, food and yard waste, and nonferrous metals drop out the bottom, while light, combustible materials rise with the airstream. The light materials are removed from the airstream by a bag filter system and subsequently sent to a secondary trommel, while the heavy reject material is conveyed to a truck for transport to a landfill.

The secondary trommel removes mostly fine glass and dirt from the light material stream. The oversized fraction exits the trommel and then passes through a contact section where it is sprayed with an embrittling agent. This agent is an aqueous solution of a proprietary mixture of chemicals which causes the refuse material (now basically paper and plastics) to become more brittle and, thus, more amenable to fractionation.

After leaving the spray section, the material enters a ball mill (similar to the kind used in the minerals processing industry). The hot rolling steel balls reduce the incoming refuse material to a fine granular product, RDF. As the balls leave the mill, they are recycled to the ball heater before reentering the mill. A temperature above the boiling point of water is required to evaporate the water present in the refuse. The granular ball mill product is then separated from the balls and pneumatically conveyed to a cyclone, where the RDF is separated from the airstream. The air discharged from the cyclone is returned to the process heater and the product material drops out onto a three-section vibrating screen. The coarsest fraction is that which is not possible to embrittle and grind to the product fuel size. This material is discarded. Next, the material smaller than the coarse

fraction but larger than the product fuel size is recycled by the ball mill. Finally, the fuel product drops out the bottom deck of the vibrating screen and is conveyed to storage silos to await shipment by truck.

The plant layout and locations of the major equipment are shown in Figure A-9.

Major areas within the Plant E facility are as follows:

- Process area

- Process heater room

- Ball mill room

- Maintenance shop

- Tipping floor and truck receiving deck

- Offices and personnel area

The process heater room, ball mill room, and maintenance shop are separated from the process area by concrete walls. Similarly, the tipping floor is segregated from the remainder of the facility by a concrete wall. The office area is an appendage to the north side of the main building, with an adjoining hallway and stairway. Directly to the west of the front offices is an open area that is covered by an overhang but is not otherwise enclosed. Some equipment parts are stored in the area and trailer trucks are also positioned there under the ferrous metals conveyor discharge. The control room is located on an upper level in the southwest corner of the process area. Unlike most control rooms at other resource recovery facilities, it does not have windows which look out over the process area of the tipping floor. Instead, important locations about the plant are monitored via closed circuit television.

An employee lunchroom and a locker room are located on the floor above the front office area. A chemical laboratory and additional offices are located above the shop area and also on the second floor. On the third floor is an electrical instrumentation lab.

The tipping floor is at the same elevation as the process area. The truck receiving deck, however, is elevated above the tipping floor to allow the incoming vehicles to discharge their loads of MSW onto the lower level. This enables the refuse to be piled on the tipping floor and keeps the vehicle area free from obstructions.

Plant E Personnel

Employees at Plant E are divided among four basic categories: administration, production, maintenance, and general labor. The majority of these workers are employed as mechanics or utility personnel (60 of the total payroll of 96). The complete job classification distribution is shown in Table A-5.

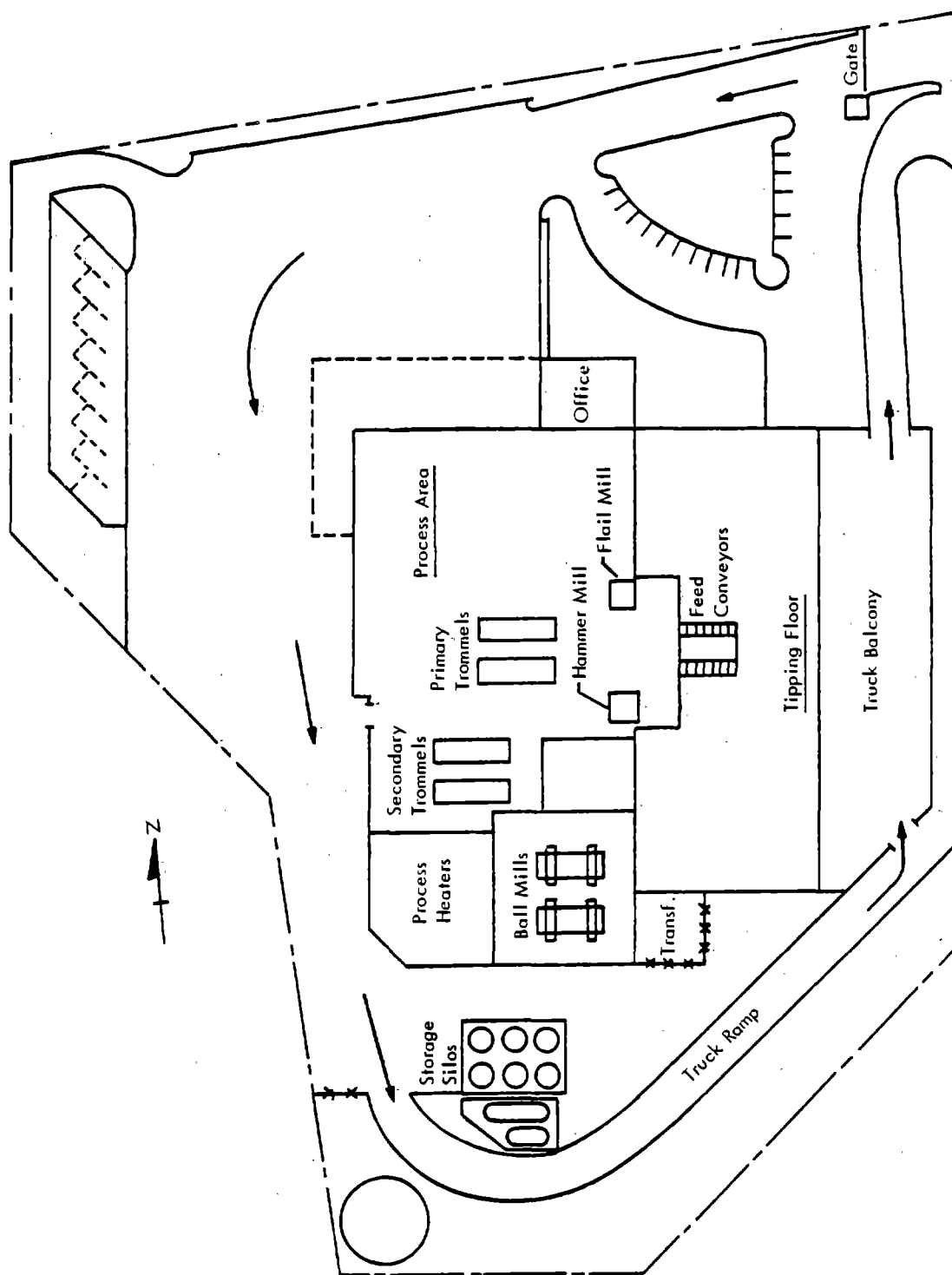


Figure A-9. Plan view of the Plant E facility.

TABLE A-5. CLASSIFICATION OF EMPLOYEES AT PLANT E

Category	Job classification	Number of employees
Administration	Management	10
	Office clerical	5
Production	Shift supervisor	4
	Assistant shift supervisor	1
	Control room technician	4
	Laboratory technician	3
	Equipment operator	4
Maintenance	Instrument specialist	2
	Electrician	3
	Mechanic	20
General Labor	Utility	<u>40</u>
Total		96

Operating shift times are 8:00 AM to 4:00 PM, 4:00 PM to 12:00 PM, and 12:00 PM to 8:00 AM. Plant E uses a rotating, four-shift system for some of its workers, which means one shift is off duty for several days before returning to the rotation. Each of these shifts usually consists of one shift supervisor, one control room technician, one equipment operator, two mechanics, and eight utility personnel. As far as could be determined, all other employees work during the day shift.

Only three workers were observed to have what could be considered as stationary jobs within the production areas of the plant. These are workers on the tipping floor (the payloader driver and two utility personnel assigned as sorters to remove bulky or hazardous items from the refuse). Working locations for the other personnel are dictated by the activities of the particular work day, since most are assigned to maintenance or cleanup duties.

RESULTS OF PLANT SURVEYS

Air Contaminants

Plant A--

Results of the industrial hygiene monitoring for air contaminants conducted during MRI's survey of Plant A are presented in this section. A summary of the sampling matrix is presented in Tables A-6 and A-7, identifying the types

TABLE A-6. SURVEY SAMPLING AND ANALYSIS MATRIX--PLANT A

Substance sampled	No. of samples	Method of sampling	Analysis method
Total dust	8	NIOSH method 29.02/ Inert or nuisance dust	Gravimetric
Respirable dust	7	NIOSH method 29.02	Gravimetric
Trace metals	4	NIOSH methods: 9.01/Beryllium 22.01/Zinc chloride S312/Cadmium dust S323/Chromium (soluble) S341/Lead	P&CAM 173
Pesticides (organophosphorus and carbamates)	2	NIOSH method 21.01/impinger (distilled water)	Enzyme assay screen
Asbestos	3	NIOSH method 2.02/asbestos	P&CAM 239
Silica	3	NIOSH method 3.02/crystalline silica	P&CAM 109
Polychlorinated biphenyls (PCBs)	2	Florisil tube	P&CAM 244
Polynuclear aromatic hydrocarbons (PNAHs)	2	Glass fiber/silver membrane filters, backed by porous polymer tube	HPLC GC/MS
Particulate morphology	4	0.47 mm, 0.1 μ m Nucleopore filter	SEM
Organics	4	Portable IR; charcoal tube	Direct reading, P&CAM 127
Carbon monoxide	-	Interscan CO monitor	Direct reading
Particle sizing	4	Acu-vol samplers with Sierra impactors	Gravimetric
Noise	-	Sound level meter, octave band analysis	Direct reading
Ventilation	-	Thermoanemometer	Direct reading

TABLE A-7.. SUBSTANCES SAMPLED BY GENERAL LOCATION--PLANT A
(area and personal samples)

<u>Tipping floor</u>												
Substance	Total dust	Resp. dust	Trace metals	Silica	CO	Noise						
No. of samples	2	2	1	1	2	2						
<u>Primary shredder</u>												
Substance	Total dust	Resp. dust	Trace metals	Silica	Asbestos	PCB	PNA	Pesticides	Part. morph.	Organics		
No. of samples	2	1	1	1	1	1	1	1	2	2		
<u>Secondary shredder</u>												
Substance	Total dust	Resp. dust	Trace metals	Silica	Asbestos	PCB	PNA	Pesticides	Part. morph.			
No. of samples	2	1	1	1	1	1	1	1	1			
<u>Rejects load out</u>												
Substance	Total dust	Resp. dust	Trace metals	Asbestos	CO	Noise	Part. morph.	Part. sizing				
No. of samples	2	2	1	1	1	2	1	2				
<u>Basement (near primary shredder)</u>												
Substance	Resp. dust	Organics	Part. sizing									
No. of samples	1	2	2									

and numbers of samples collected, sampling protocols, and analytical methods used. In all cases, NIOSH-approved methods were followed. Full-shift sampling was conducted wherever possible to characterize 8-hr time weighted average (TWA) exposure levels. In addition to the monitoring done by MRI's survey team, Charles Reaux, NIOSH Project Officer, conducted limited surveys for mercury vapor and respirable dust concentrations, using a portable mercury vapor detector and a TSI Piezobalance monitor, respectively.

Table A-8 summarizes the results of the Plant A air sampling survey (more extensive survey results are given in Appendix D, Table D-1). Data are presented according to the four designated sampling areas within the plant (i.e., tipping floor, primary shredder, secondary shredder, and rejects loading areas). Figures A-10 and A-11 show the approximate sampling locations in each area. The following subsections discuss survey results by hazard category.

Total and respirable dust--Total dust levels measured within the plant were well below the recommended 10 mg/m^3 threshold limit value (TLV) for nuisance dust, with the exception of the area near the secondary shredder. An 8-hr TWA concentration of 15.4 mg/m^3 was recorded at a sampling location (not a personnel sample) just above the C-6 conveyor which removes material from beneath the secondary shredder. During the sampling period, particulate material was seen quickly accumulating on the railings and floor grating in this area, indicating an abundance of very large particles in the air. Respirable dust levels measured at the same location verified this observation, since a TWA respirable concentration of only 0.38 mg/m^3 was found.

Other respirable dust levels within the plant were very similar in magnitude. The highest level recorded was 0.54 mg/m^3 (a personal sample), and the lowest was only 0.09 mg/m^3 in the tipping floor area. Two respirable samplers were worn by plant employees who worked generally toward the rear of the processing area. One worker was classified as a laborer whose duty was to sweep the ground floor area of accumulated refuse. The other was a maintenance worker with variable duties and work areas. Measured respirable dust loads were similar for both workers (0.39 and 0.54 mg/m^3).

Trace metals--Four particulate samples were collected and analyzed by atomic absorption spectroscopy (AAS) for five trace metals, i.e., lead, zinc, chromium, cadmium, and beryllium. In all cases, the resulting concentrations were much lower than the corresponding TLV, and most were at least an order of magnitude less. These levels would tend to indicate that any airborne concentrations of such trace metals are probably the result of the trace metal content of paper, plastics, and other shreddable materials and do not result from metal fumes or dusts. Thus, these trace metals do not appear to be a health hazard.

Silica--Analysis of three particulate samples for free silica (SiO_2) content showed the highest level detected to be 0.40 mg/m^3 near the secondary shredder. This represented 1.7% of the total weight of particulate collected.

TABLE A-8. RESULTS OF PLANT A SURVEY BY SAMPLING LOCATION

Substance monitored	Concentration during sampling (mg/m ³)	TWA (mg/M ³)	NIOSH TLV (mg/m ³)
<u>Tipping floor</u>			
Total dust	0.51 0.2	0.45 a	10 10
Respirable dust	0.09 0.36	0.09 0.36	5 5
Trace metals			
Beryllium	ND-LD 0.05 µg ^b	-	0.002
Cadmium	ND-LD 0.2 µg ^b	-	0.05
Chromium	ND-LD 0.5 µg ^b	-	0.05
Lead	0.00287	0.00257	0.05
Zinc	0.0011	0.0010	5
Silica (total)	ND-LD 0.01 mg ^b	-	-
<u>Primary shredder</u>			
Total dust	3.36 2.67	3.15 a	10 10
Respirable dust	0.35	0.33	5
Trace metals			
Beryllium	ND-LD 0.05 µg ^b	-	0.002
Cadmium	ND-LD 0.2 µg ^b	-	0.05
Chromium	ND-LD 0.5 µg ^b	-	0.05
Lead	0.00911	0.00826	0.05
Zinc	0.0058	0.0053	5
Polychlorinated biphenyls (PCBs)			
Aroclor 1242	0.00096 ^b	a	0.001
Aroclor 1254	ND-LD 0.08 µg ^b	-	0.001
Aroclor 1260	ND-LD 0.05 µg ^b	-	-
Silica (total)	0.04	0.04	-
Asbestos	0.21 fibers/cc ^d	a	0.5 fibers/cc
Pesticides	ND	-	-

TABLE A-8. (continued)

Substance monitored	Concentration during sampling (mg/m ³)	TWA (mg/m ³)	NIOSH TLV (mg/m ³)
<u>Organics^c</u>			
Benzene	ND-LD 1 µg ^b	-	3
Ethyl alcohol	ND-LD 11 µg ^b	-	1,900
Heptane	ND-LD 7 µg ^b	-	340
Hexane	ND-LD 3 µg ^b	-	360
<u>Secondary shredder</u>			
Total dust	16.4 27.1	15.4 a	10 10
Respirable dust	0.41	0.38	5
<u>Trace metals</u>			
Beryllium	ND-LD 0.05 µg ^b	-	0.002
Cadmium	ND-LD 0.2 µg ^b	-	0.05
Chromium	0.0013	0.0012	0.05
Lead	0.0202	0.0181	0.05
Zinc	0.0429	0.0385	5
<u>Polychlorinated biphenyls (PCBs)</u>			
Aroclor 1242	0.0011	a	0.001
Aroclor 1254	ND-LD 0.08 µg ^b	-	0.001
Aroclor 1260	ND-LD 0.05 µg ^b	-	-
Silica (total)	0.43	0.40	-
Asbestos	0.13 fibers/cc ^d	-	0.5 fibers/cc
Pesticides	ND	-	-
<u>Ground floor</u>			
Respirable dust	0.38	0.38	5
<u>Organics^c</u>			
Benzene	ND-LD 1 µg ^b	-	3
Ethyl alcohol	0.19	a	1,900
Heptane	ND-LD 7 µg ^b	-	340
Hexane	ND-LD 3 µg ^b	-	360
Benzene	1.2	a	3
Ethyl alcohol	28	a	1,900
Heptane	ND-LD 37 µg ^b	-	340
Hexane	0.23	a	360

TABLE A-8. (concluded)

Substance monitored	Concentration during sampling (mg/m ³)	TWA (mg/m ³)	NIOSH TLV (mg/m ³)
<u>Reject load outs</u>			
Total dust	1.20 1.1	1.13 a	10 10
Respirable dust	0.52 0.21	0.52 0.20	5 5
Trace metals			
Beryllium	ND-LD 0.05 µg ^b	-	0.002
Cadmium	ND-LD 0.2 µg ^b	-	0.05
Chromium	ND-LD 0.5 µg ^b	-	0.05
Lead	0.0060	0.0053	0.05
Zinc	0.0029	0.0026	5
Asbestos	0.070 fibers/cc ^d	-	0.5 fibers/cc
Organics ^c			
Benzene	ND-LD 10 µg ^b	-	3
Ethyl alcohol	3.7	a	1,900
Heptane	ND-LD 7 µg ^b	-	340
Hexane	1.2	a	360
Benzene	1.6	a	3
Ethyl alcohol	34	a	1,900
Heptane	ND-LD 37 µg ^b	-	340
Hexane	0.88	a	360

a Sampling period was less than 7 hr; extrapolation to TWA not appropriate.

b None detected at the limit of detection specified.

c Results of charcoal tube analyses were coordinated with peaks detected by the Miran 1-A analyzer. Ethyl alcohol represents group including: ethanol, methanol, methyl acetate, dimethoxy methane, methylcyclohexanol, diethyl malonate, 1,-heptanol. Heptane and hexane represent groups including: cyclohexane, ethylamine, isophorone, LPG, methylamine, methylcyclohexane, octane, pentane, naptha, stoddard solvent, and turpentine.

d Measured concentration of total fibers. No asbestos confirmed in sample.

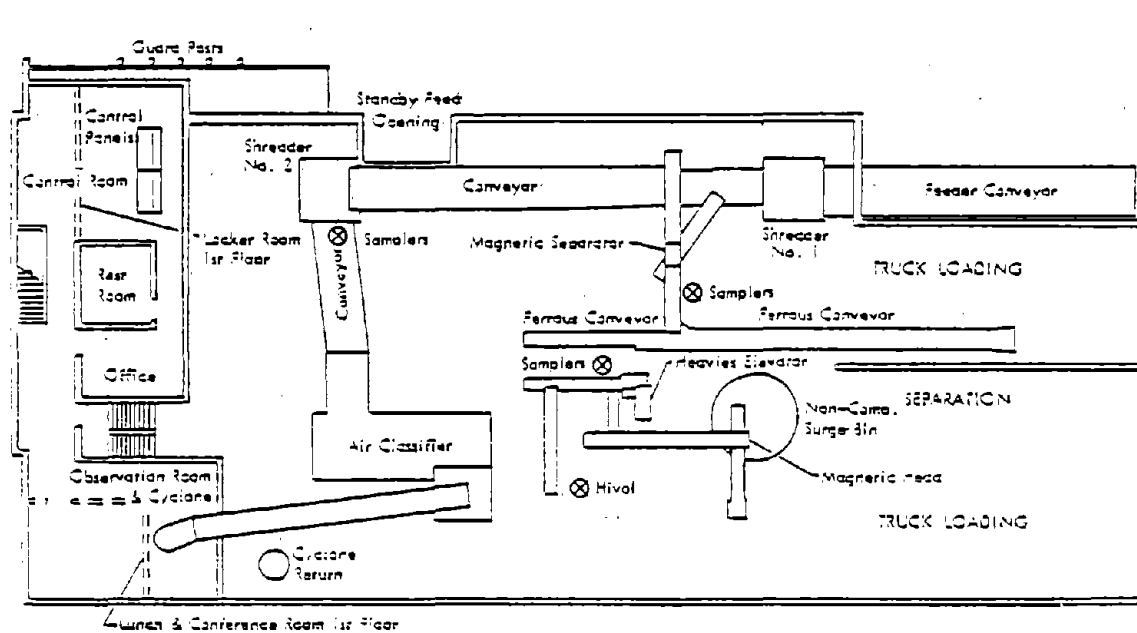
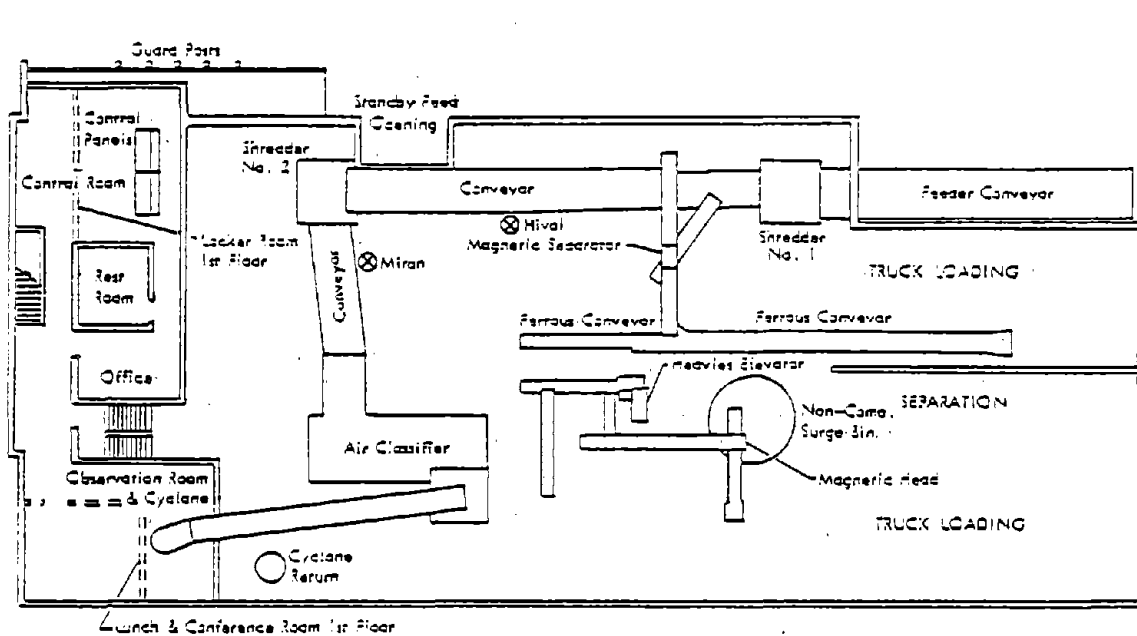


Figure A-10. Sampling locations of lower levels--Plant A
(elevations - 75 and 86 ft or 22.9 and 26.2 m)

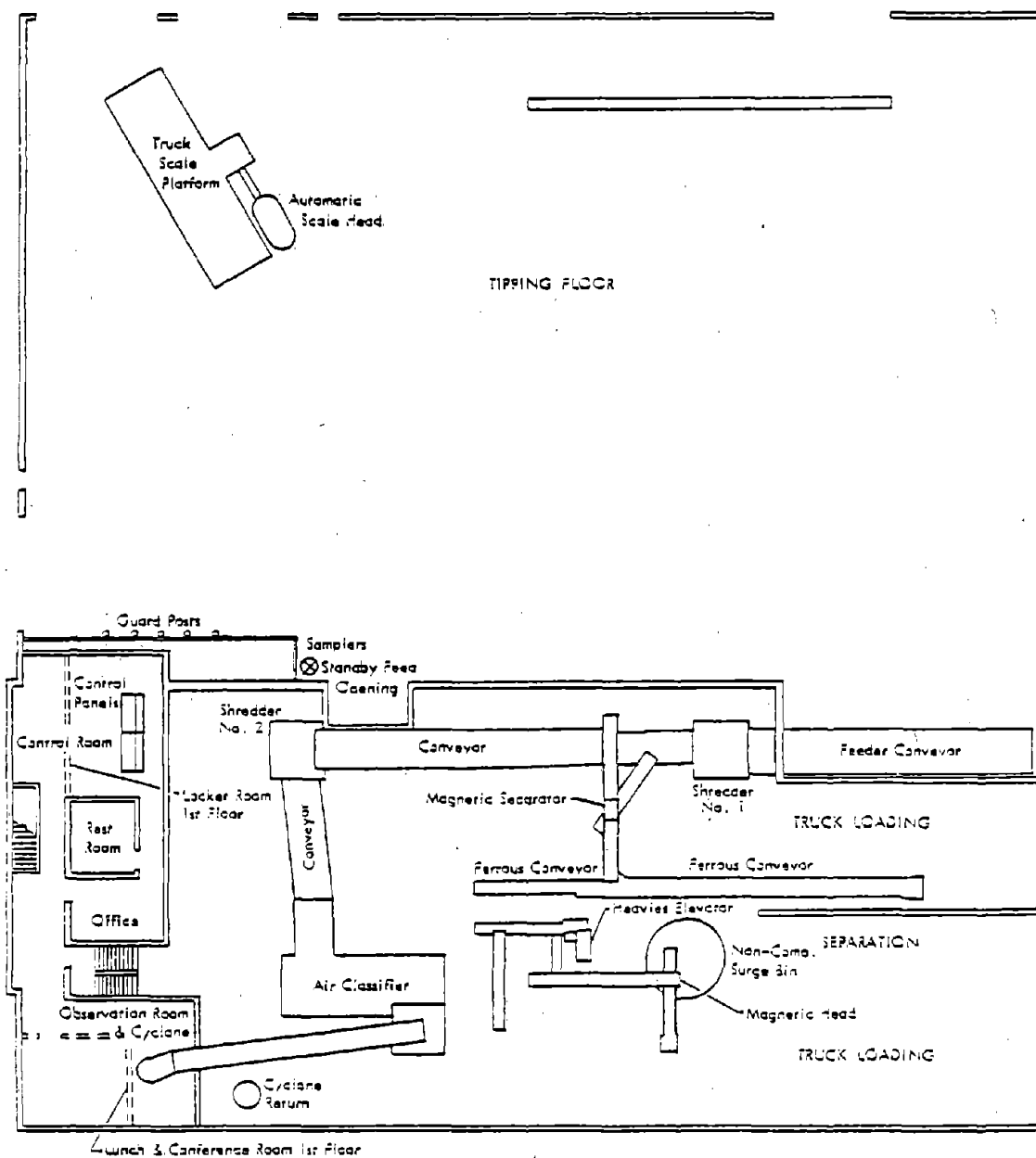


Figure A-11. Sampling locations of upper level--Plant A
(elevation - 100 ft or 30.5 m)

No silica could be detected in the second sample (< 0.01 mg) and the third contained about 1.5% silica, corresponding to 0.04 mg/m^3 . Since the ACGIH TLV for silica is 0.3 mg/m^3 , the results at this facility indicate that a potential silica exposure problem may exist.

Asbestos--Only limited asbestos sampling was conducted for this survey. Results of three measurements showed asbestos fiber concentrations to be just a fraction of the 0.5 fibers/cc TLV and, therefore, indicate that airborne asbestos fibers did not present an occupational hazard during this survey. Asbestos exposure would obviously depend on the composition of the refuse being processed at any particular time.

Pesticides--The processing area was monitored at two locations for the presence of cholinesterase-inhibiting pesticides using a water-filled impinger and a rapid screening "enzyme ticket" detection method developed by MRI. The two bubblers were operated for the duration of the working shift and their solutions checked, once just before the lunch period and again near the end of the shift, with the enzyme ticket. By this method, the absence of a color change on the ticket substrate would indicate the presence of an anticholinesterase material at a concentration greater than about 1 ppm. For this survey, all checks showed a definite color change; and thus, no pesticides of the organophosphorus and carbamate family were detected at significant levels.

Polychlorinated biphenyls (PCBs)--A solid sorbent (Florisil) method was used to monitor the workroom air for the presence of PCB compounds. The Florisil was contained in glass tubes similar to NIOSH charcoal tubes, and sampling was conducted with personal sampling pumps. Two samples were collected using this method and were analyzed for Aroclor 1242, Aroclor 1254, and Aroclor 1260. Only very low concentrations of Aroclor 1242 were detected.

General organics--Work area organic vapor levels were evaluated by three methods. Two of these employed direct reading instrumentation. A Century Systems portable gas chromatograph and a Foxboro Miran 1-A infrared analyzer were used to scan the spectrum of possible constituents for any prominent organic compounds or functional groups. The Century unit, however, did not function as well as was hoped and did not yield any useful information, except that it seemed to "track" the scan produced by the Miran. That is, it showed general agreement with the peaks indicated by the Miran, but the Century data could not be quantified. In addition, both instruments seemed to register peaks when it seemed (by smell) that paint or paint cans were being processed through the shredder.

The Miran 1-A analyzer was operated in both the scan mode and at specific absorbance wavelengths. Several organic compounds were preselected by MRI as likely to be present during MSW processing. Searches at the preselected wavelengths using data obtained from the Miran scan showed three significant absorbance peaks corresponding to benzene, ethyl alcohol and related compounds, and straight-chain hydrocarbons such as hexane, heptane, and petroleum distillates. Further monitoring was then done at these three major wavelengths to establish the approximate range of concentrations and their variation with time.

To quantify organic constituents detected by the Miran analyzer, charcoal tube sampling was conducted concurrently. Analytical results were then correlated with results from the Miran monitoring. Charcoal data are presented in Table A-8 for the three areas where organic vapor sampling was conducted. Only ethyl alcohol was detected at concentrations much above the limit of detection, and these were still well below the TLV. Thus, organic compounds were only very minor constituents of the processing area's environment during the survey period.

Particle size distribution--To determine the approximate size distribution of airborne particles in the processing area, samples were collected using high-volume samplers equipped with Sierra five-stage impactor heads. By this method, particulates were aerodynamically segregated into five discrete size categories, i.e., 10.2, 4.2, 2.1, 1.4, and 0.73 μm . Two samples were collected on consecutive days at each of two sites, one on the lowest level near the shredders and the other at the reject truck area. Results of this sampling are displayed graphically in Figures A-12 and A-13. Actual size data were adjusted to correct for a mass bias on the backup filter which follows the fifth sizing stage. An excess of particulate material was recorded on the final filters, which that would indicate that a particle "bounce" phenomenon occurred. The applied correction yields an approximation of the "true" size distribution based on previous experience with the Sierra impactor.

The median particle size in the basement area was between 10 and 20 μm . Similarly, in the rejects truck area the average size was between 7 and 20 μm . These data support the finding from the total and respirable dust sampling that many airborne particles resulting from solid waste processing are large, nonrespirable particulates.

Plant B--

Results of the sampling and analysis program conducted by MRI at Plant B are presented in this section. The survey sampling matrix is shown in Table A-9, and Table A-10 presents the same information organized according to sampling area. NIOSH-approved sampling and analytical methods were used in all cases. Full-shift sampling was emphasized and conducted wherever possible to characterize 8-hr TWA exposures. Area sampling was conducted in selected parts of the plant to define "worst case" and general plant exposures, even though employees did not work or remain in these areas for any prolonged length of time.

Table A-11 lists the general analytical results of the Plant B survey. More extensive survey results are given in Appendix D, Table D-2. The data are organized according to sampling area within the plant (i.e., picking station, primary shredder exit, loadout area, aluminum separator area, and air classifier exit). Figure A-14 shows the approximate sampling locations. The survey results are discussed next by hazard category.

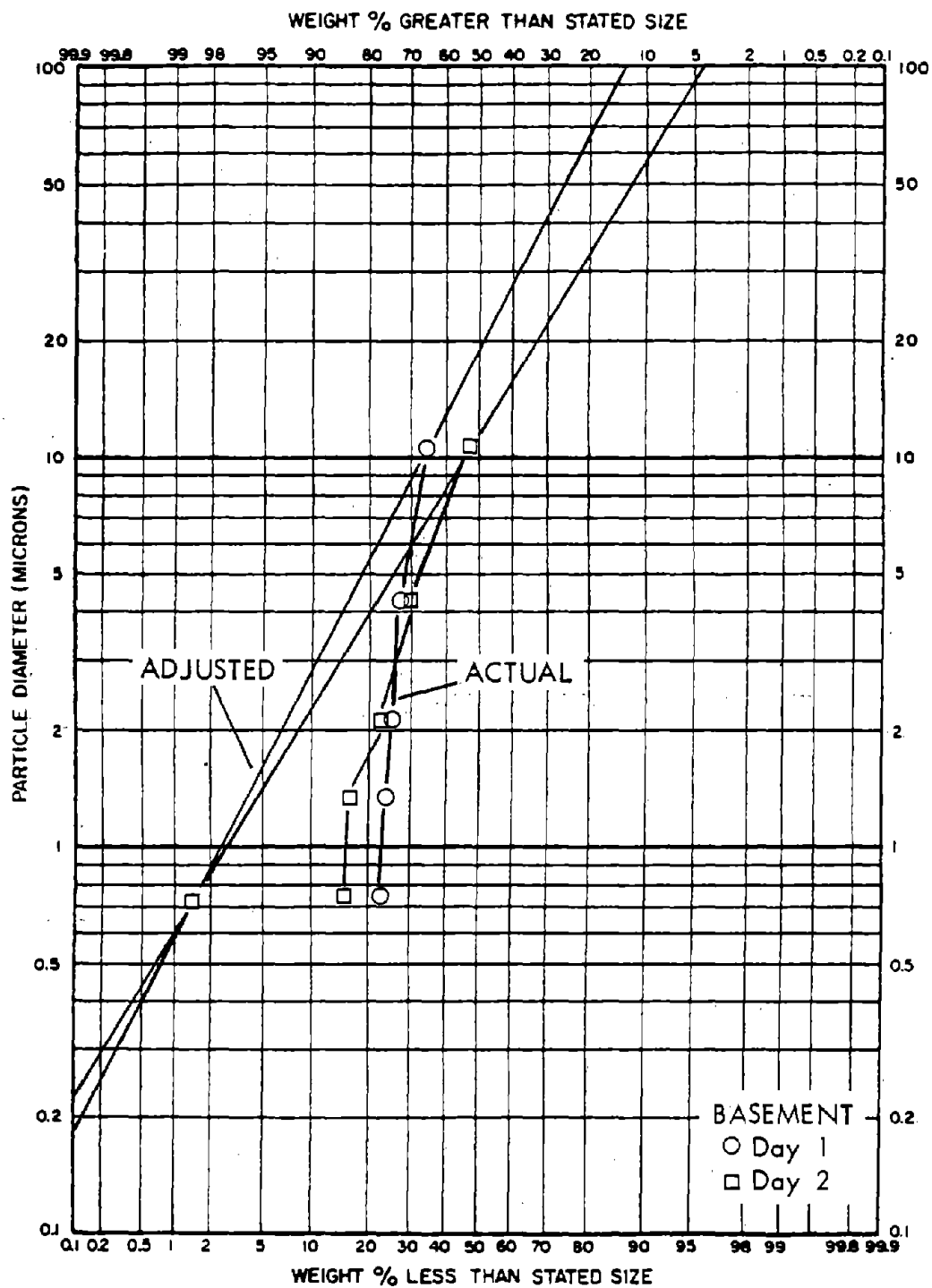


Figure A-12. Particle sizing results for bottom level sampling location--Plant A.

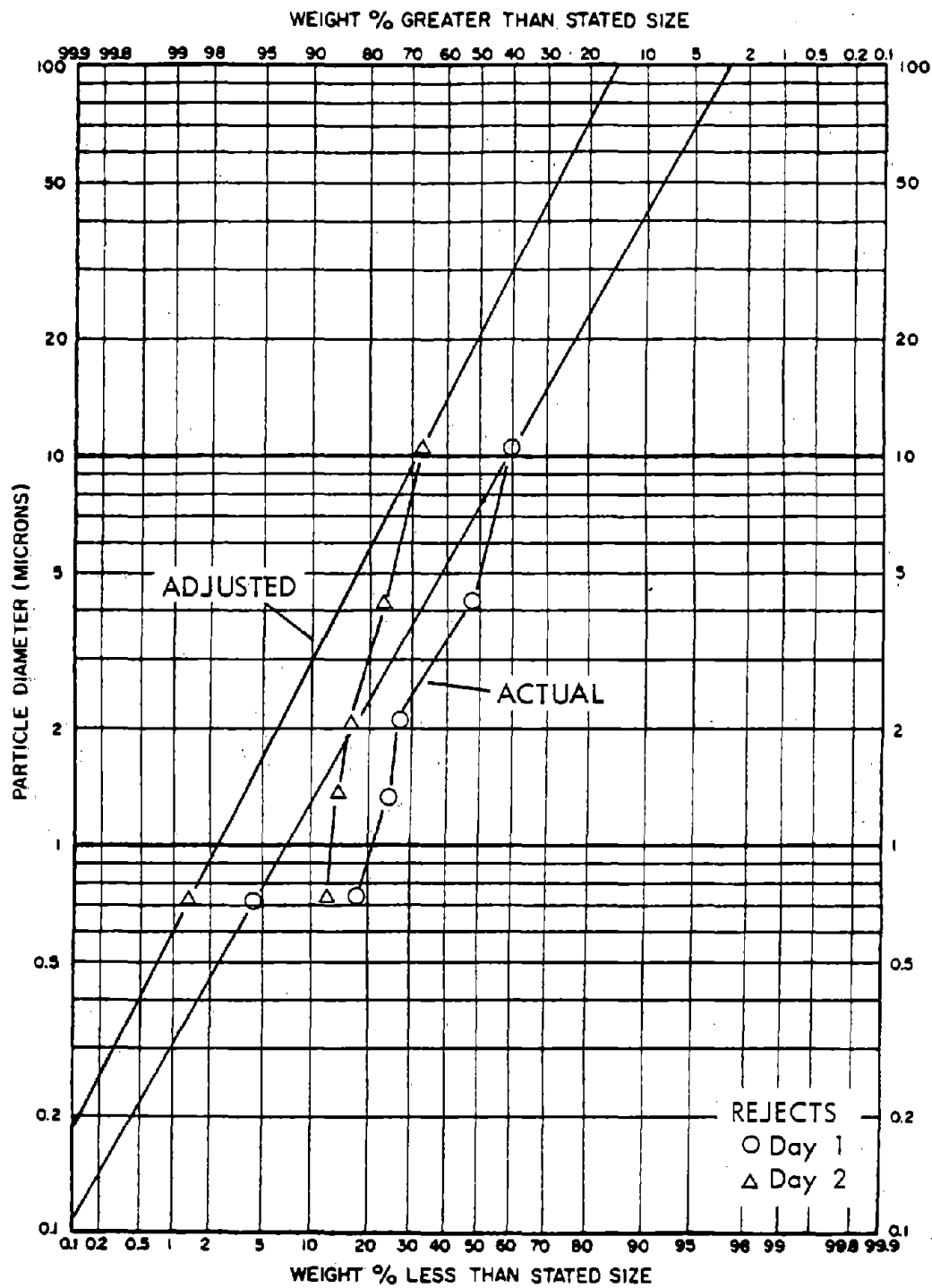


Figure A-13. Particle sizing results for rejects truck area sampling location--Plant A.

TABLE A-9. SURVEY SAMPLING AND ANALYSIS MATRIX--PLANT B

Substance sampled	No. of samples	Method of sampling	Analysis method
Total dust	8	NIOSH method 29.02/Inert or nuisance dust	Gravimetric
Respirable dust	8	NIOSH method 29.02	Gravimetric
Trace metals	4	NIOSH methods: 9.02/Beryllium 22.01/Zinc chloride S312/Cadmium dust S323/Chromium (soluble) S341/Lead	P&CAM 173
Pesticides (organophosphorus)	^a	NIOSH method 21.01/impinger (distilled water)	Enzyme assay screen
Asbestos	3	NIOSH method 2.02/asbestos	P&CAM 239
Silica	3	NIOSH method 3.02/crystalline silica	P&CAM 109
PCB	2	Florisil sorbent collection	P&CAM 244
PNAHs	2	Glass fiber/silver membrane filters, backed by porous polymer tube	HPLC GC/MS
Particulate morphology	2	0.47 mm, 0.1 µm Nucleopore filter	SEM
Organics	4	Portable IR; charcoal tube	Direct reading, P&CAM 127
Carbon monoxide	-	Interscan CO monitor	Direct reading
Particle sizing	4	Accu-vol samplers with Sierra impactors	Gravimetric
Noise	-	Sound level meter, octave band analysis	Direct reading
Ventilation	-	Thermoanemometer	Direct reading

^a Could not conduct sampling due to very cold temperatures.

TABLE A-10. SAMPLING MATRIX BY LOCATION--PLANT B

Picking station (before primary shredder)		Total dust	Resp. dust	Trace metals	Silica	Part. morph.	Asbestos	Noise	Part. sizing
Substance		2	8	2	1	1	1	6	3
No. of samples									
Air classifier exit									
Substance		Total dust	Silica	Asbestos	PNA				
No. of samples		2	1	1	1				
Tipping floor									
Substance		Noise							
No. of samples		2							
Al separator area									
Substance		Total dust	Trace metals	Silica	PCB	Part. sizing	Asbestos	Part. morph.	
No. of samples		2	2	1	1	1	1	1	
Load-out area									
Substance		Total dust							
No. of samples		2							
Welding room									
Substance		Welding fume	CO						
No. of samples		1	1						
Primary shredder exit									
Substance		Organics	PNA	PCB	CO				
No. of samples		4	1	1	1				

TABLE A-11. RESULTS OF PLANT B SURVEY BY SAMPLING LOCATION

Substance monitored	Concentration during sampling (mg/m ³)	TWA (mg/m ³)	NIOSH TLV (mg/m ³)
<u>Picking station</u>			
Total dust	1.5	a	10
	1.3	1.2	10
Respirable dust	0.49	a	5
	0.28	a	5
	0.34	a	5
	0.37	a	5
	0.43	0.41	5
	0.49	0.44	5
	0.50	0.49	5
	0.46	a	5
Trace metals			
Beryllium	ND-LD 0.05 µg ^b	-	0.002
Cadmium	ND-LD 0.2 µg ^b	-	0.05
Chromium	ND-LD 0.5 µg ^b	-	0.05
Lead	0.0037	0.0032	0.05
Zinc	0.0033	0.0029	5
Trace metals			
Beryllium	ND-LD 0.05 µg ^b	-	0.0002
Cadmium	ND-LD 0.2 µg ^b	-	0.05
Chromium	ND-LD 0.5 µg ^b	-	0.05
Lead	0.0052	a	0.05
Zinc	0.0041	a	5
Silica	0.06		-
Asbestos	1 fiber/cc ^c		0.5 fibers/cc
<u>Primary shredder exit</u>			
Organics			
Ethanol	ND-LD 1,100 µg ^b	-	1,900
Ethyl acetate	5.9	a	1,400
Methylene chloride	6.6	a	260
Organics			
Ethanol	ND-LD 980 µg ^b	-	1,900
Ethyl acetate	7.8	a	1,400
Methylene chloride	7.9	a	260

TABLE A-11. (continued)

Substance monitored	Concentration during sampling (mg/m ³)	TWA (mg/m ³)	NIOSH TLV (mg/m ³)
Organics			
Ethanol	ND-LD 88 µg ^b	-	1,900
Ethyl acetate	ND-LD 67 µg ^b	-	1,400
Methylene chloride	0.55	0.53	260
Organics			
Ethanol	ND-LD 1,100 µg ^b	-	1,900
Ethyl acetate	14	12	1,400
Methylene chloride	8.0	7.3	260
PCBs			
Aroclor 1242	ND-LD 0.04 µg ^b	-	0.001
Aroclor 1254	ND-LD 0.08 µg ^b	-	0.001
Aroclor 1260	ND-LD 0.08 µg ^b	-	-
PNAHs			
Benzo(a)anthracene	ND-LD 2 ng ^b	-	-
Benzo(a)pyrene	ND-LD 3 ng ^b	-	-
Benzene sol.	0.20	a	0.20
Chrysene	ND-LD 100 ng ^b	-	-
Fluoranthene	ND-LD 3 ng ^b	-	-
Pyrene	ND-LD 150 ng ^b	-	-
Load-out area			
Total dust	0.80	a	10
	0.68	0.59	10
Aluminum separator area			
Total dust	1.2	a	10
	0.91	0.80	10
Trace metals			
Beryllium	ND-LD 0.05 µg ^b	-	0.002
Cadmium	ND-LD 0.2 µg ^b	-	0.05
Chromium	ND-LD 0.5 µg ^b	-	0.05
Lead	0.0052	a	0.05
Zinc	0.0042	a	5

TABLE A-11. (concluded)

Substance monitored	Concentration during sampling (mg/m ³)	TWA (mg/m ³)	NIOSH TLV (mg/m ³)
Trace metals			
Beryllium	ND-LD 0.05 µg _b	-	0.002
Cadmium	ND-LD 0.2 µg _b	-	0.05
Chromium	ND-LD 0.5 µg _b	-	0.05
Lead	0.0040	0.0035	0.05
Zinc	0.0037	0.0032	5
Silica	0.02	a	-
Asbestos	1.5 fibers/cc ^c		0.5 fibers/cc
PCB			
Aroclor 1242	ND-LD 0.04 µg _b	-	0.001
Aroclor 1254	ND-LD 0.08 µg _b	-	0.001
Aroclor 1260	ND-LD 0.08 µg _b	-	-
<u>Air classifier exit</u>			
Total dust	1.0 1.1	a 0.97	10 10
Silica	ND-LD 0.01 mg _b	-	-
Asbestos	4 fibers/cc ^c		0.5 fibers/cc
PNAHs			
Benzo(a)anthracene	ND-LD 150 ng _b	-	-
Benzo(a)pyrene	ND-LD 3 ng _b	-	-
Benzene sol.	ND-LD 2 ng _b	0.06	0.20
Chrysene	ND-LD 100 ng _b	-	-
Fluoranthene	ND-LD 3 ng _b	-	-
Pyrene	ND-LD 150 ng _b	-	-
<u>Welding shed</u>			
Welding fume	10.6	a	-

a Sampling period was less than 7 hr; extrapolation to TWA not appropriate.

b None detected at limit of detection specified.

c Measured concentration of total fibers. No asbestos confirmed in sample.

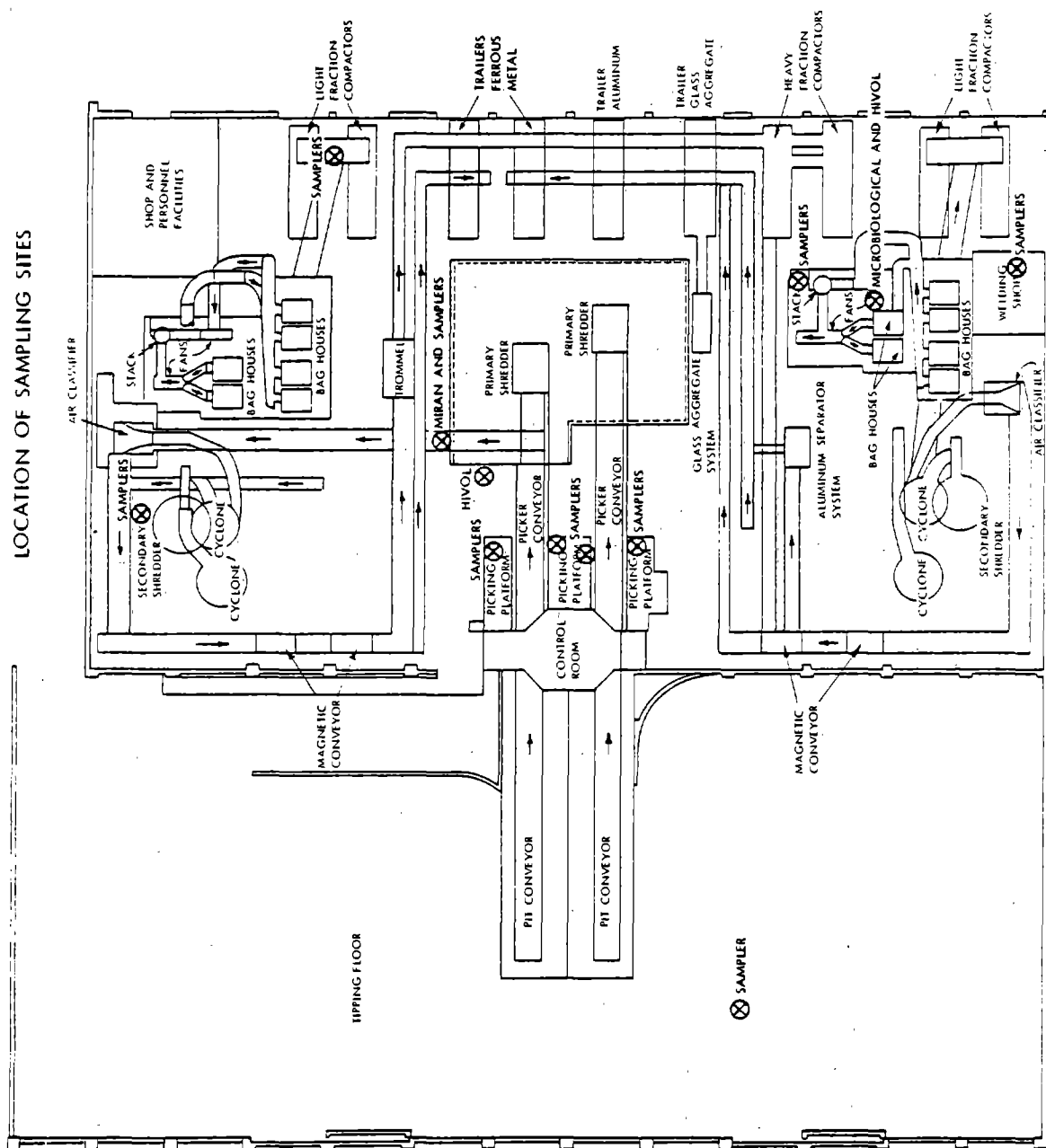


Figure A-14. Locations of air sampling sites--Plant B.

Total and respirable dust--All samples collected for evaluation of exposure to total dust showed concentrations much lower than the recommended TLV for nuisance dust (10 mg/m³, ACGIH/NIOSH). The highest exposure level was found at the picking station where a concentration of 1.5 mg/m³ was indicated. All total dust levels fell within the range of 0.5 to 1.5 mg/m³. Although somewhat higher dust concentrations may be evident within the plant at a few specific locations (e.g., directly beneath some conveyors which continually "rain" small refuse particles), the consistent total dust levels measured by MRI should be indicative of the levels to which workers in the plant are normally exposed.

Respirable dust concentrations, measured with personnel monitors worn by workers at the picking station, also showed consistently low particulate levels. The eight samples collected ranged from 0.28 to 0.50 mg/m³, which is well below the recommended NIOSH standard of 5.0 mg/m³. Respirable dust levels in other sections of the processing area could be expected to fall within the measured range.

Trace metals--The four particulate samples collected for elemental analysis were analyzed by AAS for lead, zinc, chromium, cadmium, and beryllium. All zinc, chromium, and beryllium concentrations were below their analytical limits of detection and are presented as less than values in Table A-11. Levels of lead and cadmium were also very low; at least an order of magnitude below the appropriate TLV in each case. These results indicate that such trace metals are probably not of concern as an airborne hazard and are probably present as trace constituents of the shreddable materials in solid waste.

Silica--Analysis of three particulate samples for silica (SiO₂) content indicated very low amounts of airborne silica. The highest concentration detected was 0.06 mg/m³ at the picking station which represented 4.0% of the total sample weight. No silica (< 0.01 mg) was detected in the sample collected in the vicinity of the air classifier unit, while the third sample (collected near the aluminum separator) contained about 1% silica by weight. Thus, there appeared to be no exposure problem to airborne silica during the survey, since the recommended ACGIH TLV is 0.3 mg/m³.

Asbestos--Initial optical microscopy analysis of three asbestos samples indicated total fiber concentrations in the range of 0.68 to 3.37 total fibers/cc. To determine the presence of asbestos fibers, further analysis by stain dispersion was done. Results showed negligible amounts of asbestos in the samples. Furthermore, no fibers longer than 5 µm were observed. Based on these results, it does not appear that airborne asbestos fibers were present during the MRI survey.

Polychlorinated biphenyls (PCBs)--A solid sorbent, Florisil was used to collect air samples for the detection of PCB compounds. Three samples obtained by this method were analyzed by gas-liquid chromatography for Aroclor 1242, Aroclor 1254, and Aroclor 1260. None of these compounds were detected in any of the samples (< 0.001 mg/m³). The TLV for Aroclors 1242 and 1254 is 1.0 µg/m³.

Polynuclear aromatic hydrocarbons (PNAHs)--A new NIOSH sampling method consisting of a filter cassette (containing a glass fiber filter above a silver membrane filter) followed by a porous polymer backup tube was used to monitor for PNAH compounds. Two samples were collected by this method and were analyzed for five specific PNAHs: chrysene, benzo(a)pyrene, fluoranthene, pyrene, and benzo(a)anthracene. The samples were also analyzed to determine their total benzene soluble content.

None of the five specific compounds were detected in either of the two samples. Less-than values shown in Table A-11 reflect limits of analytical detection. Benzene soluble components, however, were found. Resulting concentrations were 0.19 mg/m³ for a sample collected at the primary shredder exit and 0.06 mg/m³ for the sample collected near the air classifier. Since the TLV for particulate polycyclic aromatic hydrocarbons (as benzene solubles) is 0.2 mg/m³, the shredder exit sample indicates an exposure level at the recommended TLV. However, since specific PNAH compounds could not be detected, and since almost all nonpolar organic compounds are soluble in benzene, it is unlikely that the benzene soluble fractions of these two PNAH samples represent the polycyclic materials that are intended to be regulated by the 0.2 mg/m³ TLV.

General organics--Organic vapor constituents of the workroom air were evaluated by three methods: detector tubes, charcoal tubes, and direct reading instrumentation (Miran Model 1A analyzer). During a brief odor episode, detector tubes were used in an attempt to identify the major constituents of a strong solvent-type odor noted in the vicinity of the primary shredder. Significant color changes (100-150 ppm) were noted on both methylene chloride and ethyl acetate tubes. A peak level of benzene (4 ppm) was also detected.

Charcoal tube samples were also being collected at the shredder exit location during the time of the odor episode. They were primarily intended to accompany the use of the Miran 1A analyzer as a quantitative backup. The Miran was operated in both the scan mode and at specific absorbance wavelengths preselected by MRI as correlating to organic compounds likely to be present during MSW processing. Only one significant absorbance peak was observed on the Miran strip chart output, at a wavelength of 3.4 μ m. Unfortunately, a large number of straight-chain hydrocarbons absorb at this wavelength, so it is difficult to quantify a specific constituent.

Results of the Miran and detector tube sampling were used to determine the analytical scheme for the charcoal tube samples. Three organic compounds which showed significant peak levels on the Miran were chosen for the gas chromatography analysis: ethyl acetate, methylene chloride, and ethanol (representing a 3.4 μ m group). These three compounds also corresponded to the list of possible organic airborne contaminants associated with MSW processing which MRI had developed for the project study plan. The four samples each yielded low concentrations of each compound (see Table A-11). The highest concentration detected was that of ethyl acetate at 14 mg/m³. Since the corresponding TLV for ethyl acetate is 1,400 mg/m³, the measured workroom level is insignificant as the basis of a potential health hazard. However, the charcoal tube samples were collected for 6 hr or more, and the peak organic concentrations may well have been much higher.

On an 8-hr exposure basis, it appears that organic vapors are only very minor components of Plant B's workroom environment.

Particle size distribution--The approximate size distribution of airborne particles in the processing area was determined using a high-volume ambient sampler equipped with a Sierra, five-stage impactor head. This device aerodynamically segregated particles into five discrete size ranges: 10.2, 4.2, 2.1, 1.4, and 0.73 μm .

Four samples were obtained using this method; three near the picking station and the fourth in the aluminum separator area. Results are displayed graphically in Figures A-15 and A-16. Actual size data were adjusted to correct for a mass bias on the backup filter which follows the fifth and final sizing stage. An excess of particulate material was recorded on the final filters, indicating that a particle "bounce" phenomenon had occurred (common with this type of sampler). Thus, the applied correction yields an approximation of the "true" size distribution based on MRI's prior experience with the Sierra impactor.

The median airborne particle size in the picking station area appeared to be in the range of 4.5 to 7 μm , and in the aluminum separator area the median diameter was about 2.5 μm .

Particulate morphology--Two air samples were collected on special Nucleopore filters to determine particulate morphology characteristics. Initial examination of the samples was done by Walter C. McCrone Associates, using scanning electron microscopy (SEM) techniques. SEM examination was made at various magnifications and photographs of this work are shown in Figures A-17 to A-20. Both samples contained a mixture of fibers and particles. Dimensions of the particles varied widely, from less than 1 μm to greater than 100 μm . Some of the particles were solid while others were agglomerates of very small particles.

Energy dispersive X-ray analysis (EDXRA) of both samples was also conducted on a particle-by-particle basis. This compositional analysis revealed elemental constituents such as Si, Al, Ca, Cl, K, and Ti. Most particles were noted to be Si-Al in nature. These particles were likely derived from clay or other mineral sources, while those containing Ti were probably paint chips.

The SEM micrographs indicate that the sample collected in the shredder area had a higher ratio of particles-to-fibers (50% fibers) than did the sample collected near the aluminum separator area (about 90% fibers). Most of the fibers appeared to be either of a paper or cotton type, with a few synthetic fibers in each sample.

These samples were also examined directly by optical microscopy for visual fiber identification. The sample collected near the aluminum separator contained many pulp fibers, some of which may have resulted from sawdust. A few blue cotton fibers were noted, as well as a trace of yellow viscose fibers and a few tufts of fiberglass. The shredder area sample contained mostly colorless cotton fibers with a number of paper or wood fibers. A very few fibers of colorless rayon, yellow viscose, yellow polyester, and colorless modacrylic origin were also noted.

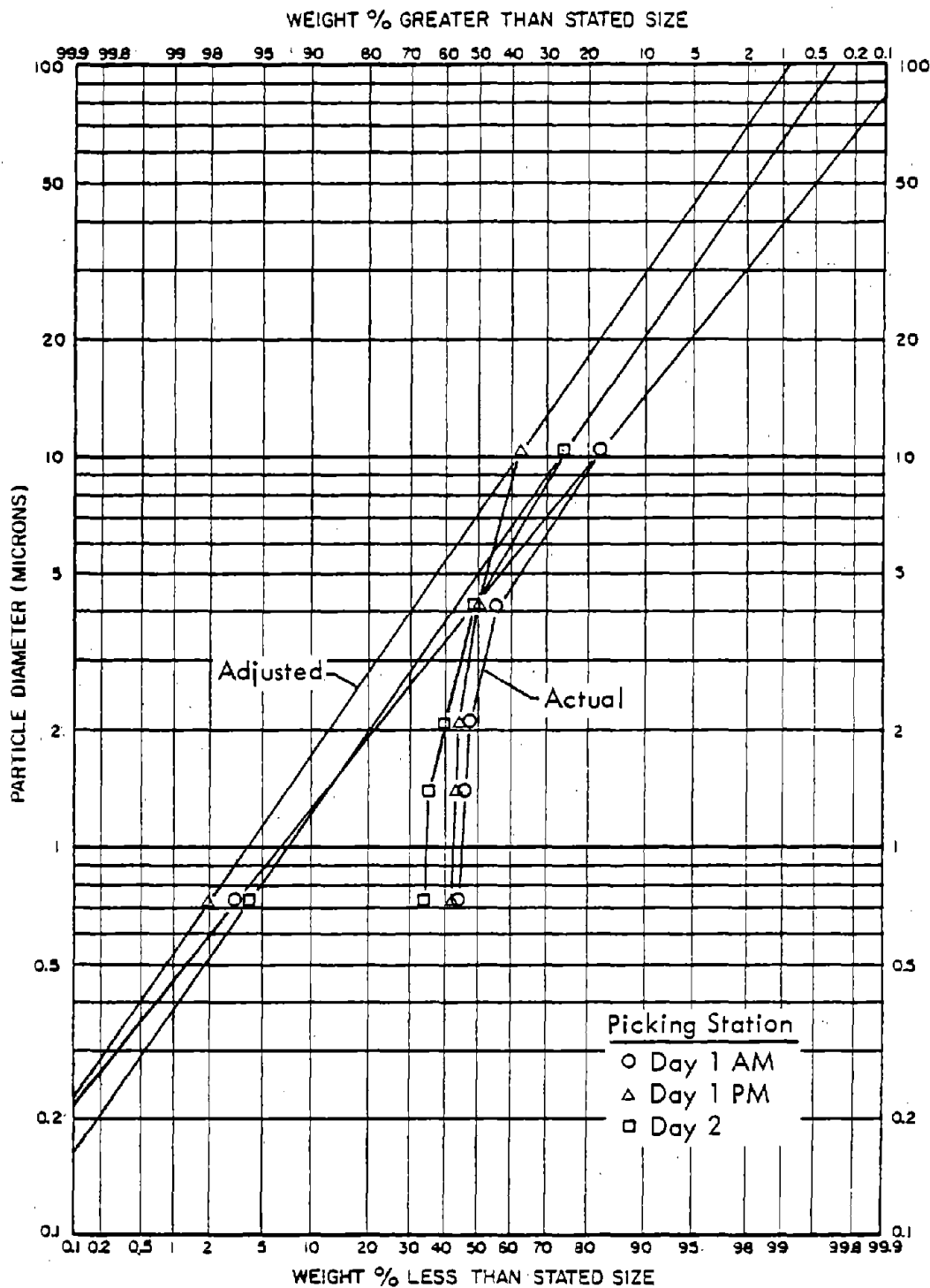


Figure A-15. Particle size distribution at picking station--Plant B.

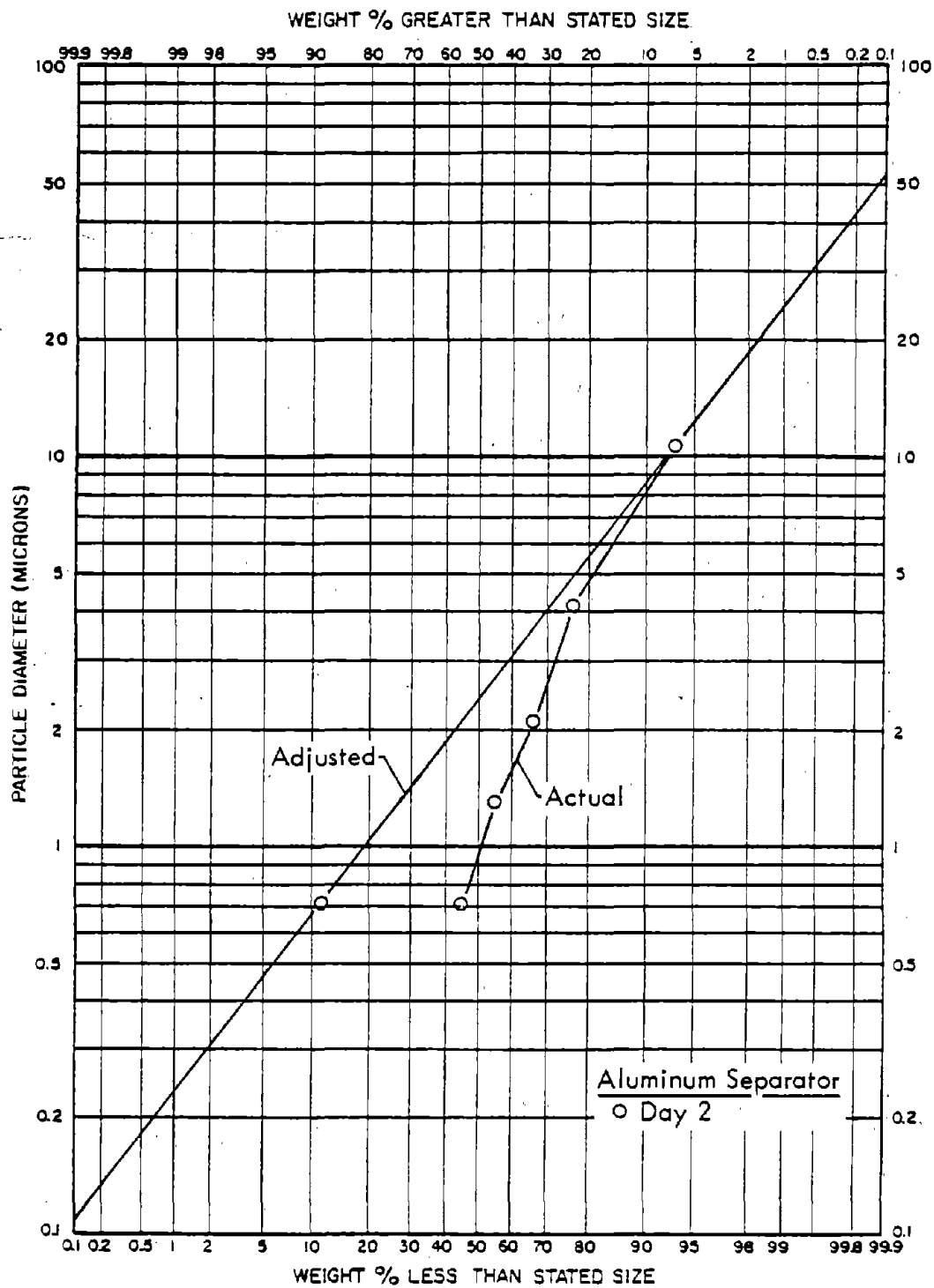


Figure A-16. Particle size distribution at aluminum separator--Plant B.

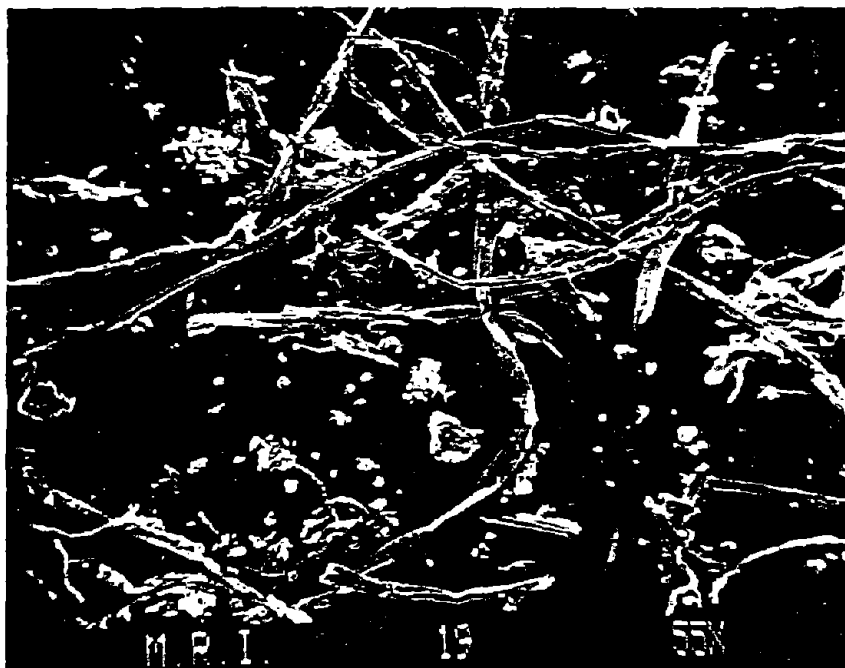
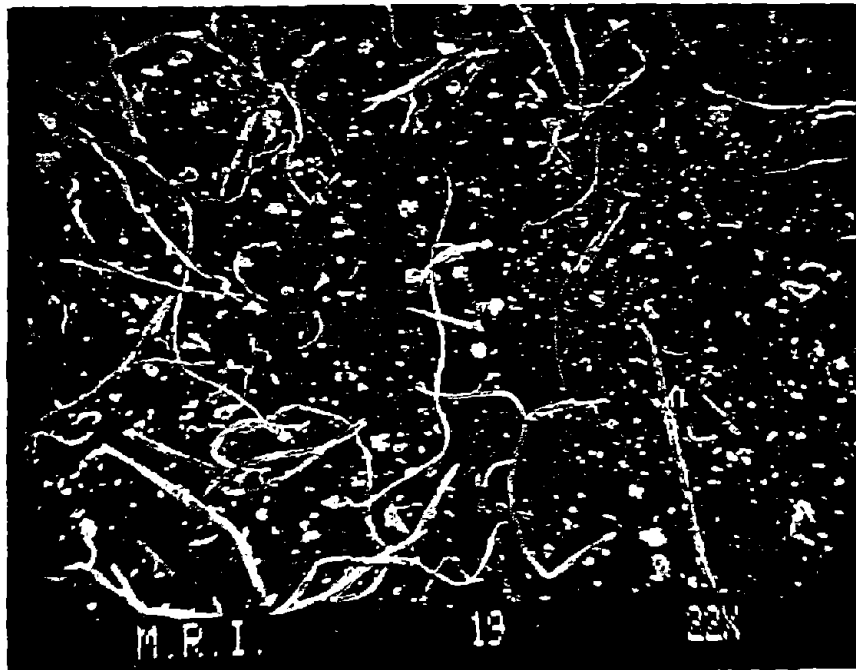


Figure A-17. Photomicrographs of particulate sample collected near the primary shredder of Plant B (magnifications 22x and 55x).

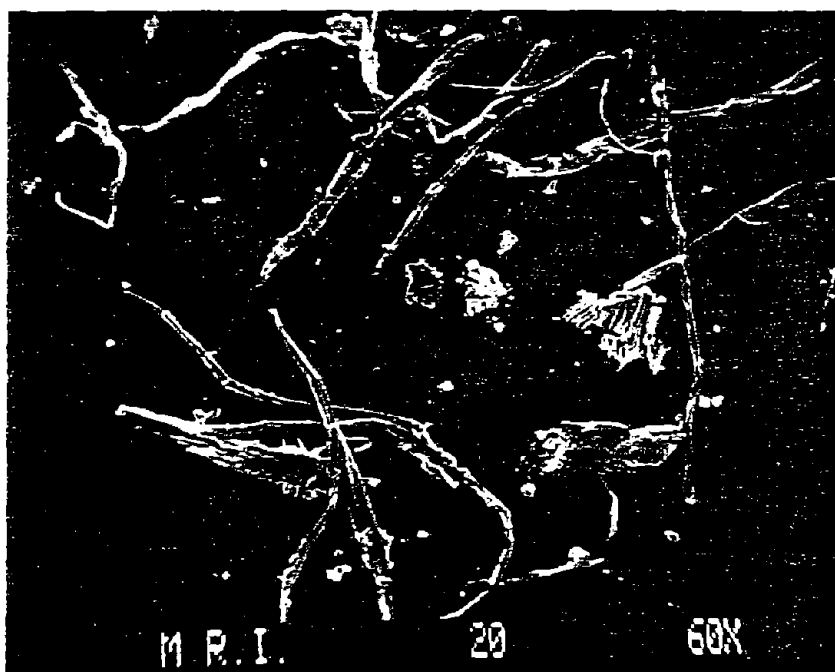
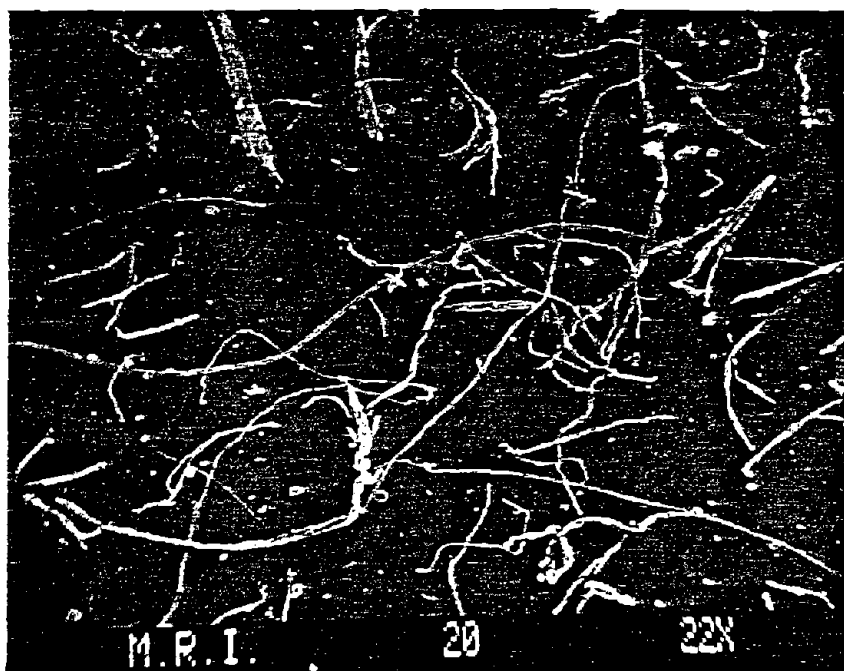


Figure A-18. Photomicrographs of particulate sample collected near the aluminum separator of Plant B (magnifications 22x and 60x).

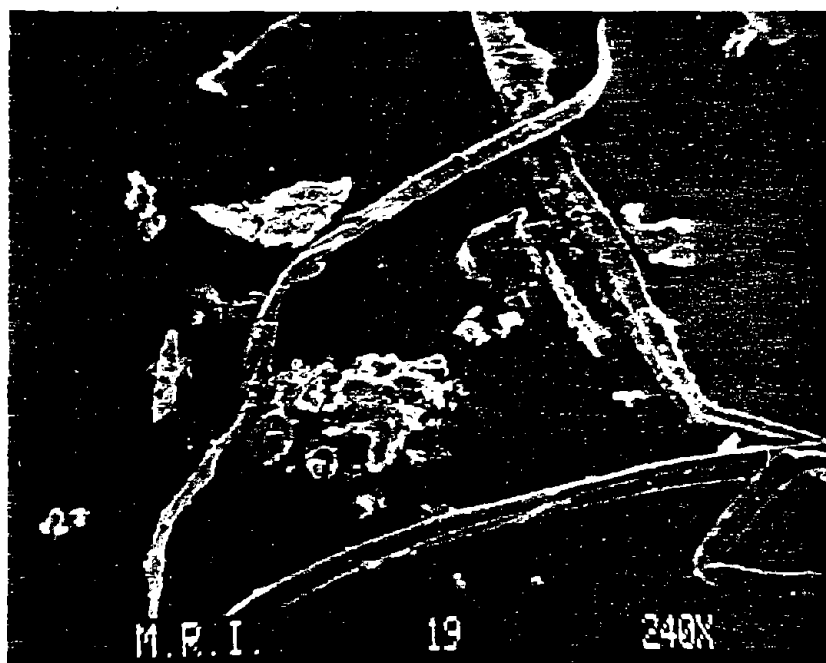
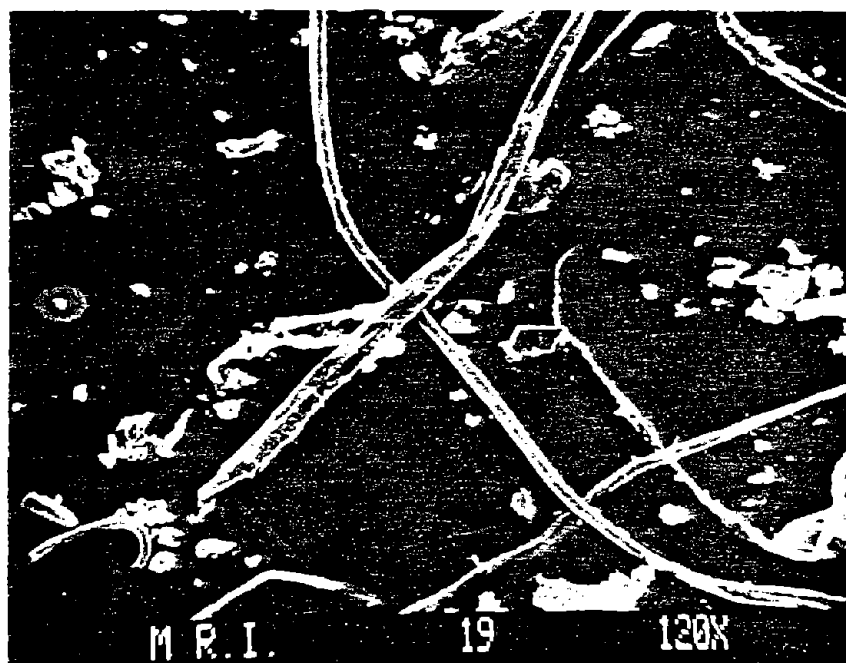


Figure A-19. Photomicrographs of particulate sample collected near the primary shredder of Plant B (magnifications 120x and 240x).

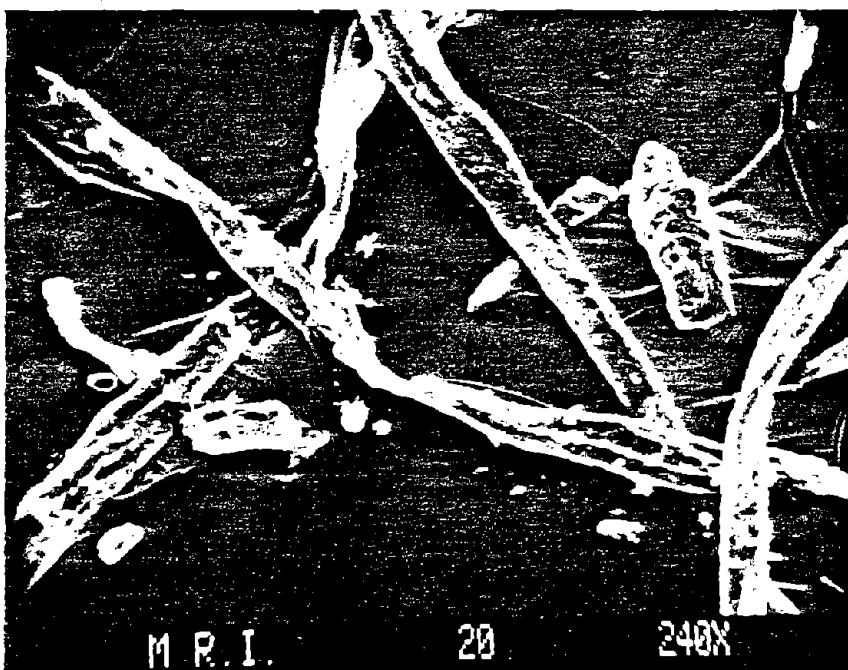
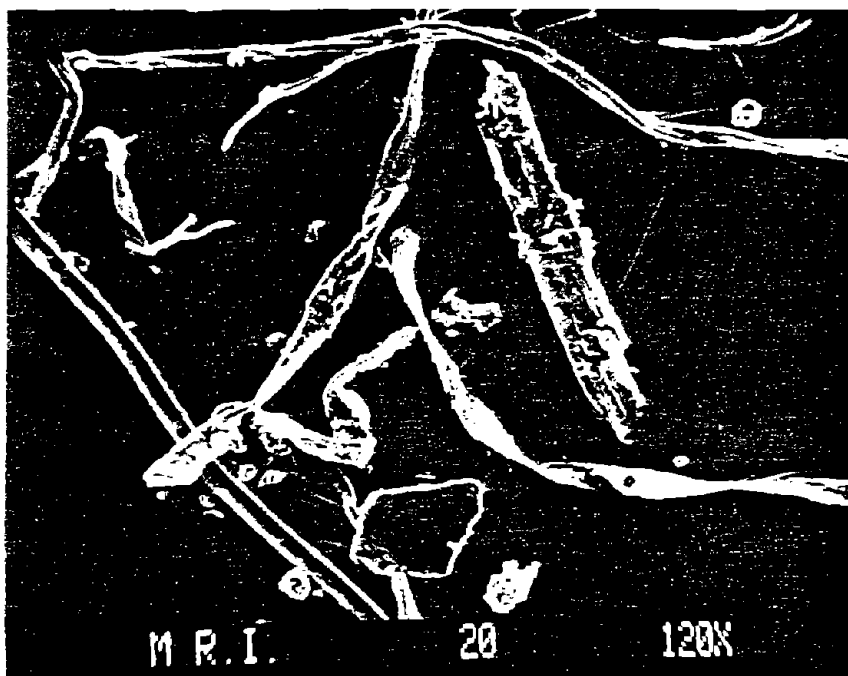


Figure A-20. Photomicrographs of particulate sample collected near the aluminum separator of Plant B (magnifications 120x and 240x).

Welding fumes--A single 2-hr personal sample was collected for evaluation for exposure to welding fume. The filter holder was placed in a worker's breathing zone, inside his welding helmet. Since the welder only works in the welding shed on an intermittent basis and usually for short periods of time, more samples could not be obtained. The collected sample showed a total fume concentration of 10.6 mg/m^3 (based on an assumed constant level of exposure), which is greater than the TLV (ACGIH) for total particulate welding fume of 5 mg/m^3 . Although the 8-hr TWA exposure is probably much less than the 10.6 mg/m^3 level measured (because the welder does not spend 8 hr in the welding shed), the exposure level is still higher than it should be, given good welding practices. The problem appears to be the result of insufficient ventilation in the welding shed. A general exhaust fan located in the wall behind the worker is inadequately sized, and a portable fan which was placed to the side of the welding location was also ineffective since it directed air toward the worker. A small local exhaust hood was the most effective portion of the overall ventilation scheme, but it was also undersized.

Carbon monoxide--Concentrations of CO were measured in the primary shredder exit area and inside the welding shed. CO was not monitored on the tipping floor because the front loader operator was in an enclosed, air-conditioned cab; and also because vehicle entry and exit doors were open and, thus, a buildup of CO would have been unlikely.

Concentrations in the welding shed ranged from 11 to 28 ppm during a 36-min monitoring period. These levels were below the NIOSH TLV of 35 ppm. No CO was detected inside the processing area at the primary shredder sampling location.

Plant C--

The comprehensive sampling and analysis program conducted during the survey of Plant C is outlined in the survey matrix presented in Table A-12. Table A-13 lists the types and numbers of samples collected in the various plant areas under study. These areas were selected on the basis of major unit operations and worker locations to represent the highest potential exposure possibilities.

NIOSH-approved sampling and analytical methods were used throughout this study. Full-shift monitoring was conducted wherever possible to characterize 8-hr, TWA exposures. Shorter term sampling was employed where those methods required limited collection times and was used to estimate the ambient contaminant levels rather than provide TWA comparison data. Personnel sampling was conducted to assess exposures to respirable dust and noise, while the other contaminants were assessed based on area sampling.

Table A-14 lists general results of the survey at Plant C. A more complete data table is presented in Appendix D, Table D-3. Data are organized by sampling location. Figure A-21 shows the approximate sampling sites in relation to the confines of the processing building and the major pieces of equipment. Survey results are discussed in the following sections.

TABLE A-12. SURVEY SAMPLING AND ANALYSIS MATRIX--PLANT C

Substance sampled	No. of samples	Method of sampling	Analysis method
Total dust	8	NIOSH method 29.02/Inert or nuisance dust	Gravimetric
Respirable dust	8	NIOSH method 29.02	Gravimetric
Trace metals	4	NIOSH methods: 9.02/Beryllium 22.01/Zinc chloride S312/Cadmium dust S323/Chromium (soluble) S341/Lead	P&CAM 173
Pesticides (organophosphorus)	2	NIOSH method 21.01/Impinger (distilled water)	Enzyme assay screen
Asbestos	3	NIOSH method 2.02/asbestos	P&CAM 239
Silica	3	NIOSH method 3.02/crystalline silica	P&CAM 109
PCB	2	Florist sorbent collection	P&CAM 244
PAH	2	Glass fiber/silver membrane filters, backed by porous polymer tube	HPLC GC/MS
Particulate morphology	2	0.47 mm, 0.1 µm Nucleopore filter	SEM
Organics	4	Portable IR; charcoal tube	Indirect reading; P&CAM 127
Carbon monoxide	-	InterScan CO monitor	Direct reading
Particle sizing	4	Accu-vol samplers with Sierra impactors	Gravimetric
Noise	-	Sound level meter, octave band analysis	Direct reading
Ventilation	-	Thermoanemometer	Direct reading

TABLE A-13. SURVEY MATRIX BY AREA--PLANT C

Sample	Receiving pits	Shredders	Metals separation	Fuel processing
Total dust	2	2	2	2
Respirable dust	2	2	2	2
Trace metals	1	1	1	1
Silica		1	1	1
Asbestos	1		1	1
Organics		2		3
Morphology			1	1
Pesticides	1	1		
PCB		2		
PNAH		1		1
CO	1			
Particle size	1	1	1	1
Welding fume		2		
Noise (dosimeter)	2	2	2	3

TABLE A-14. RESULTS OF PLANT C SURVEY
BY SAMPLING LOCATION

Substance monitored	Concentration		NIOSH TLV (mg/m ³)
	during sampling (mg/m ³)	TWA (mg/m ³)	
<u>Receiving pit area</u>			
Total dust	3.05 1.38	3.05 1.38	10 10
Respirable dust	0.37 0.52	0.37 0.52	5 5
Trace metals			
Beryllium	ND-LD 0.05 µg ^b	-	0.002
Cadmium	ND-LD 0.2 µg ^b	-	0.05
Chromium	ND-LD 0.5 µg ^b	-	0.05
Lead	0.0043	0.0043	0.05
Zinc	0.0051	0.0051	5
Pesticides	ND		
Asbestos	- 1 fiber/cc		0.5 fibers/cc
<u>Shredders</u>			
Total dust	1.90 0.74	1.90 0.74	10 10
Respirable dust	0.22 0.18	0.22 0.16	5 5
Trace metals			
Beryllium	ND-LD 0.05 µg ^b	-	0.002
Cadmium	ND-LD 0.2 µg ^b	-	0.05
Chromium	ND-LD 0.5 µg ^b	-	0.05
Lead	0.0011	0.0011	0.05
Zinc	0.0015	0.0015	5
Welding fume	6.27 6.20	a a	- -
Polychlorinated biphenyls (PCBs)			
Aroclor 1242	ND-LD 0.01 µg ^b		0.001
Aroclor 1254	ND-LD 0.02 µg ^b		0.001
Aroclor 1260	ND-LD 0.04 µg ^b		-

TABLE A-14. (continued)

Substance monitored	Concentration		NIOSH TLV (mg/m ³)
	during sampling (mg/m ³)	TWA (mg/m ³)	
Polychlorinated biphenyls (PCBs)			
Aroclor 1242	ND-LD 0.01 µg ^b	-	0.001
Aroclor 1254	ND-LD 0.02 µg ^b	-	0.001
Aroclor 1260	ND-LD 0.04 µg ^b	-	-
Organics			
Ethanol	ND-LD 41 µg ^b	-	1,900
Ethyl acetate	ND-LD 14 µg ^b	-	1,400
Methylene chloride	ND-LD 40 µg ^b	-	260
Turpentine	0.76	a	560
Organics			
Ethanol	ND-LD 41 µg ^b	-	1,900
Ethyl acetate	ND-LD 14 µg ^b	-	1,400
Methylene chloride	ND-LD 40 µg ^b	-	260
Turpentine	0.74	a	560
Pesticides	ND	-	-
Silica	0.049	0.049	-
<u>Metals separation</u>			
Total dust	0.55	0.55	10
	3.43	3.43	10
Respirable dust	0.27	0.25	5
	0.15	0.15	5
Trace metals			
Beryllium	ND-LD 0.05 µg ^b	-	0.002
Cadmium	ND-LD 0.2 µg ^b	-	0.05
Chromium	ND-LD 0.5 µg ^b	-	0.05
Lead	ND-LD 0.5 µg ^b	-	0.05
Zinc	ND-LD 0.5 µg ^b	-	5
Silica	0.013	0.012	-
Asbestos	2 fibers/cc ^c		0.5 fibers/cc

TABLE A-14. (concluded)

Substance monitored	Concentration		NIOSH TLV (mg/m ³)
	during sampling (mg/m ³)	TWA (mg/m ³)	
<u>Fuel processing area</u>			
Total dust	0.97 0.53	0.97 0.53	10 10
Respirable dust	0.16 0.28	0.16 a	5 5
Trace metals			
Beryllium	ND-LD 0.05 µg ^b	-	0.002
Cadmium	ND-LD 0.2 µg ^b	-	0.05
Chromium	ND-LD 0.5 µg ^b	-	0.05
Lead	0.00099	0.00099	0.05
Zinc	0.00089	0.00089	5
Organics			
Ethanol	ND-LD 41 µg ^b	-	1,900
Ethyl acetate	ND-LD 14 µg ^b	-	1,400
Methylene chloride	ND-LD 40 µg ^b	-	260
Turpentine	ND-LD 11 µg ^b	-	560
Organics			
Ethanol	ND-LD 41 µg ^b	-	1,900
Ethyl acetate	ND-LD 14 µg ^b	-	1,400
Methylene chloride	ND-LD 40 µg ^b	-	260
Turpentine	0.98	a	560
Organics			
Ethanol	ND-LD 41 µg ^b	-	1,900
Ethyl acetate	ND-LD 14 µg ^b	-	1,400
Methylene chloride	ND-LD 40 µg ^b	-	260
Turpentine	0.63	a	560
Silica	0.05	a	-
Asbestos	1 fiber/cc ^c		0.5 fibers/cc

^a Sampling period was less than 7 hr; extrapolation to TWA not appropriate.

^b None detected at the limit of detection specified.

^c Measured concentration of total fibers. No asbestos confirmed in sample.

Total and respirable dust--MRI's evaluation of total dust levels at Plant C showed the measured concentrations to be lower than the recommended TLV for nuisance dust (10 mg/m³, ACGIH/NIOSH).

The greatest concentration of airborne particulate was found in the area beneath the magnetic separator tower (3.43 mg/m³). All other measured particulate levels were in the range of 0.55 to 3.05 mg/m³. Based on visual observations, it appeared that ambient dust levels varied widely, depending upon the amount of fugitive emissions from nearby equipment (e.g., overhead conveyors) and wind effects from open doorways.

Respirable dust concentrations were determined via personnel monitoring at the locations indicated in Table A-14. Consistently low levels were found in all areas of the facility. The eight samples collected showed concentrations ranging from 0.15 to 0.52 mg/m³, which are well below the recommended standard of 5.0 mg/m³. Thus, the occupational hazard from exposure to respirable size airborne particles appears to be minimal.

Trace metals--Four particulate samples were collected and analyzed by AAS for lead, zinc, chromium, cadmium, and beryllium. The measured concentrations of chromium, cadmium, and beryllium in all samples were below the level of instrument detectability. Only lead and zinc concentrations were detectable, but these were usually at very low levels. The highest concentrations of these two trace metals were found in the push pit area. The measured lead concentration was approximately 0.0004 mg/m³ (versus a TLV of 0.15 mg/m³) and the measured concentration of zinc was 0.0005 mg/m³. These results indicate that trace metals are not likely to constitute an airborne hazard at this facility.

Silica--The analysis of three particulate samples for silica content (SiO₂) showed very low levels of airborne silica at Plant C. Concentrations ranged from 0.012 to 0.05 mg/m³ (5.9 to 8.1% silica by weight). The highest concentrations corresponded to a sample collected in the vicinity of one of the shredders. Since the ACGIH recommended TLV for silica is 0.3 mg/m³, no exposure hazard is indicated by the MRI survey results.

Asbestos--Three samples were collected at Plant C to determine if asbestos fibers were present in the work atmosphere. Initial laboratory analysis consisted of a total fiber count (i.e., particles longer than 5 µm with a minimum 3:1 aspect ratio) by the phase contrast microscopy method. Results showed concentrations of 1, 1, and 2 fibers/cc.

The samples were then sent to NIOSH for confirmatory asbestos analysis. These tests indicated that no asbestos fibers were present in any of the samples. Other morphological studies done by McCrone Associates on samples collected at this facility revealed that most of the airborne fibers were from natural (cotton, wool) or synthetic fabrics.

Polychlorinated biphenyls (PCB)--Air samples were collected for the detection of PCB compounds using a solid sorbent (Florisol) method. Three samples were obtained by this method and analyzed by GLC for Aroclors 1242, 1254, and 1260. None of these compounds were detected in any of the samples.

Polynuclear aromatic hydrocarbons (PNAHs)--The possible presence of PNAH compounds in the work areas at Plant C were evaluated using a method consisting of a combination glass fiber filter/silver membrane filter cassette followed by a porous polymer backup tube. Two samples were collected using this configuration and were analyzed for five specific compounds: chrysene, benzo(a)pyrene, fluoranthene, pyrene, and benzo(a)anthracene.

Laboratory results indicated that PNAH compounds were present in both the samples and the blank that was submitted with them. Since these results were not characteristic of previous survey data, they are suspected to be due to contamination (although the source of such contamination is unknown). Additional blank samples were submitted to the laboratory in an effort to determine if laboratory procedures were at fault. Results, however, did not indicate any contamination problem with the sample analysis.

Nevertheless, it is highly unlikely that PNAH compounds would have been present in the workroom atmosphere at Plant C. Negative results from the previous resource recovery plant surveys supports this contention.

Pesticides--The processing area was monitored at two locations for the presence of cholinesterase-inhibiting pesticides using water-filled midge impingers. The analysis consisted of an "enzyme ticket" detection method developed by MRI. Samples were collected from over half of the working shift and the solutions were subsequently checked by the enzyme ticket. By this method, the absence of a color change on the ticket substrate would indicate the presence of an anticholinesterase compound at a concentration greater than about 1 ppm. The two samples collected by MRI showed a definite color change and, thus, negative results for general organophosphorus and carbamate pesticides.

General organics--Organic constituents of the workroom air at Plant C were evaluated using charcoal tubes and direct reading instrumentation (Miran 1A analyzer). The Miran 1A was operated primarily in the scan mode, but also at specific absorbance wavelengths. These were selected by MRI to correlate with organic compounds which were likely to be present during MSW processing. The Miran 1A was set up in the shredder area, as well as the fuel processing area, with several scans made at each location. No significant absorbance peaks were observed on the strip chart outputs at either site. The lack of response from the Miran usually indicates that the target compounds are not present at the ppm, or even sub-ppm, range.

Charcoal tube samples were collected concurrently with the operation of the Miran 1A and were intended as a quantitative backup. The analytical scheme for the samples was predicated on the results of the Miran 1A scans and the findings from earlier surveys. On this basis, four compounds were selected for gas chromatography analysis: ethyl acetate, methylene chloride, ethanol, and turpentine. Low concentrations of all the compounds were observed in each of the samples. The highest concentration detected was that of turpentine (0.98 mg/m^3), which, when compared to its corresponding TLV (560 mg/m^3), indicates a negligible hazard. Since the TLVs for the other three compounds are of the same order of magnitude, none of the organics measured appear to present any health hazard.

Welding fumes--Two personal samples were collected from welders on the second shift to evaluate their exposure to total welding fume. The sampling period, 2-1/2 hr, corresponds to the time in which they were actually welding. The remainder of their shift time was spent on other maintenance activities. The sample cassettes were placed inside the welders' face masks where they were working on the shredder hammers in a semienclosed area. (Portions of the shredder housing were removed to allow access to the hammers.)

Concentrations of 6.27 and 6.20 mg/m³ were determined from the analysis of the two samples. These results are high in relation to the ACGIH TLV for total particulate welding fume of 5.0 mg/m³. However, the TLV is based on an 8-hr exposure, while these welding samples were collected over only 2-1/2 hr. Thus, unless the welders were exposed to the same concentrations for nearly the full work shift, they would be within the recommended exposure limitation. Nonetheless, it is still recommended that some form of additional protection be afforded the welders, such as increased ventilation from portable fans to direct the welding fumes away from the worker's breathing zone.

Carbon monoxide (CO)--CO levels were measured with a direct-reading instrument in the unloading pit area, since it was the only area of the plant where any CO might be expected. The CO meter was placed on a railing next to one of the bridges spanning the storage pit. Incoming trucks backed up onto the bridge and then dumped into one of the push pits.

Concentrations of CO varied from 3 to 18 ppm, usually remaining near 5 ppm. Readings were observed over a 1/2-hr period while several trucks moved in and out. The 18-ppm reading was measured during the time sequence in which a truck was on the bridge unloading.

Airborne particle size--High-volume ambient air samplers equipped with Sierra five-stage impactor heads were used to determine the particle size distribution of airborne dust in Plant C. The Sierra impactor aerodynamically segregates particles into five discrete categories: 10.2, 4.2, 2.1, 1.4, and 0.73 μ m.

One sample was collected in each of the four MRI sampling areas (i.e., receiving pit, shredder, metals separation tower, and fuel processing). Results are displayed graphically in Figures A-22 through A-25. "Actual" sizing data shown are adjusted to compensate for a known mass bias on the final filter of the Sierra sampler (the final filter follows the fifth sizing stage). An excess of material (as was recorded) on the final filters indicates that a particle "bounce" phenomenon has occurred through the impactor, and thus the applied correction yields the more "true" size distribution.

Median particle size in the receiving pit and shredder areas was 12 and 6 μ m, respectively. Smaller particles were observed in the metals separation tower and fuel processing areas, where the median size was about 3 μ m.

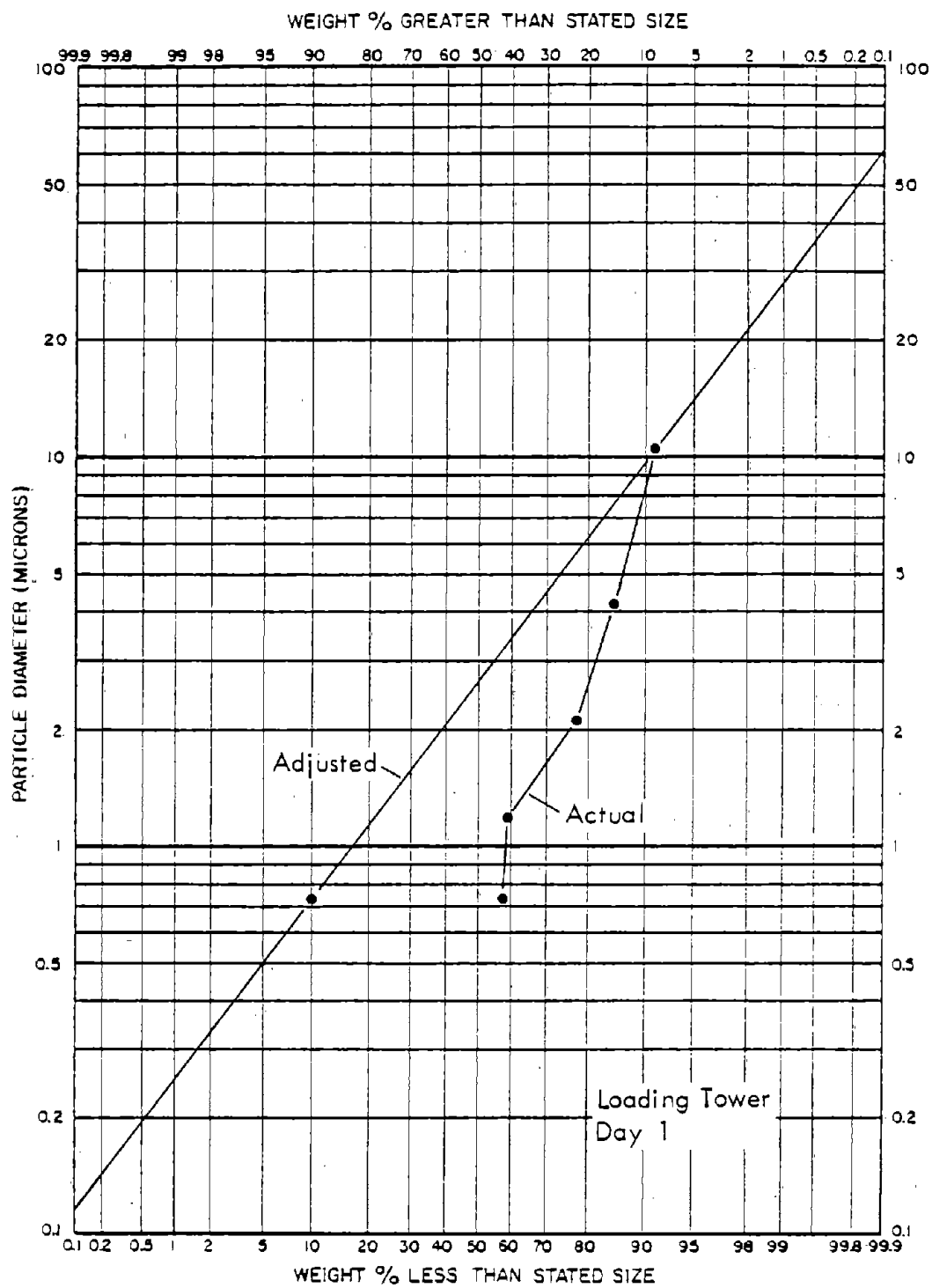


Figure A-22. Particle size distribution in the metals separation area of Plant C.

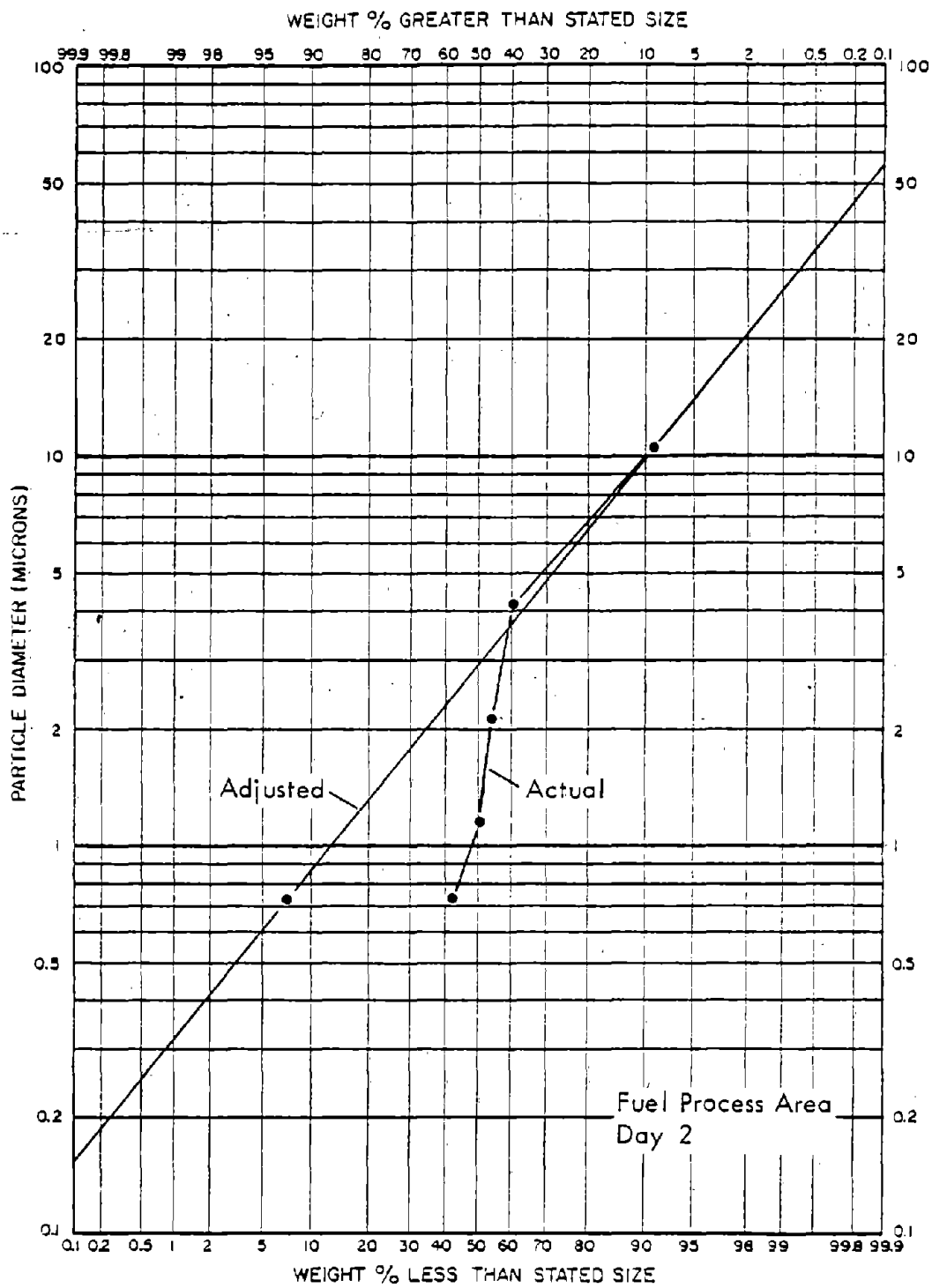


Figure A-23. Particle size distribution in the fuel processing area of Plant C.

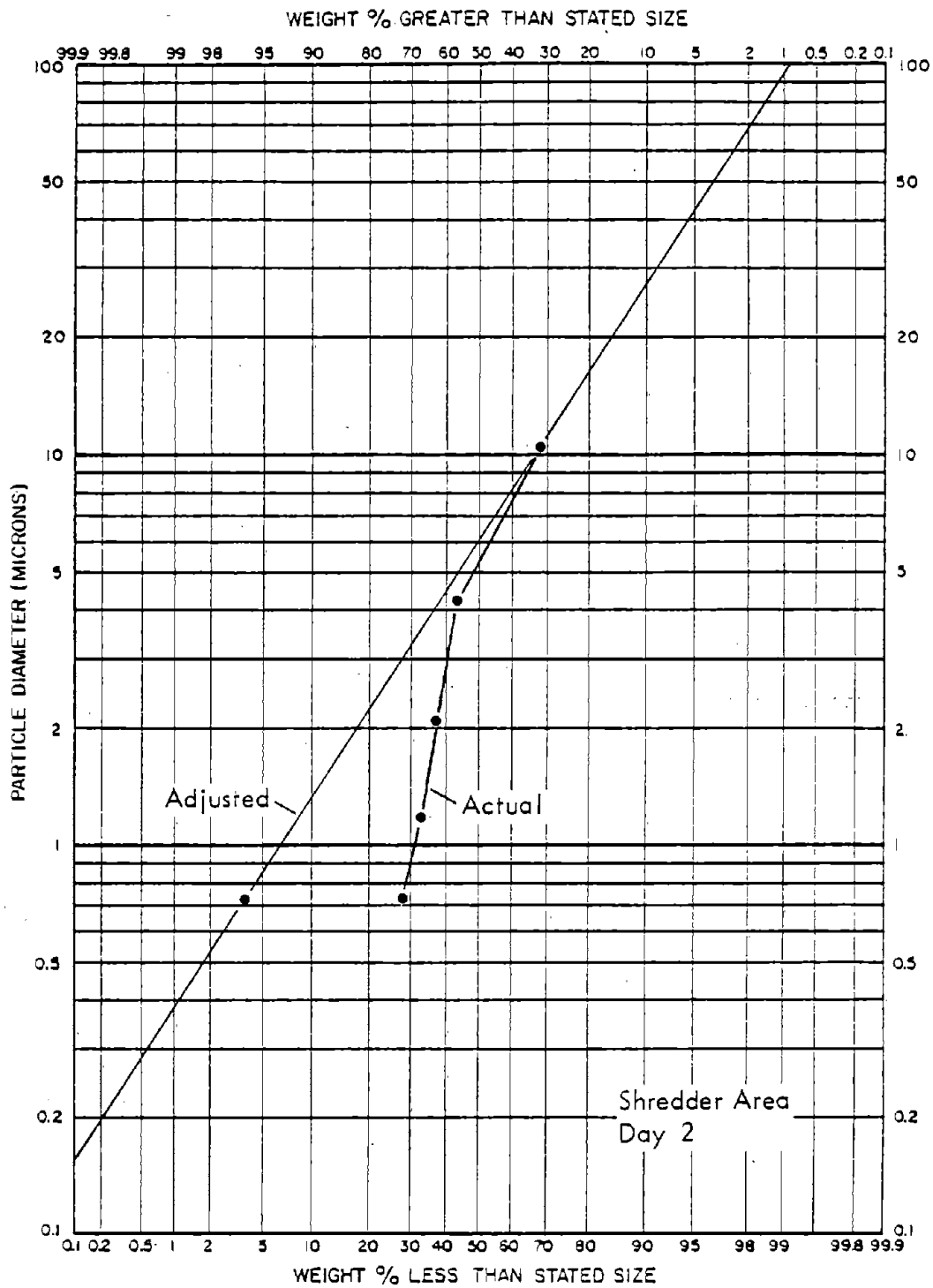


Figure A-24. Particle size distribution in the shredder area of Plant C.

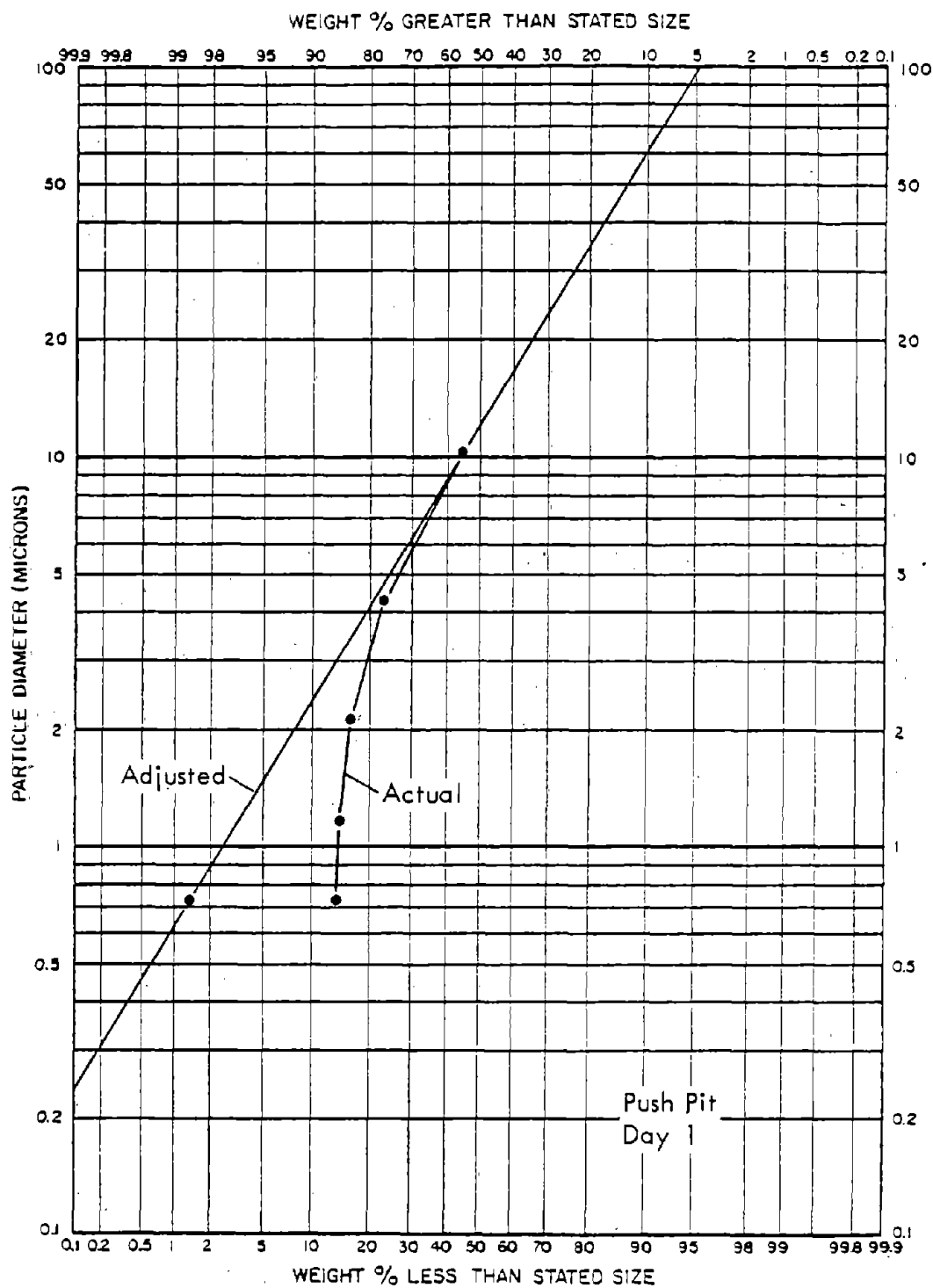


Figure A-25. Particle size distribution in the unloading pit area of Plant C.

Particulate morphology--Two air samples were collected on special Nucleopore filters to determine the morphological characteristics of airborne particles at Plant C. One sample was taken in the area beneath the metals separation tower, and the other in the fuel processing area. Examination of the filters was done by Walter C. McCrone Associates, using SEM and optical microscopy techniques.

SEM examination was made at a low magnification of 22x because of the prevalence of large particles on the filters. Photomicrographs of this work are shown in Figures A-26 and A-27. The sample of particulate from the fuel processing area showed fewer large, amorphous particles and a greater percentage of shredded fibers than the sample from the metals separation area. Neither sample exhibited any particularly unusual morphological characteristics.

Optical microscopic examination showed the following particle compositions in the fuel processing area: softwood sawdust, quartz grain, unidentified crystal, glass chip, cotton fiber, chemically separated wood fiber, starch grain, dandruff, calcite, and glass fiber covered with soot; and in the metals separation area: leaf fragment, cellulose acetate fiber, chemically separated wood fiber, microcrystalline limestone grain, asphalt particle, plant stem tissue, polycrystalline quartz, glass chip, fiberglass mat particle, feather, softened sawdust, quartz grain, and black rubber particle.

Plant E--The air sampling and analysis program used to determine chemical contaminant concentrations and worker exposures is outlined in Table A-15. The types and numbers of samples collected in each of the various plant areas under study are shown in Table A-16. Sampling locations were selected by MRI on the basis of the location of the major sources of air contaminants and the locations of workers so as to yield data corresponding to the greatest potential exposures. The sampling sites are shown in Figures A-28 and A-29.

NIOSH-approved sampling and analytical methods were used throughout this study. Full-shift monitoring was conducted wherever possible in order to characterize 8-hr, TWA exposures. Shorter term sampling was employed where limited collection times were required. These methods were used to estimate the ambient contaminant levels rather than provide TWA comparison data. Personnel sampling was also conducted to assess worker exposures to respirable dust and noise. All other contaminants were assessed via area sampling.

Table A-17 lists general results of the survey at Plant E. A more complete data table is presented in Appendix D, Table D-5. Data in both tables are organized by sampling location. These survey results are discussed in detail in the following sections.

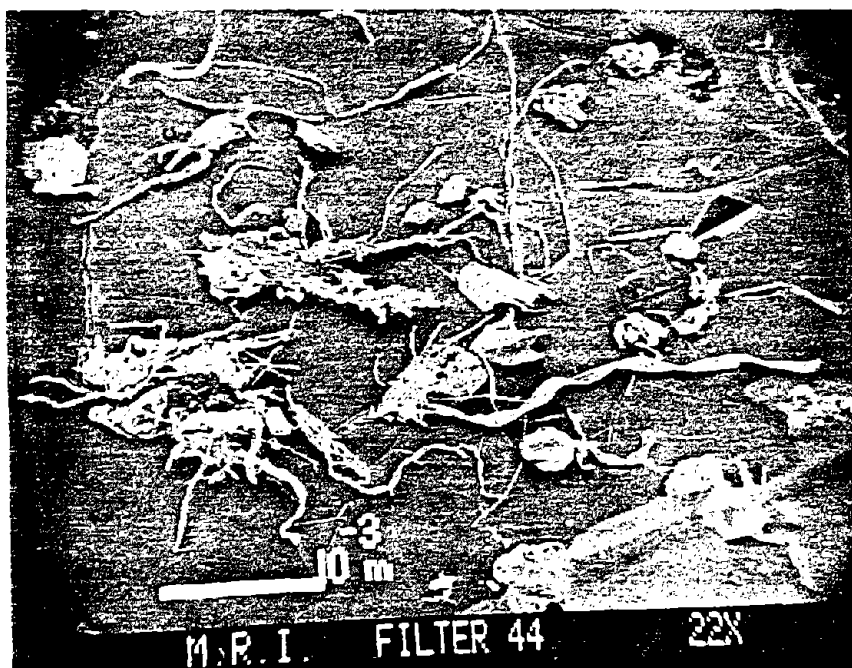
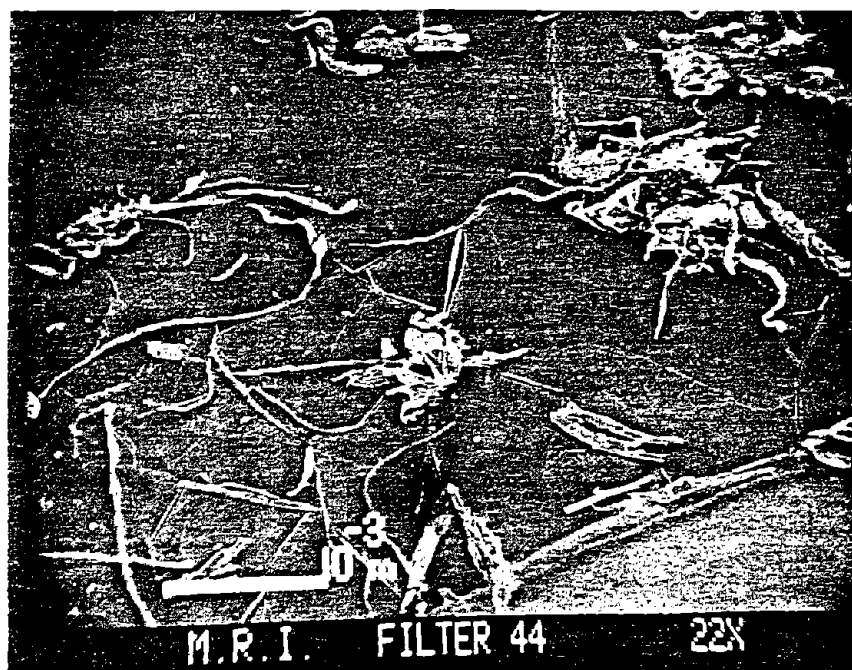


Figure A-26. Photomicrographs of particulate sample collected in fuel processing area of Plant C.

TABLE A-15. SURVEY SAMPLING AND ANALYSIS MATRIX--PLANT E

Substance sampled	No. of samples	Method of sampling	Analysis method
Total dust	14	NIOSH method 29.02/inert or nuisance dust	Gravimetric
Respirable dust	12	NIOSH method 29.02	Gravimetric
Trace metals	1	NIOSH methods: 9.01/Beryllium 22.01/Zinc chloride S312/Cadmium dust S323/Chromium (soluble) S341/Lead	P&CAM 173
Pesticides (organophosphate/ carbamate)	1	NIOSH method 21.01/impinger (distilled water)	Enzyme assay screen
Asbestos	1	NIOSH method 2.02/asbestos	P&CAM 239
Organics	2	Portable IR; charcoal tube	Direct reading, P&CAM 127
Carbon monoxide	2	Interscan CO monitor	Direct reading
Particle sizing	4	Accu-vol samplers with Sierra impactors	Gravimetric
Noise	-	Sound level meter, octave band analysis	Direct reading
Ventilation	-	Thermoanemometer	Direct reading

TABLE A-16. SAMPLING MATRIX BY AREA--PLANT E

Sample	Tipping floor	Production area
Total dust	4	10
Respirable dust	6	6
Trace metals		1
Asbestos		1
Organics	2	6
Pesticides		1
CO	1	1
Particle size	1	3
Noise (dosimetry)	4	6

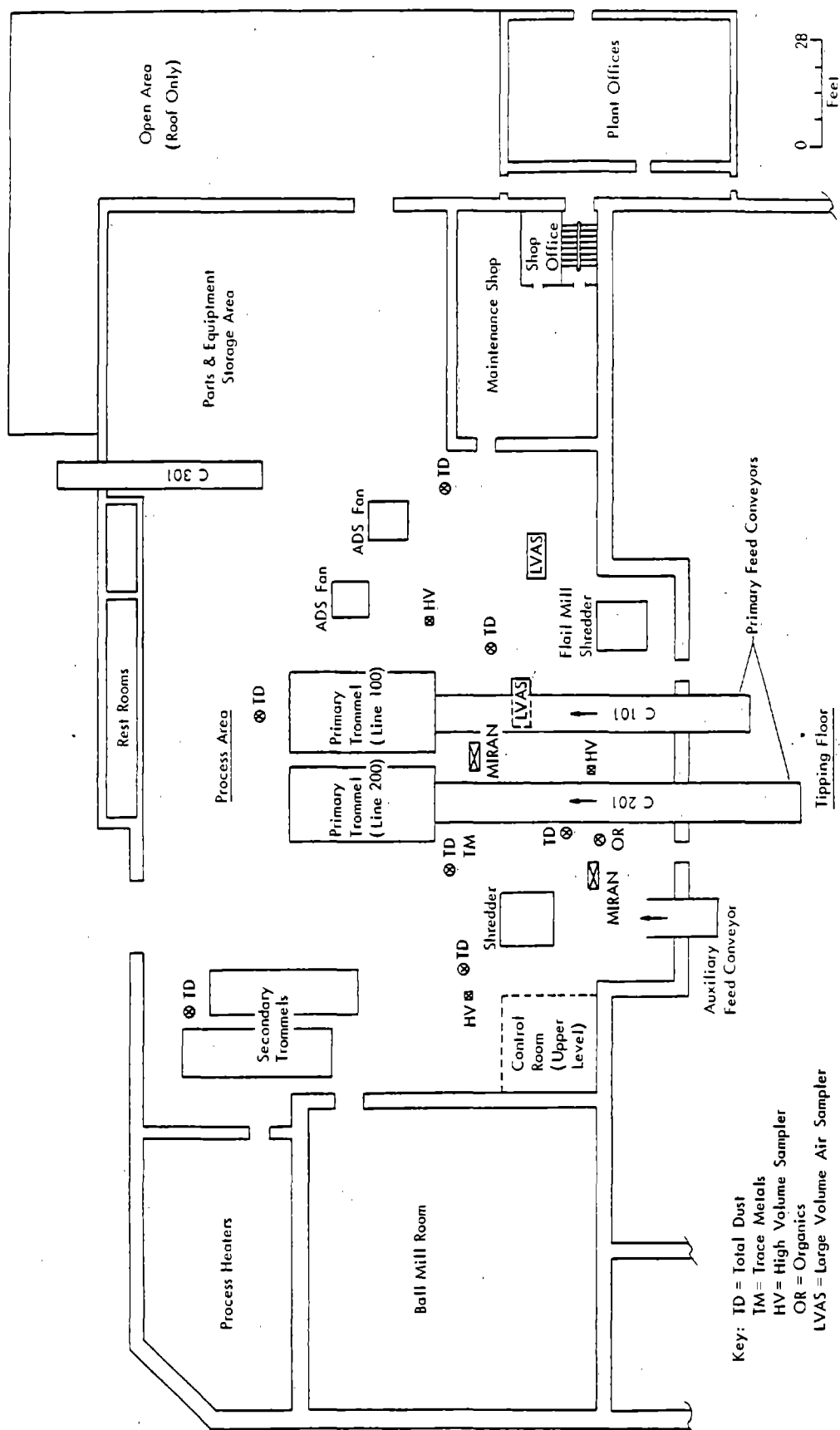


Figure A-28. MRI sampling locations in process areas--Plant E.

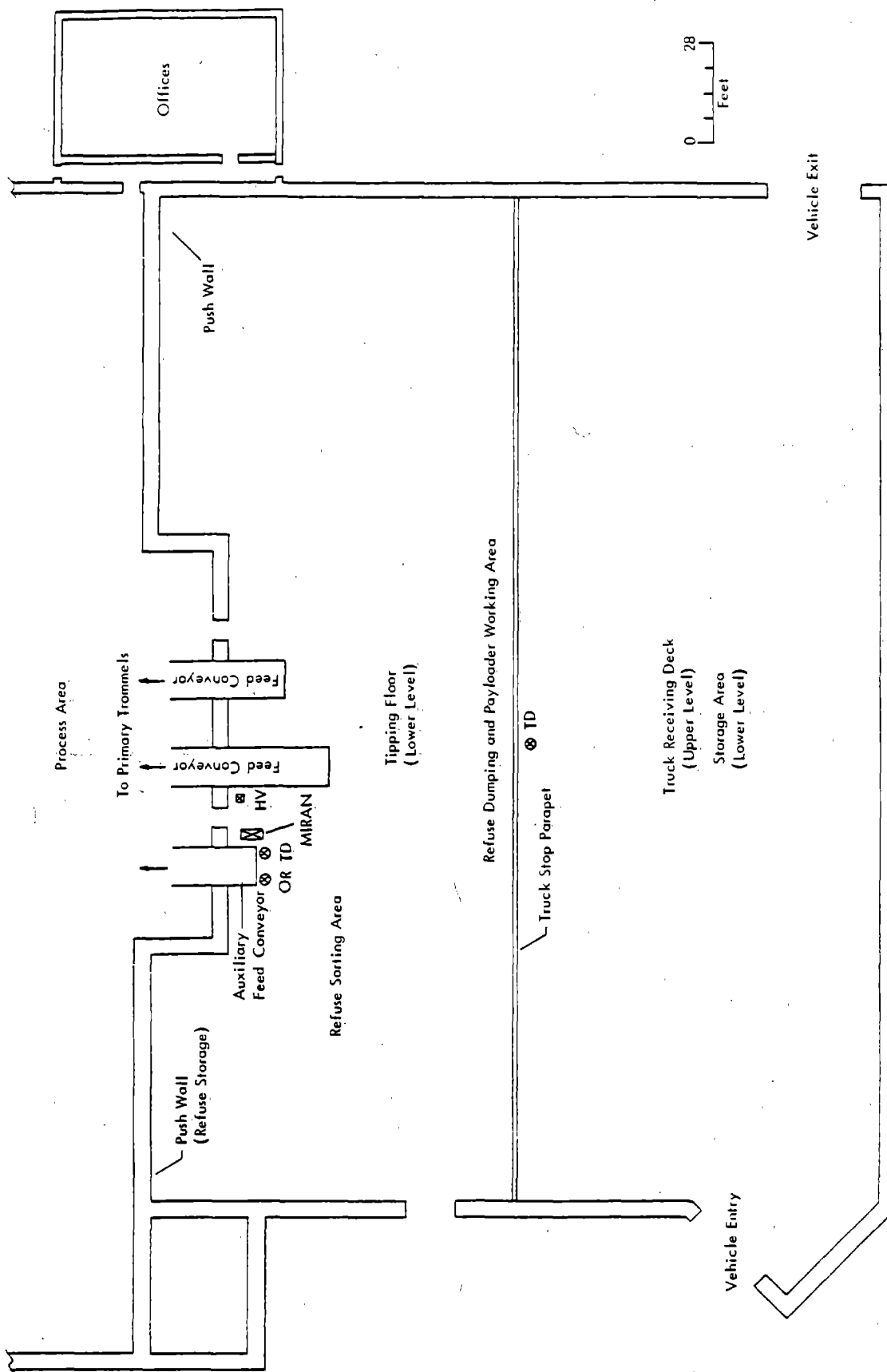


Figure A-29. MRI sampling locations in receiving and tipping floor areas--Plant E.

TABLE A-17. RESULTS OF PLANT E SAMPLING BY LOCATION

Substance monitored	Conc. during sampling (mg/m ³)	TWA (mg/m ³)	NIOSH TLV (mg/m ³)
<u>Tipping floor</u>			
Total dust	0.53	0.53	10
	0.70	0.70	10
	0.09	a	10
	0.33	0.29	10
Respirable dust	0.01	0.01	5
	0.2	a	5
	0.09	0.09	5
	0.2	a	5
	0.18	a	5
	0.1	a	5
<u>Processing area</u>			
Total dust	0.33	0.33	10
	0.66	0.66	10
	0.36	a	10
	0.29	0.29	10
	0.90	0.90	10
	0.2	a	10
	0.33	a	10
	0.07	0.07	10
	0.1	0.1	10
	0.40	0.40	10
Respirable dust	0.16	0.16	5
	0.03	a	5
	0.09	0.09	5
	0.05	0.05	5
	0.07	a	5
	0.1	a	5
<u>Trace metals</u>			
Beryllium	ND-LD 0.1 µg ^b	-	0.002
Cadmium	ND-LD 0.15 µg ^b	-	0.05
Chromium	0.0001	0.0001	0.05
Lead	0.001	0.001	0.05
Zinc	0.00068	0.00068	5
Pesticides	None detected		
Asbestos	0.5 total fibers/cc ^c		0.5 asbestos fibers/cc

a Sampling period was less than 7 hr; extrapolation to TWA not appropriate.

b None detected at the limit of detection specified.

c Measured concentration of total fibers. No asbestos confirmed in sample.

Total and respirable dust--Airborne total dust and respirable dust concentrations were determined in the tipping floor area and also in the main processing area of Plant E. As indicated in Table A-17, all measured concentrations were much lower than the recommended (ACGIH/NIOSH) permissible exposure limits (total nuisance dust = 10 mg/m^3 , and respirable nuisance dust = 5 mg/m^3). A total of 14 total dust samples were collected; four on the tipping floor and 10 in the processing area. All showed concentrations less than 1.0 mg/m^3 , with an overall range of 0.07 to 0.90 mg/m^3 on the basis of an 8-hr TWA.

One possible reason for the low dust levels measured by MRI was the amount of downtime experienced by the plant during the 3 days of sampling. The level of activity on the tipping floor was low because of the low daily processing rate by the rest of the plant. Only a very few trucks unloaded refuse each day, and only one payloader was used to move the new material and to supply sorted MSW to the feed conveyors. In addition, the feed conveyor for the one processing line that was being used was often stopped due to equipment problems inside the processing area. Therefore, activity on the tipping floor was held to a minimum.

The respirable dust samples likewise yielded very low particulate concentrations. They ranged from 0.01 to 0.16 mg/m^3 , with no significant difference between the tipping floor samples and those collected in the processing area.

Trace metals--One particulate sample (filter cassette) was collected in the processing area near the "200 line" shredder and analyzed by AAS for five trace metals, lead, zinc, chromium, cadmium, and beryllium. No concentrations of cadmium or beryllium could be detected, and levels of the other three metals were very low. The highest trace metal concentration was only 0.001 mg/m^3 (lead).

Only one sample was collected at Plant E because data from the previous surveys on this program have consistently indicated negligible concentrations of the five trace metals. The shredder area was chosen as a check of the plant atmosphere since it was one of the dustiest locations within the facility.

Asbestos--As with the trace metal evaluation, a single particulate sample was collected as a cursory examination for asbestos contamination. This sample, which was taken next to the shredder, showed a total fiber count of 0.5 fibers/cc by the standard NIOSH optical microscopy analytical technique. No confirmation of the presence of any asbestos fibers can be made until further analytical work is done by NIOSH. However, because the total fiber concentration is not greater than the NIOSH-proposed TLV for asbestos of 0.5 fibers/cc, it does not appear likely, based on MRI's limited survey, that asbestos fibers pose a health hazard at Plant E.

General organics--The survey evaluation for general organic compounds was conducted using direct reading instrumentation (Miran 1A analyzer) supported by concurrent charcoal tube sampling. The Miran 1A was operated primarily in the scan mode to search for absorbance peaks signifying the presence of

organic compound groups. The instrument was also run at specific absorbance wavelengths which were preselected by MRI to correlate with organic compounds that are likely to be evolved during MSW processing. The Miran 1A was used in the processing area as well as on the tipping floor, and several scans were run at each location. No compound absorbance peaks were observed on the strip chart data tapes at any of the sites.

Charcoal tube samples were collected concurrently with the operation of the Miran 1A and were intended as a quantitative backup. Since no absorbance peaks were detected by the Miran 1A, the charcoal tubes were not submitted for analysis.

Pesticides--The processing area was monitored at one location for the presence of cholinesterase-inhibiting pesticides using a water-filled midget impinger. The analysis consisted of the enzyme ticket detection method developed by MRI. The sample was collected from over half of the working shift and the solution subsequently checked by the enzyme ticket. By this method, the absence of a color change on the ticket substrate would indicate the presence of an anticholinesterase compound at a concentration greater than about 1 ppm. The sample collected by MRI showed a definite color change, and thus indicated a lack of general organophosphorus and carbamate pesticides contamination above about 1 ppm.

Carbon monoxide (CO)--Concentrations of CO were measured with a direct reading, hand-held instrument. A walk-through survey of the plant was made, stopping at various locations to obtain instantaneous readings. CO levels of 1 to 3 ppm were indicated in the tipping floor area, and concentrations up to 20 ppm were detected in the processing area. The highest readings (12 to 20 ppm) were obtained in the near vicinity of one of the ADS fans. Concentrations of 12 to 15 ppm were also detected along the aisle at the south end of the processing area, near the restrooms.

Since the NIOSH recommended exposure limit for CO is 35 ppm, employees at Plant E were not subjected to hazardous concentrations. However, it is unclear why the ambient levels of CO within the processing area were as high as the MRI measurements indicated. Such readings were unexpected and would be more probable in the tipping floor area.

Airborne particle size--High-volume ambient air samplers equipped with Sierra five-stage cascade impactors were used to determine the approximate particle size distribution of the airborne dust within the plant. The Sierra impactor aerodynamically segregates particles at five size stages: 10.2, 4.2, 2.1, 1.4, and 0.73 μm .

Four samples were collected during the MRI survey; three in the processing area and one on the tipping floor. Data are presented graphically in Figures A-30 through A-33. The curves designated "actual" were generated by adjusting the "raw" data for a known mass bias on the final filter of the Sierra impactor. It is typical to find an excess of particulate material on the final filter, indicating that a particle "bounce" phenomenon had occurred as the sample was collected. The applied correction is used to yield the more true size distribution.

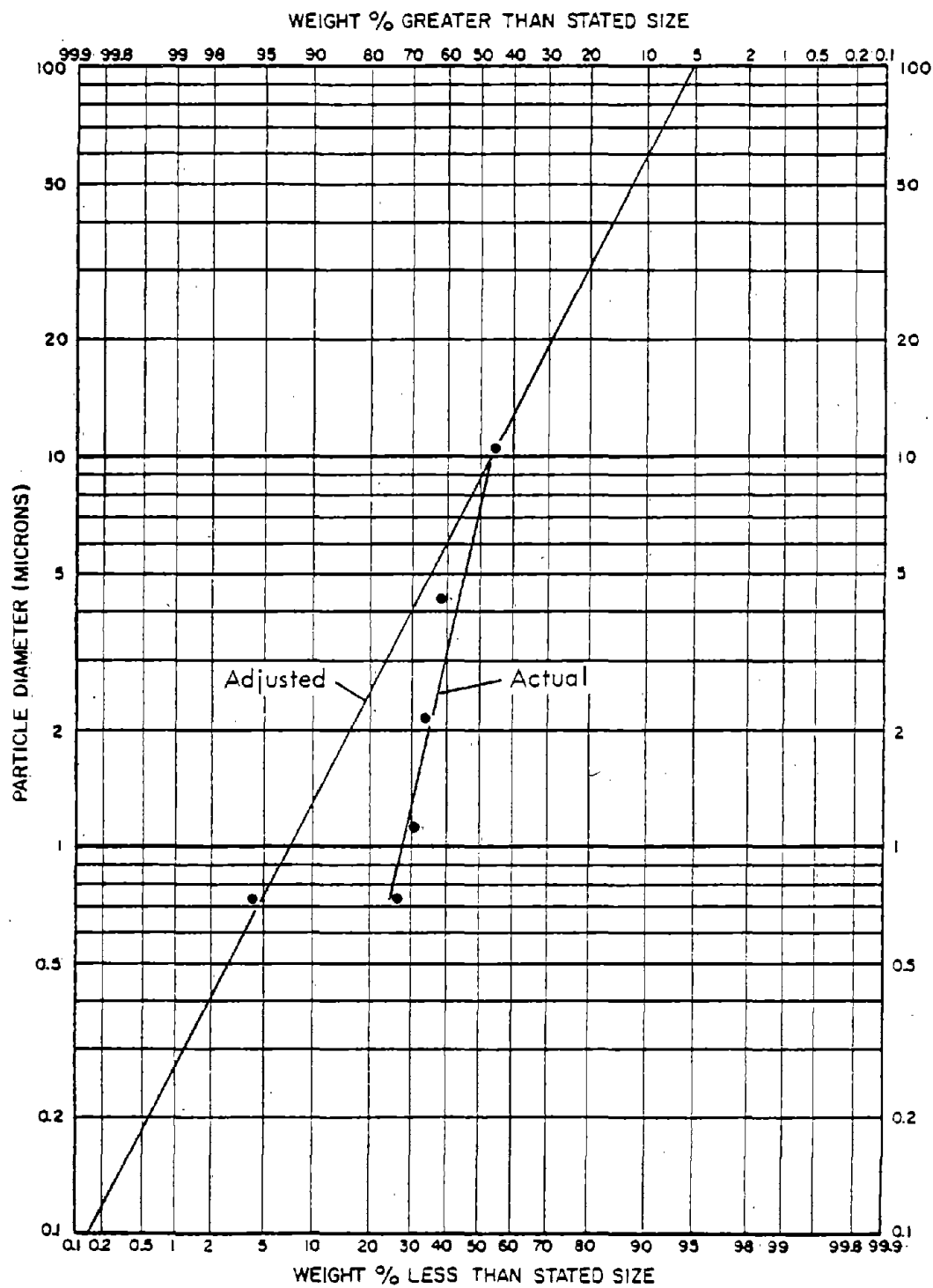


Figure A-30. Particle size distribution near line 100 primary trommel--of Plant E.

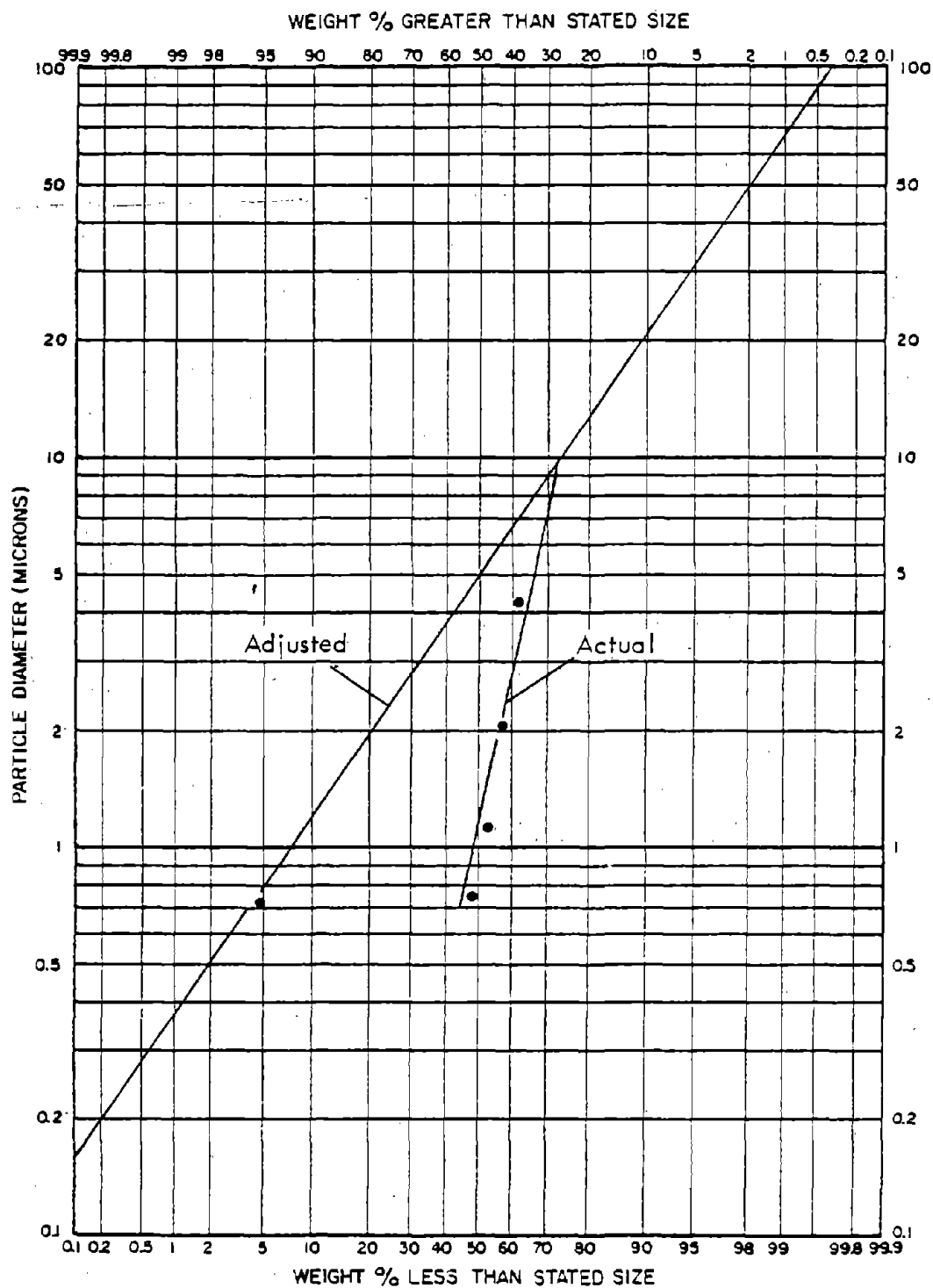


Figure A-31. Particle size distribution near line 200 shredder and rejects truck loading of Plant E.

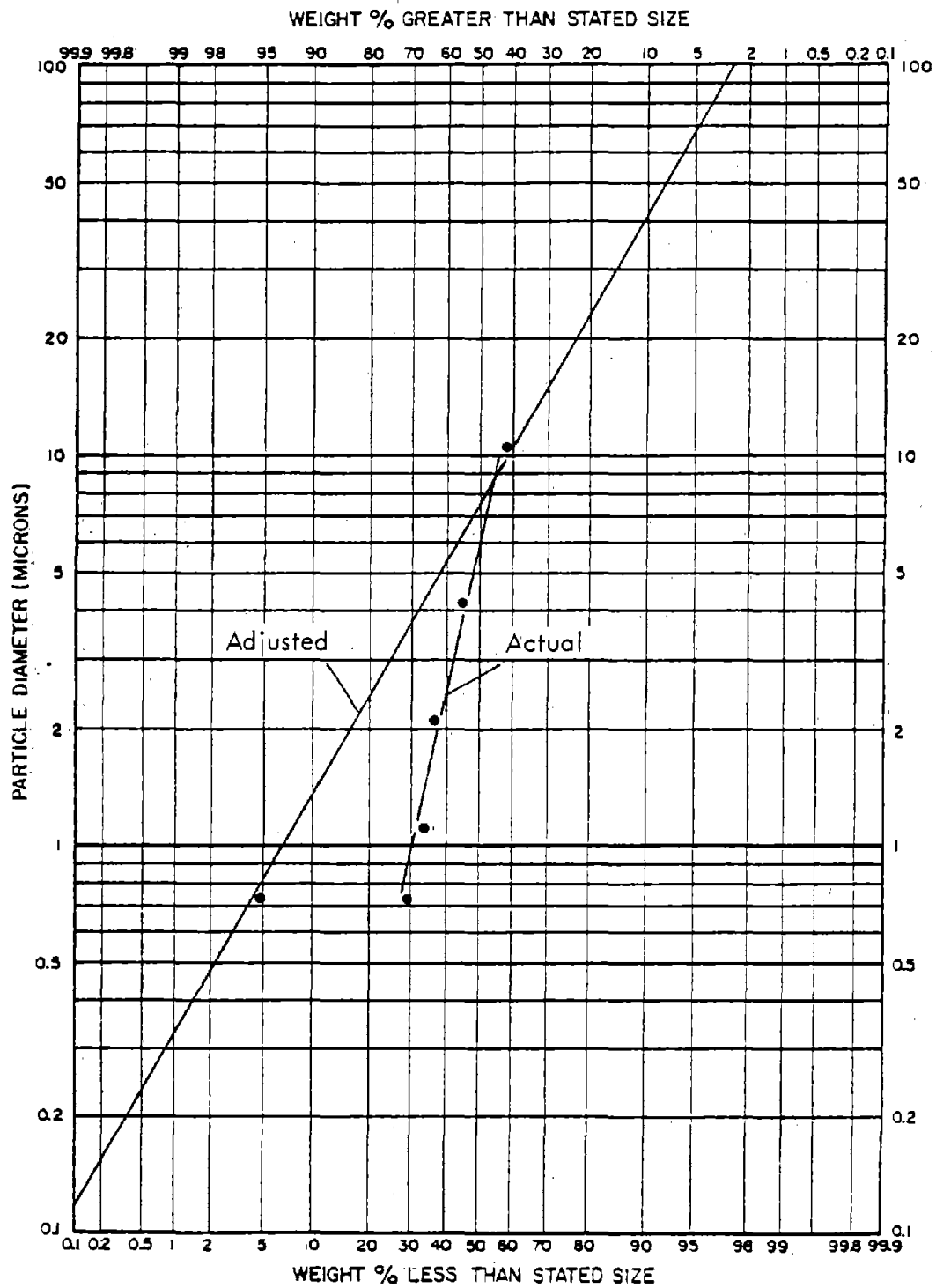


Figure A-32. Particle size distribution near line 200 shredder output conveyor of Plant E.

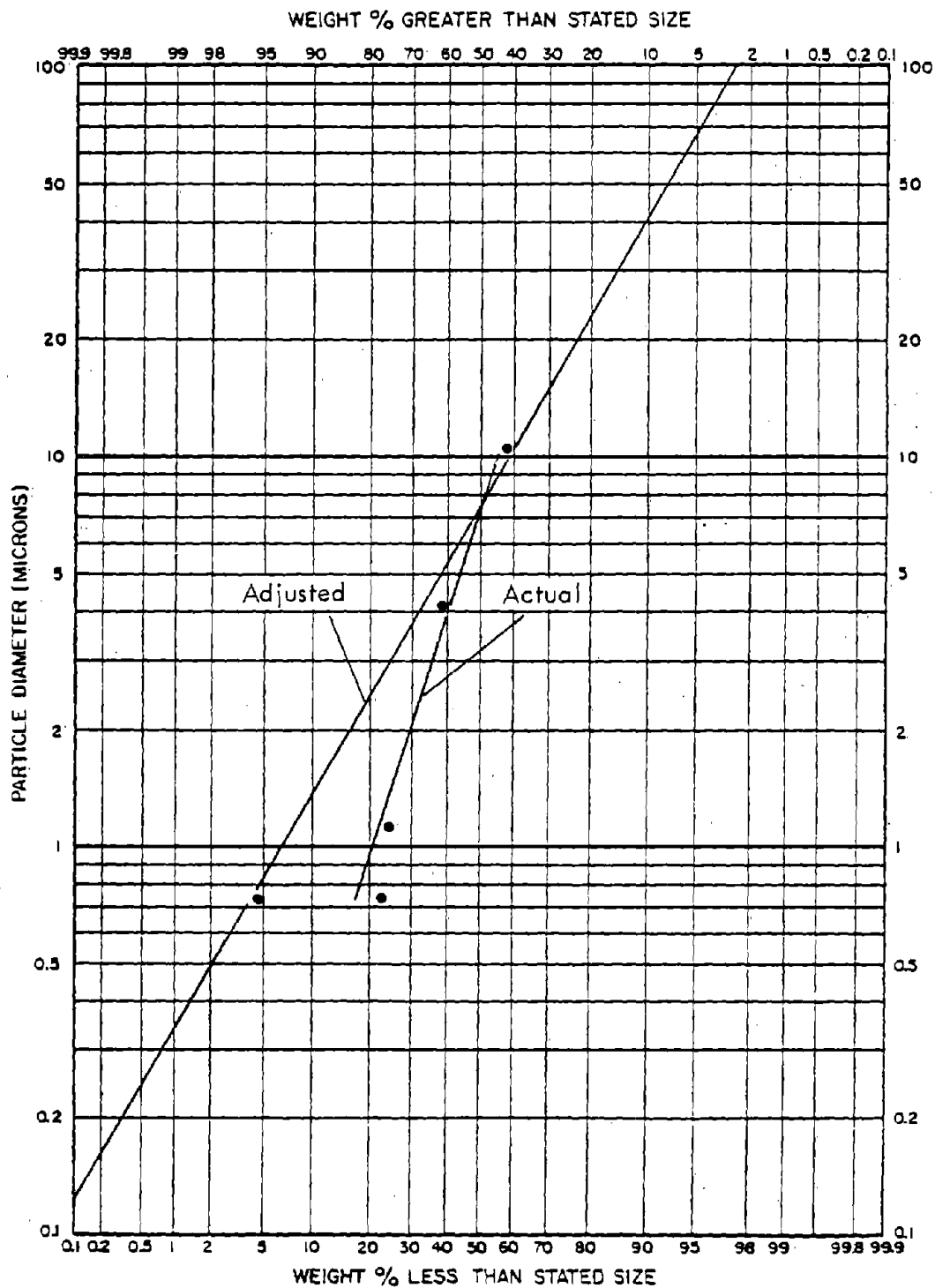


Figure A-33. Particle size distribution on tipping floor near line 200 feed conveyor of Plant E.

The mass median aerodynamic diameter (MMAD) was very similar for all four samples, with a range from 5.0 to 8.7 μm . A slightly smaller average particle size (MMAD = 5.0 μm) was detected in the area where the reject material from the secondary trommels is loaded into open-top trucks. No significant difference was observed in the particle size distributions shown by the other samples.

Microbiological Aerosols

The following sections detail the results of the microbiological sampling and analysis for plants B, C, and E. A microbiological survey was attempted at Plant A; however, a major equipment failure stopped production for the 3-day period the survey team was on-site. Thus, no monitoring was completed for this phase. Survey results, by plant, for the other RDF production facilities follow.

Plant B--

Analytical results of the microbiological sampling program conducted by MRI at the Plant B resource recovery facility are presented in this section. This microbiological survey included analyses for selected bacterial indicator complexes and infectious agents (see Table 2). These analyses were performed on aerosol, solid waste, and settled dust samples. It should be kept in mind that ambient environmental microbiology standards have not been established and that any microbiological results must be interpreted with extreme care. Complete descriptions of the sampling and analytical methodologies are included in Appendix G.

Sampling site--Microbial aerosol samples were collected at a single location within the plant. This sampling site was on the south side of the building on the concrete pad that supports the discharge fans for the dust control and air classifier systems. This site was selected as being generally representative of dust levels throughout the building, and also because it was slightly warmer than the ambient building temperature.

Solid waste samples were collected from the north conveyor leading from the primary shredder. The grab samples were taken on a random basis.

Analytical results--The freezing and subfreezing temperatures encountered at Plant B required that glycerol be added to the aerosol sampling menstrooms. Even with the glycerol, the gelatin-milk solution used in conjunction with the impinger samples contained ice crystals at the end of each sampling period. The ice crystals and glycerol provided less than optimum conditions for the recovery of viable microbial aerosols.

The microgiological results obtained on the solid waste samples are presented in Table A-18. Aerosol sample results are presented in Tables A-19 and A-20. The average ($n = 3$) total bacteria count was 5.0×10^8 bacteria/g of solid waste. Total bacteria concentration of a dust sample collected from the safety railings near the aerosol sampling area was 1.2×10^7 bacteria/g. The aerosolized total bacteria concentration was 6.9×10^5 bacteria/ m^3 with the AGI-30 and 7.5×10^3 bacteria/ m^3 with the LVAS.

TABLE A-18. MICROBIOLOGICAL SOLID SAMPLE RESULTS OBTAINED FROM PLANT B

Microbial assay	Microbiological results (cfu/g)			
	Solid waste samples			Railing dust sample
	3 - 1	3 - 2	3 - 3	3 - 4
Total Bacteria	7.9×10^8	4.1×10^8	2.9×10^8	1.2×10^7
Fecal Coliform	$\geq 4.8 \times 10^4$	$\geq 4.8 \times 10^4$	$\geq 4.8 \times 10^4$	2.2×10^4
Salmonella sp.	<1	<1	<1	<1
Shigella sp.	<1	<1	<1	<1
Klebsiella sp.	6.6×10^4 ^a	2.0×10^5 ^a	2.5×10^5 ^b	1.7×10^5 ^c
Staphylococcus aureus	3.0×10^5	$<2.0 \times 10^2$	3.0×10^4	2.4×10^5
Nocardia asteroides	$<2.0 \times 10^3$	$<2.0 \times 10^4$	$<2.0 \times 10^3$	OG ^d
Streptomyces sp.	2.0×10^4	2.0×10^3	$<2.0 \times 10^2$	4.0×10^4
Aspergillus fumigatus	$<2.0 \times 10^2$	$<2.0 \times 10^2$	$<2.0 \times 10^2$	4.0×10^4
Aspergillus flavus	$<1.0 \times 10^1$	$<2.0 \times 10^2$	$<2.0 \times 10^2$	$<2.0 \times 10^2$
Mycobacterium sp.	OG	OG	OG	OG

a 100% Klebsiella pneumoniae.

b 87% Klebsiella pneumoniae, 13% K. oxytoca.

c 78% Klebsiella pneumoniae, 22% K. oxytoca.

"OG" - overgrown by mycelial fungi.

TABLE A-19. MICROBIOLOGICAL COMPOSITION OF AEROSOL SAMPLES COLLECTED BY THE AGI SAMPLER AT PLANT B

Parameter	AGI samples					
	1 - 1	1 - 2	2 - 1	2 - 2	3 - 1	3 - 2
Sampling data:						
Sampling date	1/28/80	1/28/80	1/29/80	1/29/80	1/30/80	1/30/80
Air volume sampled (m ³)	0.49	0.49	0.49	0.49	0.49	0.49
Microbial analyses (cfu/m ³):						
Total bacteria	<2.0 x 10 ⁶	<2.0 x 10 ⁶	2.0 x 10 ⁶	2.0 x 10 ⁶	6.1 x 10 ⁴	8.2 x 10 ⁴
Fecal coliform	4.9 x 10 ²	9.4 x 10 ²	<6.0	<6.0	<6.0	2.5 x 10 ²
Salmonella sp.	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²
Shigella sp.	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²
Klebsiella sp.	<2.0 x 10 ³	<2.0 x 10 ^{3a}	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³
Staphylococcus aureus	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	6.3 x 10 ³	<2.0 x 10 ³
Nocardia asteroides	<2.0 x 10 ⁴	<2.0 x 10 ⁴	<2.0 x 10 ⁴	<2.0 x 10 ⁴	<4.1 x 10 ⁵	<4.1 x 10 ⁵
Streptomyces sp.	<2.0 x 10 ⁴	<2.0 x 10 ⁵	<2.0 x 10 ³	<4.1 x 10 ³	<2.0 x 10 ⁴	<2.0 x 10 ⁴
Aspergillus fumigatus	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³
Aspergillus flavus	<2.0 x 10 ³	2.0 x 10 ^{3a}	<2.0 x 10 ³	<2.0 x 10 ³	2.0 x 10 ³	<2.0 x 10 ³
Mycobacterium sp.	OG ^b	OG	OG	OG	OG	OG

a Concentration based on a statistically available count.

b "OG" means overgrowth with mycelial fungi.

TABLE A-20. MICROBIOLOGICAL COMPOSITION OF AEROSOL SAMPLES COLLECTED BY THE
LITTON LARGE VOLUME AIR SAMPLER AT PLANT B

Parameter	IVAS samples					
	1 - 1	1 - 2	2 - 1	2 - 2	3 - 1	3 - 2
Sampling data:						
Sampling date	1/28/80	1/28/80	1/29/80	1/29/80	1/30/80	1/30/80
Air volume sampled (m ³)	26.0	31.0	34.0	41.0	35.0	28.0
Microbial analyses (cfu/m ³):						
Total bacteria	<1.3 x 10 ⁵	<1.1 x 10 ⁵	<9.5 x 10 ⁴	<9.5 x 10 ⁵	3.7 x 10 ⁴	7.7 x 10 ⁴
Fecal coliform	1.4 x 10 ²	1.7 x 10 ¹	4.1	3.7	2.5 x 10 ²	1.2 x 10 ²
Salmonella sp.	<1.3 x 10 ¹	<1.1 x 10 ¹	<9.5	<9.5	<1.0 x 10 ¹	<1.1 x 10 ¹
Shigella sp.	<1.3 x 10 ¹	<1.1 x 10 ¹	<9.5	<9.5	<1.0 x 10 ¹	<1.1 x 10 ¹
Klebsiella sp.	<1.3 x 10 ²	<1.1 x 10 ²	<9.5 x 10 ¹	<9.5 x 10 ¹	<1.0 x 10 ²	<1.1 x 10 ²
Staphylococcus aureus	<1.3 x 10 ²	<1.1 x 10 ²	<9.5 x 10 ¹	<9.5 x 10 ¹	2.0	<1.1 x 10 ²
Nocardia asteroides	<1.2 x 10 ³	<1.1 x 10 ³	<9.5 x 10 ³	<9.5 x 10 ³	<2.0 x 10 ⁵	<2.0 x 10 ⁵
Streptomyces sp.	OG ^a	OG	1.9 x 10 ³	<9.5 x 10 ²	<1.0 x 10 ³	<1.1 x 10 ²
Aspergillus fumigatus	1.0 x 10 ³	2.3 x 10 ²	9.5 x 10 ¹	2.8 x 10 ²	<1.0 x 10 ³	<1.1 x 10 ²
Aspergillus flavus	2.5 x 10 ²	3.4 x 10 ²	<9.5 x 10 ¹	2.8 x 10 ³	<1.0 x 10 ³	<1.1 x 10 ²
Mycobacterium sp.	OG ^a	OG	OG	OG	OG	OG

a "OG" means overgrowth with mycelial fungi.

The fecal coliform content of the solid waste was $> 4.8 \times 10^4$ cells/g, while the railing dust contained 2.2×10^4 coliforms/g. Aerosolized fecal coliform concentrations were 2.8×10^2 cells/m³ with the AGI-30 and 89 cells/m³ with the LVAS.

No Salmonella or Shigella were detected in either the solids or aerosol samples.

Klebsiella was found in both the solid waste and dust samples at 1.7×10^5 cells/g. Most (78%) of the Klebsiella isolates were identified as K. pneumoniae. The remaining Klebsiella isolates were K. oxytoca.

Klebsiella pneumoniae was detected in only one aerosol sample taken on January 28 with the impinger. Though not statistically reliable, the aerosolized Klebsiella concentration was 3.0×10^3 cells/m³.

The solid waste was found to contain an average of 1.1×10^5 Staphylococcus aureus/g material. The railing dust contained 2.4×10^5 S. aureus/g. Aerosolized S. aureus was detected on the third day of sampling by both the impinger (6.3×10^3 cells/m³) and the LVAS (2.0 cells/m³) during the same sampling period.

All data from the Nocardia sp. and Mycobacterium sp. analyses were lost due to overgrowth of the media by molds. Analytical methodology was modified to circumvent this problem during future surveys.

The solid waste samples contained 7.3×10^3 Streptomyces sp./g. Streptomyces content of the railing dusts was slightly higher at 4.0×10^4 cfu/g material. Aerosolized Streptomyces were also detected at two separate times on the same day by either the impinger (4.1×10^3 cfu/m³) or the LVAS (1.9×10^3 cfu/m³).

The Aspergilli were not detected in the solid waste samples. Aspergillus fumigatus was found in the railing dusts at 4.0×10^4 cfu/g. A. fumigatus was detected by the LVAS in four of the six air samples collected. The average concentration of aerosolized A. fumigatus was 4.0×10^2 /m³. Aerosolized A. flavus was detected twice by the impinger (2.0×10^3 cfu/m³) and twice by the LVAS (1.6×10^3 cfu/m³).

No fluorescing bacteria resembling the Legionnaires' Disease Bacteria (LDB) or the Legionella-like (LLO) bacteria were seen in any of the direct aerosol sample smears. The results of the LDB assays are presented in Table A-21. It is possible that problems resulting from sample shipment errors could have affected the LDB analysis since the samples were not received at CDC until about 2 days after shipment. However, it was CDC's feeling that the delay did not adversely affect the analyses.

TABLE A-21. AEROSOL SAMPLE RESULTS FOR LEGIONNAIRES'
DISEASE BACTERIA AT PLANT B

CDC No.	MRI No.	Air volume sampled (m ³)	LDBs per sample	LDB concentration (LDB/m ³)
53	LVAS-CDC-3-2	36.0	< 75	< 2.1
54	LVAS-CDC-3-4	36.0	< 75	< 2.1
55	AGI-CDC-3-2	0.375	< 75	< 200
56	AGE-CDC-3-4	0.49	< 75	< 153.1

Plant C--

Analytical results of the microbiological sampling program conducted by MRI at the Plant C resource recovery facility are presented in this section. The microbiological survey included analyses for selected bacterial indicator complexes and infectious agents (see Table 2). These analyses were performed on aerosol, solid waste, compressed fuel pellet, and settled dust samples. Complete descriptions of the analytical methodologies are included in Appendix G.

Sampling site--Microbial aerosol samples were collected at two locations within the plant. Control aerosol samples were collected on the first day (3/24/80) when the plant was not operating. The control sampling site was situated on an elevated concrete platform between the two primary shredders. Aerosol samples collected during normal plant operations were taken in the middle of the fuel processing area (see Figure A-21).

Solid samples were collected on a random basis within the fuel processing area. Shredded solid waste and processed fuel pellets were collected from conveyors. Settled-dust samples were collected from railings in the same general vicinity.

Analytical results--Microbiological analysis results from samples collected at Plant C are presented in this section. The results from analysis of solid samples are presented in Table A-22. Aerosol sample results may be found in Tables A-23 and A-24.

The average ($n = 4$) total bacterial count was 4.1×10^7 bacteria/g of solid waste. A dust sample collected from safety railings near the aerosol sampling location contained slightly higher total bacteria counts at 1.0×10^8 bacteria/g. Compressed solid waste fuel pellets, at 4.0×10^3 bacteria/g, contained the lowest total bacteria levels of any of the solids tested.

TABLE A-22. MICROBIOLOGICAL SOLID SAMPLE RESULTS OBTAINED FROM PLANT C

Microbial assay	Microbiological results (cfu/g)					
	Solid waste samples		Fuel pellets		Railing dust	
	2-1	2-2	3-1	3-2	3-1	3-4
Total bacteria	4.4×10^7	2.5×10^7	3.8×10^7	5.8×10^7	4.0×10^3	1.0×10^8
Fecal coliform	1.1×10^3	7.2×10^2	1.0×10^3	2.4×10^1	<8	1.8×10^2
Salmonella sp.	$<2.0 \times 10^2$	$<2.0 \times 10^2$	$<2.0 \times 10^2$	$<2.0 \times 10^2$	$<2.0 \times 10^2$	$<2.0 \times 10^2$
Shigella sp.	$<2.0 \times 10^2$	$<2.0 \times 10^2$	$<2.0 \times 10^2$	$<2.0 \times 10^2$	$<2.0 \times 10^2$	$<2.0 \times 10^2$
Klebsiella pneumoniae	1.4×10^4	1.6×10^5	6.0×10^4	3.0×10^5	$<2.0 \times 10^3$	6.0×10^4
Klebsiella oxytoca	3.7×10^5	6.0×10^4	6.0×10^4	$<2.0 \times 10^3$	$<2.0 \times 10^3$	$<2.0 \times 10^3$
Klebsiella ozaenae	$<2.0 \times 10^3$	$<2.0 \times 10^3$	$<2.0 \times 10^3$	$<2.0 \times 10^3$	$<2.0 \times 10^3$	$<2.0 \times 10^3$
Staphylococcus aureus	4.4×10^4	1.7×10^5	2.1×10^3	3.2×10^5	$<2.0 \times 10^2$	$<2.0 \times 10^2$
Nocardia asteroides	$<2.0 \times 10^3$	$<2.0 \times 10^4$	$<2.0 \times 10^3$	$<2.0 \times 10^3$	$<2.0 \times 10^3$	$<2.0 \times 10^3$
Streptomyces sp.	6.0×10^4	2.0×10^3	1.0×10^4	1.6×10^4	$<2.0 \times 10^3$	4.0×10^3
Aspergillus fumigatus	$<2.0 \times 10^4$	$<2.0 \times 10^4$	$<2.0 \times 10^4$	$<2.0 \times 10^4$	$<2.0 \times 10^3$	2.0×10^4
Aspergillus flavus	$<2.0 \times 10^2$	$<2.0 \times 10^2$	$<2.0 \times 10^2$	$<2.0 \times 10^2$	$<2.0 \times 10^2$	$<2.0 \times 10^2$
Mycobacterium sp. ^a	2.0×10^1	2.0×10^1	4.0×10^1	0.6 ^b	<1	2.0×10^1

^a Mycobacterium sp., not tuberculosis^b "OG" = Overgrown by molds

TABLE A-23. MICROBIOLOGICAL COMPOSITION OF AEROSOL SAMPLES COLLECTED
BY THE AGI-30 SAMPLER AT PLANT C

Parameter	AGI-30 samples					
	1-1		1-2		2-1	
	Control		Control		2-2	3-2
Sampling date	3/24/80	3/24/80	3/24/80	3/25/80	3/25/80	3/26/80
Air volume sampled (m ³)	0.5	0.5	0.5	0.5	0.5	0.5
Microbial analysis (cfu/m ³)						
Total bacteria	<2.0 x 10 ⁴	<2.0 x 10 ⁴	<2.0 x 10 ⁴	4.0 x 10 ⁴	4.0 x 10 ⁴	6.0 x 10 ⁴
Fecal coliforms	<4.0 x 10 ¹	<4.0 x 10 ¹	<4.0 x 10 ¹	1.4 x 10 ²	1.0 x 10 ²	1.0 x 10 ²
Salmonella sp.	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²
Shigella sp.	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²
Klebsiella pneumoniae	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³
Klebsiella oxytoca	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³
Klebsiella ozaenae	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³
Staphylococcus aureus	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³
Nocardia asteroides	<2.0 x 10 ⁴	<2.0 x 10 ⁴	<2.0 x 10 ⁴	<2.0 x 10 ⁴	<2.0 x 10 ⁴	<2.0 x 10 ⁴
Streptomyces sp.	<2.0 x 10 ⁴	<2.0 x 10 ⁴	<2.0 x 10 ⁴	<2.0 x 10 ⁴	<2.0 x 10 ⁴	<2.0 x 10 ⁴
Aspergillus fumigatus	<2.0 x 10 ⁴	<2.0 x 10 ⁴	<2.0 x 10 ⁴	<2.0 x 10 ⁴	<2.0 x 10 ⁴	<2.0 x 10 ⁴
Aspergillus flavus	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	2.0 x 10 ^{3a}	<2.0 x 10 ³
Mycobacterium sp.	<2.0 x 10 ^{2c}	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²	6.0 x 10 ^{2b}	2.0 x 10 ^{2b}

^a Concentration based upon statistically unreliable microbial count, i.e., < 30 colonies/plate.

^b Mycobacterium sp. not tuberculosis.

^c Positive on subculture but < 2.0 x 10² cfu/m³.

TABLE A-24. MICROBIOLOGICAL COMPOSITION OF AEROSOL SAMPLES COLLECTED BY THE LITTON LARGE VOLUME AIR SAMPLER (LVAS) AT PLANT C

Parameter	LVAS samples				
	1-1 Control	1-2 Control	2-1	2-2	3-1 3-2
Sampling date	3/24/80	3/24/80	3/25/80	3/25/80	3/26/80
Air volume sampled (m ³)	23.0	16.5	25.0	18.0	14.5
Microbial analyses (cfu/m ³)					
Total bacteria	7.6 x 10 ³	4.4 x 10 ⁴	2.5 x 10 ⁵	7.0 x 10 ⁴	4.0 x 10 ⁴
Fecal coliforms	1.5 x 10 ¹	<2.8	5.3 x 10 ¹	4.0 x 10 ¹	3.8 x 10 ¹
Salmonella sp.	<1.5 x 10 ¹	<1.4 x 10 ¹	<1.6 x 10 ¹	<1.5 x 10 ¹	<1.1 x 10 ¹
Shigella sp.	<1.5 x 10 ¹	<1.4 x 10 ¹	<1.6 x 10 ¹	<1.5 x 10 ¹	<1.1 x 10 ¹
Klebsiella pneumoniae	<1.5 x 10 ²	<1.4 x 10 ²	1.6 x 10 ^{2a}	<1.5 x 10 ²	2.3 x 10 ^{2a}
Klebsiella oxytoca	<1.5 x 10 ²	<1.4 x 10 ²	1.6 x 10 ^{2a}	<1.5 x 10 ²	<1.1 x 10 ²
Klebsiella ozaenae	<1.5 x 10 ²	<1.4 x 10 ²	<1.6 x 10 ²	1.5 x 10 ^{2a}	<1.1 x 10 ²
Staphylococcus aureus	<1.5 x 10 ²	<1.4 x 10 ²	<1.6 x 10 ²	<1.5 x 10 ²	4.6 x 10 ^{2a}
Nocardia asteroides	<1.5 x 10 ³	<1.4 x 10 ³	<1.6 x 10 ³	<1.5 x 10 ³	<1.1 x 10 ³
Streptomyces sp.	<1.5 x 10 ³	<1.4 x 10 ³	<1.6 x 10 ³	<1.5 x 10 ³	<1.1 x 10 ³
Aspergillus fumigatus	6.1 x 10 ³	<1.4 x 10 ³	<1.6 x 10 ³	<1.5 x 10 ³	<1.1 x 10 ³
Aspergillus flavus	<1.5 x 10 ²	<1.4 x 10 ²	1.6 x 10 ^{2a}	4.5 x 10 ³	<1.1 x 10 ²
Mycobacterium sp.	OG ^b	OG	<1.6 x 10 ¹	1.5 x 10 ^{1c}	<1.1 x 10 ¹

^a Concentration based upon statistically unreliable microbial count, i.e., < 30 colonies per plate.

^b OG = Overgrown by molds.

^c Mycobacterium sp. not tuberculosis.

Average total bacteria aerosols during control testing were $< 2.0 \times 10^4$ and 2.6×10^4 cfu/m³ for the AGI and LVAS samples, respectively. These levels increased to 5.0×10^4 (AGI) and 1.0×10^5 (LVAS) cfu/m³ when the plant was operating.

The solid waste contained an average ($n = 4$) fecal coliform concentration of 7.1×10^2 cfu/g. The railing dust sample contained slightly lower fecal coliform levels at 1.8×10^2 cfu/g. No fecal coliforms were detected in the fuel pellets (< 8 /g).

Fecal coliform aerosols were detected at 7.5 cfu/m³ by the LVAS during control testing when the plant was not operating. During plant operation, fecal coliform aerosols were detected at 85 (AGI) and 43 (LVAS) cfu/m³.

Neither Salmonella or Shigella were detected in either the solid or aerosol samples.

The Klebsiella were found in both solids and aerosol samples. The solid waste samples contained an average ($n = 4$) of 1.3×10^5 K. pneumoniae/g and 1.2×10^5 K. oxytoca/g. K. pneumoniae was also found in the railing-dust samples at 6.0×10^4 /g. No Klebsiella within the detection limits (2.0×10^3 /g) were found in the fuel pellets.

Klebsiella aerosols were detected only with the LVAS. Klebsiella were not detected during control testing. During plant operation, however, K. pneumoniae was detected twice on separate days (1.6×10^2 and 2.3×10^2 cfu/m³). Klebsiella oxytoca and K. ozaenae were detected once at 1.6×10^2 and 1.5×10^2 cfu/m³, respectively. It should be noted that Klebsiella aerosols were barely within detection limits and as a result, the concentrations reported are not statistically reliable.

The solid waste contained an average ($n = 4$) Staphylococcus aureus concentration of 1.3×10^5 cfu/g. S. aureus was not found in either the railing dust or fuel pellets within detection limits. S. aureus aerosols were detected once with the LVAS at 4.6×10^2 cfu/m³. However, the aerosol concentration is not statistically reliable.

Nocardia asteroides was not detected in either solid or aerosol form despite modifications in analytical methodology.

The Streptomyces population of solid waste was found to average ($n = 4$) 2.2×10^4 cfu/g. Railing dust concentrations of Streptomyces sp. were similar to solid waste at 2.0×10^4 cfu/g. Streptomyces were not detected in the fuel pellets. Aerosolized Streptomyces were detected only once with the AGI-30 sampler during plant operation at 4.0×10^4 cfu/m³.

Aspergillus fumigatus was isolated from the railing dust sample at 2.0×10^4 cfu/g. Aerosolized A. fumigatus was detected once during control sampling with the LVAS at 6.1×10^3 cfu/m³.

Aspergillus flavus was not detected in any of the solid samples. Yet, A. flavus aerosols were detected three separate times with the LVAS when the

plant was operating. The average A. flavus concentration ($n = 3$) as detected by the LVAS was 3.1×10^3 cfu/m³. These concentrations were corroborated twice with the AGI during similar sampling times. The average A. flavus concentration ($n = 2$) as detected by the AGI was 2.0×10^3 cfu/m³. A. flavus was not detected during control sampling.

Modification in Mycobacterium analysis methodology succeeded in preventing mold overgrowth in most of the Plant C samples. The average Mycobacterium sp. (not tuberculosis) populations in the solid waste samples were determined to be 2.6×10^1 cfu/g ($n = 3$). The railing dust contained 2.0×10^1 Mycobacterium sp. (not tuberculosis) per gram. Mycobacteria were not isolated from the fuel pellets.

Mycobacteria isolates were found in aerosol form by both the AGI and LVAS during normal plant operation. The average Mycobacterium sp. (not tuberculosis) concentration ($n = 4$) detected by the AGI-30 was 2.0×10^2 cfu/m³. Mycobacteria were detected with LVAS at 1.5×10^1 cfu/m³ during a single sampling interval. Table A-25 details the Mycobacterium species and relative pathogenicity to humans.

Legionnaires' Disease Bacteria or other Legionella-like bacteria were not found in any aerosol samples taken at Plant C. The results of the LDB assays are presented in Table A-26.

Viral sampling results at Plant C were negative, as shown in Table A-27.

Plant E--

Analytical results of the microbiological sampling program conducted by MRI at the Plant E resource recovery facility are presented in this section. The microbiological survey included analyses for selected bacterial indicator complexes, and infectious agents (see Table 2). These analyses were performed on aerosol, solid waste, settled dust, and powdered fuel samples. Complete descriptions of the sampling and analytical methodologies are included in Appendix G.

Sampling sites--Microbial aerosol samples were collected at two locations in Plant E. Most of the aerosol samples were collected in the relatively open area of the main processing floor adjacent to the hammermill. The sampling site was located between the primary trommel (Line 100) and the maintenance shop (see Figure A-28). A single aerosol sample (AGI-3-4) was also collected in the plant's office area beneath the air supply duct located in the hallway adjacent to the laboratory doorway.

Three types of solid samples were collected for microbiological analysis at Plant E. Solid waste samples were randomly collected from the conveyor leading from the hammermill, just before they entered the magnetic separator. Settled dust samples were collected from the equipment and floor surfaces in the immediate vicinity of the aerosol sampling site. The powdered fuel sample was collected by Plant E laboratory personnel (Plant E Sample No. 061).

TABLE A-25. MYCOBACTERIUM SP. RESULTS FROM PLANT C

MRI No.	KIMC No.	CDC No.	Sample Type	Date collected	Collection method	Air volume sample (m ³)	Isolation method	Concentration (aerosols cfu/m ³) (solids cfu/g)	Organism Identify	Relative pathogenicity to humans ^a (M. tuberculosis=****)
AGI 1-1 Control	M034#1	80-1204	Aerosol	3/24/80	AGI-30	0.5	Enrichment	<2.0x10 ²	Mycobacterium scrofulaceum ^b	**
AGI 1-1 Control	M034#2	80-1205	Aerosol	3/24/80	AGI-30	0.5	Enrichment	<2.0x10 ²	Mycobacterium azulgal ^c	***
AGI 2-2	M039#1	80-1206	Aerosol	3/25/80	AGI-30	0.5	Plate	6.0x10 ²	M. scrofulaceum	**
AGI 2-2	M039#2	80-1207	Aerosol	3/25/80	AGI-30	0.5	Plate	6.0x10 ²	M. scrofulaceum	**
LVAS 2-2	M041	80-1208	Aerosol	3/25/80	LVAS	18.0	Plate	1.5x10 ¹	M. terrae complex	Rare
AGI 3-1	M042#1	80-1209	Aerosol	3/26/80	AGI-30	0.5	Enrichment	<2.0x10 ²	M. scrofulaceum	**
AGI 3-1	M042#2	80-1210	Aerosol	3/26/80	AGI-30	0.5	Enrichment	<2.0x10 ²	M. scrofulaceum	**
AGI 3-2	M043#1	80-1211	Aerosol	3/26/80	AGI-30	0.5	Plate	2.0x10 ²	M. scrofulaceum	**
AGI 3-2	M043#2	80-1212	Aerosol	3/26/80	AGI-30	0.5	Plate	2.0x10 ²	M. gordonae	0
Rattling dust 3-4	M050	80-1213	Dust	3/26/80	Aseptic grab	-	Plate	2.0x10 ¹	M. fortuitum ^d	*
Solid waste 2-2	M052#1	80-1214	Solid waste	3/25/80	Aseptic grab	-	Plate	2.0x10 ¹	M. fortuitum	*
Solid waste 2-2	M052#2	80-1215	Solid waste	3/25/80	Aseptic grab	-	Plate	2.0x10 ¹	M. terrae complex	Rare
Solid waste 3-1	M053#1	80-1216	Solid waste	3/26/80	Aseptic grab	-	Plate	4.0x10 ¹	M. terrae complex	Rare
Solid waste 3-1	M053#2	80-1217	Solid waste	3/26/80	Aseptic grab	-	Plate	4.0x10 ¹	M. terrae complex	Rare
Solid waste 3-1	M053#3	80-1218	Solid waste	3/26/80	Aseptic grab	-	Plate	4.0x10 ¹	M. terrae complex	Rare
Solid waste 3-1	M053#4	80-1219	Solid waste	3/26/80	Aseptic grab	-	Plate	4.0x10 ¹	M. terrae complex	Rare
Solid waste 3-1	M053#5	80-1220	Solid waste	3/26/80	Aseptic grab	-	Plate	4.0x10 ¹	M. terrae complex	Rare
Solid waste 2-1	M051	-	Solid waste	3/25/80	Aseptic grab	-	Plate	2.0x10 ¹	Not identified	-

^a From: Youmans, G.P. 1980. Disease Due to Mycobacteria Other Than Mycobacterium tuberculosis. In: The Biologic and Clinical Basis of Infectious Diseases.

^b G.P. Youmans, P. Y. Paterson, and H. M. Saunders, eds. W.H. Saunders, Co., Philadelphia. p. 392.

^c M. scrofulaceum primarily causes cervical and submandibular lymphadenitis in children

^d Most isolates of M. azulgal have been associated with disease. It causes pulmonary disease, cervical adenitis in children and olecranon bursitis Disease most frequently caused by M. fortuitum is cutaneous infection and abscess formation.

TABLE A-26. AEROSOL SAMPLE RESULTS FOR LEGIONNAIRES'
DISEASE BACTERIA AT PLANT C

MRI No.	Air volume sampled (m ³)	LDBs per sample	LDB concentration (LDB/m ³)
LVAS-CDC-2-3	23.0	< 75	< 3.2
LVAS-CDC-3-2	5.0	< 75	< 15.0
AGI-CDC-2-3	0.5	< 75	< 150
AGI-CDC-3-2	0.5	< 75	< 150

TABLE A-27. VIRUS COMPOSITION OF SAMPLES COLLECTED AT PLANT C

Sample No.	Date collected	Air volume sampled (m ³) or assay wt. (g)	Virus isolation results (viral particles/m ³ or g) ^a										Electron microscopy rotavirus, etc.
			Adeno	Rhino	Herpes	Polio	Cox. B.	Echo	Influenza ^c	ParaInfluenza ^c	Inoculation	Cox. A	
ACI 1-1 ^e	3/24/80	0.5	< 30 ^d	< 30	< 30	< 20	< 20	< 20	< 30	< 30	< 20	< 20	< 13,000
ACI 1-2 ^e	3/24/80	0.5	< 30	< 30	< 30	< 20	< 20	< 20	< 30	< 30	< 20	< 20	< 13,000
ACI 2-1	3/25/80	0.5	< 30	< 30	< 30	< 20	< 20	< 20	< 30	< 30	< 20	< 20	< 13,000
ACI 3-3	3/26/80	0.5	< 30	< 30	< 30	< 20	< 20	< 20	< 30	< 30	< 20	< 20	< 13,000
IVAS 1-2 ^e	3/24/80	16.5	< 0.8	< 0.8	< 0.8	< 0.5	< 0.5	< 0.5	< 0.8	< 0.8	< 0.5	< 0.5	< 400
IVAS 2-2	3/25/80	18.0	< 0.7	< 0.7	< 0.7	< 0.4	< 0.4	< 0.4	< 0.7	< 0.7	< 0.4	< 0.4	< 400
Dust 3-4	3/26/80	15.0	< 0.9	< 0.9	< 0.9	< 0.5	< 0.5	< 0.5	< 0.9	< 0.9	< 0.5	< 0.5	< 400
Pellet 3-1	3/26/80	30.0	< 0.4	< 0.4	< 0.4	< 0.3	< 0.3	< 0.3	< 0.4	< 0.4	< 0.3	< 0.3	< 200

a ACI and IVAS aerosol sample results are expressed as viral particles/m³. Solid waste results are expressed as viral particles/g.

b PHK = primary monkey (Cynomolgus) kidney; HEL = human embryonic lung; MDCK = Madin Darby canine kidney.

c Inoculated PHK and MDCK tubes were tested for hemagglutination and hemadsorption for detection of influenza and parainfluenza viruses.

d All less-than values, e.g., < 30, indicate the theoretical detection limits and that no viruses were detected.

e Indoor control.

Analytical results--Analytical results of microbiological samples collected at Plant E are presented in this section. The results from bacteriological analysis of solid material samples are presented in Table A-28. Aerosol sample results may be found in Tables A-29, A-30, and A-31.

The total bacteria aerosol concentration of the office air supply was 8.0×10^6 bacteria/m³ (AGI). This level was higher than the process floor control sample taken when the plant was shut down, which contained 4.0×10^4 bacteria/m³ (AGI) and 1.9×10^6 (LVAS).

Average total bacteria aerosol concentration in the process area ranged from 3.2×10^5 (AGI) to 9.0×10^6 (LVAS) bacteria/m³. These samples were taken when varying degrees of personnel and machinery activity were occurring.

Fecal coliform results--The fecal coliform concentration of Plant E solid samples varied considerably. The average fecal coliform content of MSW samples was 1.9×10^5 fecal coliforms/g. However, the fecal coliform content of the MSW samples varied widely over a 2-day period. On one day the fecal coliform content was 4.8×10^2 fecal coliforms/g, while on the following day the content was 3.7×10^5 fecal coliforms/g. The dust samples contained 3.9×10^4 fecal coliforms/g. No fecal coliforms were detected in the powdered fuel sample (< 80 fecal coliforms/g).

Fecal coliform aerosols were not detected in either the office or process area control samples (< 40 fecal coliforms/m³). However, the process control sample collected with the LVAS contained 1.8×10^2 fecal coliforms/m³. Routine process area aerosol samples contained an average of 1.2×10^3 (AGI) and 2.5×10^2 (LVAS) fecal coliforms/m³.

Salmonella and Shigella--Neither Salmonella nor Shigella were detected in the solids or aerosol samples.

Klebsiella--Klebsiella pneumoniae was found consistently in solid samples, whereas K. oxytoca was found only sporadically. The average K. pneumoniae content of the solids samples was 1.6×10^5 cfu/g (MSW), 2.6×10^5 cfu/g (dust), and 2.0×10^3 cfu/g (fuel). Klebsiella oxytoca was found in one-half of the MSW and dust samples at an average concentration of 1.5×10^5 cfu/g (MSW, n = 2) and 5.0×10^4 cfu/g (dust, n = 1). Klebsiella oxytoca was not detected in the fuel samples.

Klebsiella pneumoniae aerosols were detected in the process area by both sampling methods during one of four sampling periods. The concentrations were 2.0×10^3 cfu/m³ (AGI) and 1.0×10^2 cfu/m³ (LVAS). Klebsiella pneumoniae (5.5×10^1 cfu/m³) was also collected by the LVAS during the process area control sampling.

Klebsiella oxytoca aerosols were detected in the production samples but not in the controls. One sample set collected simultaneously by AGI and LVAS on September 16 contained K. oxytoca (AGI = 2.0×10^3 cfu/m³; LVAS = 5.2×10^1 cfu/m³). The AGI sample collected on September 17 also contained K. oxytoca at 6.7×10^3 cfu/m³.

TABLE A-28. MICROBIOLOGICAL SOLID SAMPLE RESULTS OBTAINED AT PLANT E

	Microbiological results (cfu/g) ^a								Fuel product 2-1
	Solid waste samples				Dust samples				
	2-1	2-2	3-1	3-2	2-1	3-1	3-2	3-1	
Total bacteria	9.7 x 10 ⁷	1.3 x 10 ⁸	5.5 x 10 ⁷	7.5 x 10 ⁷	8.2 x 10 ⁷	1.3 x 10 ⁸			<6.0 x 10 ⁴
Fecal coliforms	4.8 x 10 ²	4.8 x 10 ²	2.2 x 10 ⁵	5.2 x 10 ⁵	6.4 x 10 ⁴	1.4 x 10 ⁴			<8.0 x 10 ¹
Salmonella sp.	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²			<2.0 x 10 ²
Shigella sp.	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²			<2.0 x 10 ²
Klebsiella sp.:									
K. pneumoniae	4.7 x 10 ⁵	2.0 x 10 ³	7.6 x 10 ⁴	8.6 x 10 ⁴	3.5 x 10 ⁵	1.6 x 10 ⁵			2.0 x 10 ³
K. oxytoca	2.8 x 10 ⁵	<2.0 x 10 ³	1.2 x 10 ⁴	<2.0 x 10 ³	5.0 x 10 ⁴	<2.0 x 10 ³			<2.0 x 10 ³
Staphylococcus aureus	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³			<2.0 x 10 ³
^b									
Nocardia sp.	<2.0 x 10 ³	2.0 x 10 ^{3C}	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	2.0 x 10 ^{4C}			<2.0 x 10 ³
Streptomyces sp.	7.5 x 10 ⁴	7.7 x 10 ⁴	1.0 x 10 ⁴	4.0 x 10 ^{2C}	1.8 x 10 ⁵	8.0 x 10 ⁴			<2.0 x 10 ²
Aspergillus fumigatus	4.0 x 10 ^{2C}	1.4 x 10 ⁴	<2.0 x 10 ²	<2.0 x 10 ²	1.2 x 10 ^{4C}	<2.0 x 10 ²			<2.0 x 10 ²
Aspergillus flavus	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²	<2.0 x 10 ²			<2.0 x 10 ²
Mycobacterium sp.	<2.0	<2.0	OG ^d	OG	OG	OG			<2.0

^a Less-than values, e.g., <2.0 x 10², indicate the overall minimum detection limits and that no microorganisms were detected.

^b *Nocardia* sp. were not *asteroides* or *brasiliensis*

^c Concentration based upon statistically unreliable microbial count, i.e., < 30 colonies per plate.

^d OG = Overgrown by molds.

TABLE A-29. MICROBIOLOGICAL COMPOSITION OF AEROSOL SAMPLES COLLECTED BY
THE AGI-30 SAMPLER AT PLANT E

Parameter	AGI-30 samples					Indoor controls ^b	
	1-1	2-1	2-3	3-1	3-4 ^a	3-5	
Sampling data:							
Sampling date	9/15/80	9/16/80	9/16/80	9/17/80	9/17/80	9/17/80	9/17/80
Air volume sampled (m ³)	0.5	0.5	0.5	0.75	0.5	0.5	0.5
Microbiological assay (cfu/m ³) ⁴							
Total bacterial	<2.0 x 10 ⁴	1.2 x 10 ^{5e}	1.4 x 10 ^{5e}	6.3 x 10 ⁵	8.0 x 10 ⁶	4.0 x 10 ^{4e}	
Fecal coliforms	<4.0 x 10 ¹	4.0 x 10 ¹	4.0 x 10 ¹	4.7 x 10 ³	<4.0 x 10 ¹	<4.0 x 10 ¹	
Salmonella sp.	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	<1.3 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	
Shigella sp.	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	<1.3 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	
Klebsiella sp.:							
K. pneumoniae	<2.0 x 10 ³	<2.0 x 10 ³	2.0 x 10 ^{3e}	<1.3 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	
K. oxytoca	<2.0 x 10 ³	<2.0 x 10 ³	2.0 x 10 ^{3e}	6.7 x 10 ^{3e}	<2.0 x 10 ³	<2.0 x 10 ³	
Staphylococcus aureus	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	<1.3 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	
Nocardia sp.	<2.0 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	4.0 x 10 ^{3e}	<2.0 x 10 ³	<2.0 x 10 ^{3e}	
Streptomyces sp.	<2.0 x 10 ³	1.6 x 10 ^{4e}	6.0 x 10 ^{3e}	1.3 x 10 ^{3e}	<2.0 x 10 ³	<2.0 x 10 ³	
Aspergillus fumigatus	<2.0 x 10 ³	1.8 x 10 ^{4e}	1.2 x 10 ⁵	<1.3 x 10 ³	<2.0 x 10 ³	<2.0 x 10 ³	
Aspergillus flavus	<2.0 x 10 ³	4.0 x 10 ^{5e}	2.0 x 10 ^{3e}	2.7 x 10 ⁴	<2.0 x 10 ³	<2.0 x 10 ³	
Mycobacterium sp.	<2.0 x 10 ³	OG ^f	OG	OG	OG	<2.0 x 10 ³	

^a Indoor control sample collected in the office area beneath an air supply vent.

^b Indoor control sample collected in the production area when the plant was not operating.

^c Less-than values, e.g., < 2.0 x 10¹, indicate the overall minimum detection limits and that no microorganisms were detected.

^d Nocardia sp. were not asteroides or brasiliensis

^e Concentration based upon statistically unreliable microbial count, i.e., < 30 colonies per plate.

^f OG = Overgrown by molds.

TABLE A-30. MICROBIOLOGICAL COMPOSITION OF AEROSOL SAMPLES COLLECTED BY THE LARGE VOLUME AIR SAMPLER (LVAS) AT PLANT E

Parameter	LVAS samples			
	1-1	2-1	2-3	3-3 ^a
<u>Sampling data</u>				
Sampling date	9/15/80	9/16/80	9/16/80	9/17/80
Air volume sampled (m ³)	53.8	55.0	59.1	59.9
<u>Microbiological assay (cfu/m³)^b</u>				
Total bacteria	2.6 x 10 ^{3d}	1.1 x 10 ⁷	1.0 x 10 ⁷	1.5 x 10 ⁷
Fecal coliforms	<1.0	2.3 x 10 ²	1.7 x 10 ²	5.8 x 10 ¹
Salmonella sp.	<5.3 x 10 ¹	<6.6 x 10 ¹	<5.2 x 10 ¹	<7.3 x 10 ¹
Shigella sp.	<5.3 x 10 ¹	<6.6 x 10 ¹	<5.2 x 10 ¹	<7.3 x 10 ¹
Klebsiella sp.:				
K. pneumoniae	<5.3 x 10 ¹	<6.6 x 10 ¹	1.0 x 10 ^{2d}	<7.3 x 10 ¹
K. oxytoca	<5.3 x 10 ¹	<6.6 x 10 ¹	5.2 x 10 ^{1d}	<7.3 x 10 ¹
Staphylococcus aureus	<5.3 x 10 ¹	<6.6 x 10 ¹	5.2 x 10 ¹	<7.3 x 10 ¹
Nocardia sp.	5.3 x 10 ^{1d}	3.3 x 10 ³	4.1 x 10 ^{2d}	4.4 x 10 ^{3d}
Streptomyces sp.	<5.3 x 10 ¹	8.6 x 10 ^{2d}	1.4 x 10 ³	3.6 x 10 ^{2d}
Aspergillus fumigatus	<5.3 x 10 ¹	2.6 x 10 ⁴	1.6 x 10 ⁴	<7.3 x 10 ¹
Aspergillus flavus	<5.3 x 10 ¹	9.2 x 10 ³	1.1 x 10 ⁴	4.4 x 10 ³
Mycobacterium sp.	<5.3	OG ^e	OG	<7.3

^a Indoor control sample collected in the production area when the plant was not operating.

^b Less than values, e.g., < 2.0 x 10¹, indicate the overall minimum detection limits and that no microorganisms were detected.

^c Nocardia sp. were not asteroides or brasiliensis.

^d Concentration based upon statistically unreliable microbial count, i.e., 30 colonies per plate.

^e OG = Overgrown by molds.

TABLE A-31. AEROSOL SAMPLE RESULTS FOR LEGIONNAIRES' DISEASE
BACTERIA AT PLANT E

MRI No.	Air volume sampled (m ³)	LDBs per sample	LDB concentration (LDB/m ³) ^a
LVAS-CDC-2-2	56.9	<75	<1.3
LVAS-CDC-3-2	41.4	<75	<1.8
AGI-CDC-2-3	0.5	<75	<150
AGI-CDC-3-3	0.5	<75	<150

^a Less than values, e.g., < 1.3, indicates the overall
detection limits and that no microorganisms were detected.

Staphylococcus aureus--Staphylococcus aureus was not detected in any of the solid or aerosol samples at Plant E.

Nocardia sp.--Species of Nocardia other than the pathogens N. asteroides and N. brasiliensis were found intermittently in Plant E samples. Nocardia sp. were obtained in one MSW sample (2.0×10^3 cfu/g) and one dust sample (2.0×10^4 cfu/g). Average Nocardia aerosol concentration in the processing area was 2.0×10^3 cfu/m³ (LVAS). Nocardia aerosols were detected only once by the AGI, in the process area (4.0×10^3 cfu/m³). Nocardia sp. was detected by both sampling devices during process area control sampling. (AGI = 2.0×10^3 cfu/m³; LVAS = 1.6×10^2 cfu/m³).

Streptomyces sp.--Streptomyces were found in all solid samples except the powdered fuel. Average Streptomyces content of MSW was 4.1×10^4 cfu/g. Settled dust contained 1.3×10^5 cfu/g. Average Streptomyces aerosols were 5.8×10^3 cfu/m³ (AGI) and 6.6×10^2 cfu/m³ (LVAS). Process area control aerosol samples contained 2.2×10^3 cfu/m³ (LVAS only).

Aspergillus fumigatus--Aspergillus fumigatus was found in 50% of the MSW and dust samples but not in the powdered fuel. The average (n = 2) concentration of A. fumigatus in MSW was 7.2×10^3 cfu/g. A. fumigatus content of one dust sample was 1.2×10^4 cfu/g. A. fumigatus aerosols were only detected on September 16 at Plant E. The average (n = 2) A. fumigatus aerosol concentration was 6.9×10^4 cfu/m³ (AGI) and 2.1×10^4 cfu/m³ (LVAS).

Aspergillus flavus--Aspergillus flavus was found occasionally in aerosol samples but not in the solid samples. Average (n = 4) A. flavus aerosol concentration in the process area was 8.3×10^3 cfu/m³ (AGI) and 6.2×10^3 (LVAS). Aspergillus flavus aerosols were only detected in the process control sample by the LVAS (1.6×10^3 cfu/m³).

Mycobacterium sp.--Mycobacteria were not found at Plant E within detection limits. However, the methodology is plagued by mold overgrowth problems.

Legionnaires' Disease bacteria--Legionnaire's disease bacteria or other Legionella-like bacteria were not found in any aerosol samples taken at Plant E. The results of the Legionella assays are presented in Table A-31.

Viral assay results--The results of the virus analyses were negative within the detection limits specified (see Table A-32). No animal viruses were isolated in either the cell culture or in newborn mice. Similarly, particles resembling viruses were not observed by electron microscopy.

Noise Exposures

The following sections detail the noise exposure survey results from plants designated A, B, C, and E. These noise surveys of work areas were conducted as part of the overall industrial hygiene assesement of the facilities.

TABLE A-32. VIRUS COMPOSITION OF SAMPLES COLLECTED AT PLANT E

Sample No.	Date collected	Air volume sampled (m ³) or assay wt. (g)	Virus isolation in cell cultures PRK, HEL, and MDCK ^a (viral particles/m ³ or g)										Newborn mice inoculation Cox A	Electron microscopy rotavirus, etc
			Adeno	Rhino	Heppes	Polio	Cox. B	ECMO	Influenza ^c	Parainfluenza ^c				
AGI-1-1 (Indoor Control)	9/15/81	0.5	<30	<30	<30	<20	<20	<20	<20	<30	<30	<160	<13,000	
AGI-2-2	9/16/81	0.5	<30	<30	<30	<20	<20	<20	<20	<30	<30	<160	<13,000	
AGI-2-4	9/16/81	0.5	<30	<30	<30	<20	<20	<20	<20	<30	<30	<160	<13,000	
AGI-3-2	9/17/81	0.5	<30	<30	<30	<20	<20	<20	<20	<30	<30	<160	<13,000	
AGI-3-6	9/17/81	0.5	<30	<30	<30	<20	<20	<20	<20	<30	<30	<160	<13,000	
IVAS-1-1	9/15/81	40.3	<.3	<0.3	<0.3	<0.2	<0.2	<0.2	<0.2	<0.3	<0.3	<0.2	<160	
IVAS-2-1	9/16/81	39.8	<.03	<0.3	<0.3	<0.2	<0.2	<0.2	<0.2	<0.3	<0.3	<0.2	<160	
IVAS-2-3	9/16/81	43.6	<.03	<0.3	<0.3	<0.2	<0.2	<0.2	<0.2	<0.3	<0.3	<0.1	<150	
IVAS-3-1	9/17/81	35.1	<0.4	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	<0.4	<0.4	<0.2	<190	
IVAS-3-3	9/17/81	53.1	<.03	<0.3	<0.3	<0.2	<0.2	<0.2	<0.2	<0.3	<0.3	<0.2	<120	
SW-2-1	9/116/81	30.5	<0.4	<0.4	<0.4	<0.3	<0.3	<0.3	<0.3	<0.4	<0.4	<0.3	<210	
SW-3-1	9/17/81	36.2	<0.4	<0.4	<0.4	<0.2	<0.2	<0.2	<0.2	<0.4	<0.4	<0.2	<180	
Dust-3-1	9/17/81	17.5	<0.8	<0.8	<0.8	<0.5	<0.5	<0.5	<0.5	<0.8	<0.8	<0.5	<370	
Fuel-2-1	9/16/81	15.0	<0.9	<0.9	<0.9	<0.6	<0.6	<0.6	<0.9	<0.9	<0.9	<0.6	<430	

^a All less than values, e.g., <30, indicate the theoretical detection limits and that no viruses were detected.
PINK = primary monkey (Cynomolgus) kidney; HEL = human embryonic lung; MDCK = Madin Darby canine kidney.

^b AGI and IVAS aerosol sample results are expressed as viral particles/m³. Solid waste, dust, and fuel results are expressed as viral particles/g.

^c Inoculated PINK and MDCK tubes were tested for hemagglutination and hemadsorption for detection of influenza and parainfluenza viruses.

Three measurement techniques were used for evaluating noise exposures: a general plant survey utilizing a sound level meter (NIOSH type 1), octave band analysis at the most significant noise level locations, and personnel dosimetry of selected at-risk employees.

OSHA, NIOSH, and ACGIH Standards--

The current OSHA standard and the proposed NIOSH and ACGIH standards are presented in Table A-33. However, OSHA and other standards are based on personnel exposure rather than source generation. Therefore, compliance efforts should not be based solely on noise level production by the equipment, but rather on time/motion, cumulative index studies, or personnel dosimetry.

TABLE A-33. OSHA NOISE STANDARDS AND SUGGESTED OR PROPOSED STANDARDS

Exposure (hr/day)	Continuous noise		
	OSHA (dBA)	ACGIH (dBA)	NIOSH proposed (dBA)
16	90	80	
8	90	85	85
4	95	90	90
2	100	95	95
1	105	100	100
1/4	115 (max)	110	110
1/8		115 (max)	115 (max)
<u>Impact or impulse noise^a</u>			
Sound pressure level (dB)	OSHA	ACGIH	
140	Not to exceed	100 ^b	
130	140 dB	1,000	
120		10,000	

^a Impacts at intervals > 1 sec.

^b Maximum number of impacts permitted per 8-hr day.

Plant A Results

Noise monitoring was conducted during the 3-day study period concurrently with the other industrial hygiene measurements. Many obstacles were encountered in the noise survey. These included a restriction in the number of survey personnel allowed in the process area at any one time (4), the fact

that the process area is bounded by concrete containment walls on all sides, the presence of multilevel processing equipment with only catwalk access, reluctance of plant personnel to wear dosimetry devices, and intermittent plant operations. These factors and others precluded the detailed analysis that had been planned. However, a general noise survey (i.e., octave band analysis, impact/peak measurements at station 1, and limited noise dosimetry) was conducted.

Noise level measurements were conducted at regular intervals on the tipping floor area, ground floor of the processing plant, and along the access catwalks on the upper levels. The survey results generally correspond to earlier measurements reported by MRI and the Engineering Research Institute. Those areas near the main processing equipment (primary shredder, secondary shredder, and air classifier) generally were between 90 and 95 dBA, and those areas outside the major machinery areas, but within the concrete containment walls, were between 85 and 90 dBA.

It should be noted that while many sections of the processing area were above 90 dBA (the OSHA limit), the employees are not stationed in any specific segment of the plant, but move freely about as their duties require. The personnel with the greatest potential exposure were the laborers working on the ground floor.

All measurements inside the processing area were taken on catwalks or on the ground floor level at approximately a 5-ft (1.5-m) elevation. Intermittent levels were recorded as a range, such as on the tipping floor area and near the primary shredder. No major impact influence was noted except for the primary shredder area where a separate study was conducted. General survey measurements are documented in Figures A-34 and A-35.

It might be expected that process area noise exposures would be significantly above 100% of the allowable dose. However, mobility of the workers about the area, coupled with their avoidance of long periods near the shredder or in other noisy equipment areas, appears to reduce their overall exposure below the current OSHA standard. However, it is still recommended that employees wear personal protective equipment (muffs or plugs) when in high noise areas to further ensure their safety. We were informed that this equipment was presently available to them.

A detailed noise study was conducted at an area designated as Station 1 in the process area. This position was selected since it was adjacent to the primary noise generation source of the plant. Station 1 is on a catwalk platform approximately 8 ft (2.4 m) south of the junction of the primary shredder and the magnetic separator conveyor (see Figure A-34). The noise level meter was positioned 4.5 ft (1.4 m) above the catwalk floor and 2 ft (0.6 m) from the east catwalk railing on a tripod.

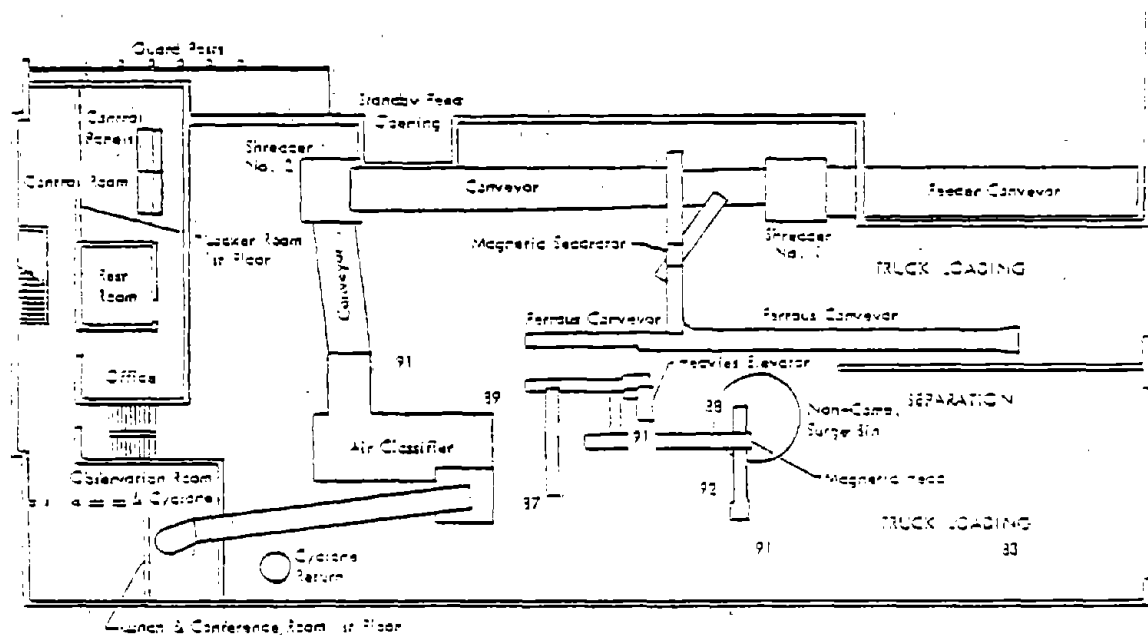
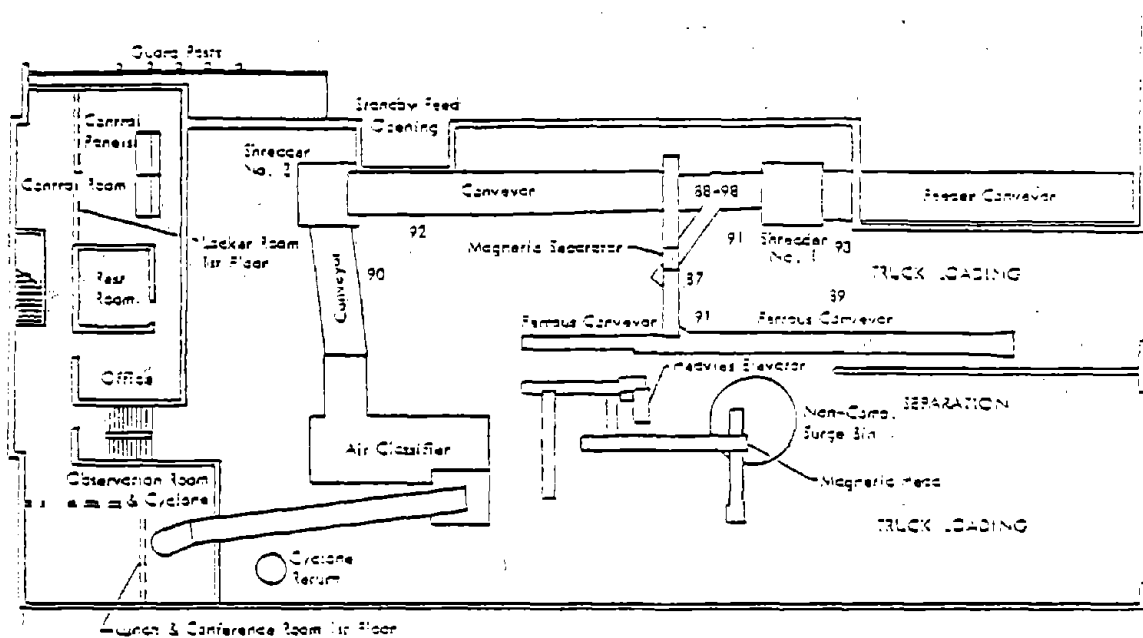


Figure A-34. Noise level readings on lower levels of Plant A
(elevation - 75 and 86 ft or 22.9 and 26.2 m)

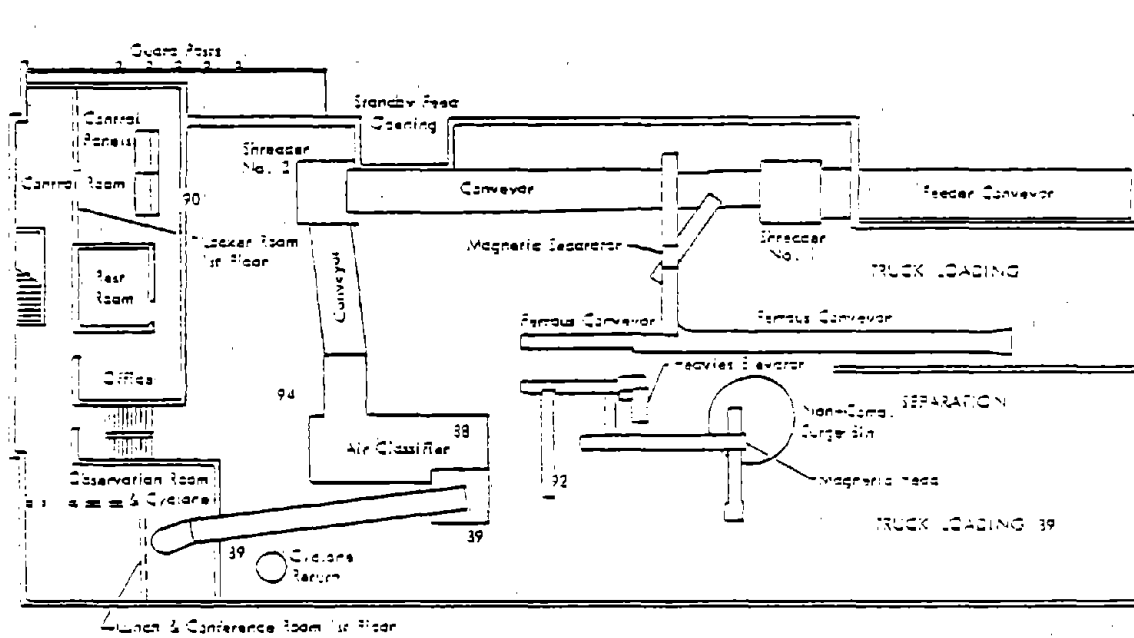
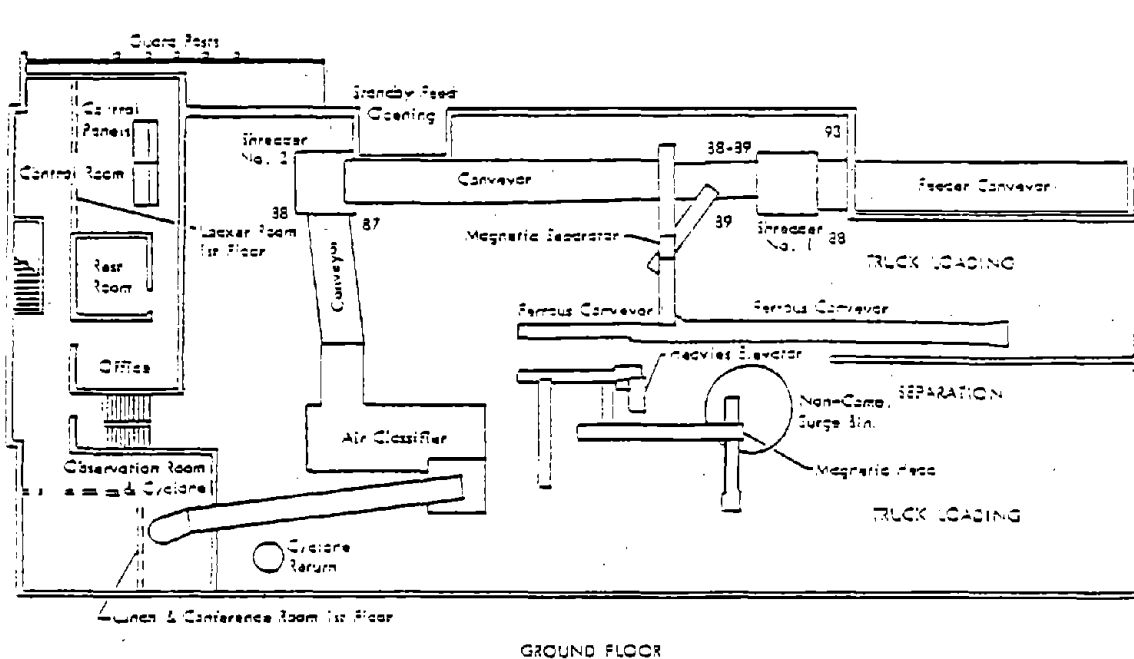


Figure A-35. Noise level readings on upper levels of Plant A
(elevations - 100 and 111 ft or 30.5 and 33.9 m)

Peak and impulse measurements were taken with a dust/windscreen in place on the microphone and a 10-dB attenuator attached. The meter was calibrated on-site (with the attenuator). The results are as follows:

Impulse - without material processing but shredder in operation:

107.7 dBA

Impulse - with material throughput: 115.4 dBA

Peak - with material throughput: 122.3 dBA

These results represent the maximum value over a 60-min (3.6-ks) trial. They may not completely reflect the maximums which may occur since these will be affected by the type of material processed by the shredder. When metal pieces or rigid bulky items enter the shredder, high levels of noise are generated. It should also be noted that these peaks are irregular and infrequent and thus probably do not represent significant contributions to the total noise levels. When the shredder was evaluated with the meter set at maximum function, the highest reading observed on a continuous basis was 98.5 dBA with an overall level at Station 1 (slow response) of 93 ± 2 dBA.

Octave band measurements were taken in two modes: as a mean value of three trials of 5 min (300 s) each with the meter function on maximum; and as a maximum value of those trials. Figure A-36 reflects the maximum noise levels obtained at 10 octave band center frequencies with a dBA correction shown, while Figure A-37 represents the mean values of all trials, and Figure A-38 are those values corrected for A weighting.

The significance of the octave band studies is the apparent major contribution of frequencies below 1,000 Hz and significant generation at the most damaging range of 1,000 to 4,000 Hz. These studies would imply low frequency vibration control to reduce noise generation of this equipment. In addition, it might be expected that ear protection in the form of ear muffs and/or plugs would provide adequate protection.

Plant B Results

The MRI survey team conducted noise monitoring at numerous plant locations during the course of the 3-day study. The survey consisted of three measurement techniques: sound level measurements throughout the facility, octave band analysis at the four highest noise level locations from the preceding measurement results, and personal dosimetry of selected at-risk employees. Background noise levels were also determined on the second day of the survey when the plant was not in operation.

On the first survey day, with the plant in operation, noise levels ranged from 85 to 96 dBA in the processing area. Noise levels on the plant floor were generally from 85 to 88 dBA, while levels above 90 dBA were measured near major equipment such as the air classifier, magnetic separator, and secondary shredder. It should be noted that while many sections of the processing area may be above 90 dBA, Plant B employees (with the exception of the picking station workers) are not stationed in any specific segment of the facility, but move freely about as their duties require.

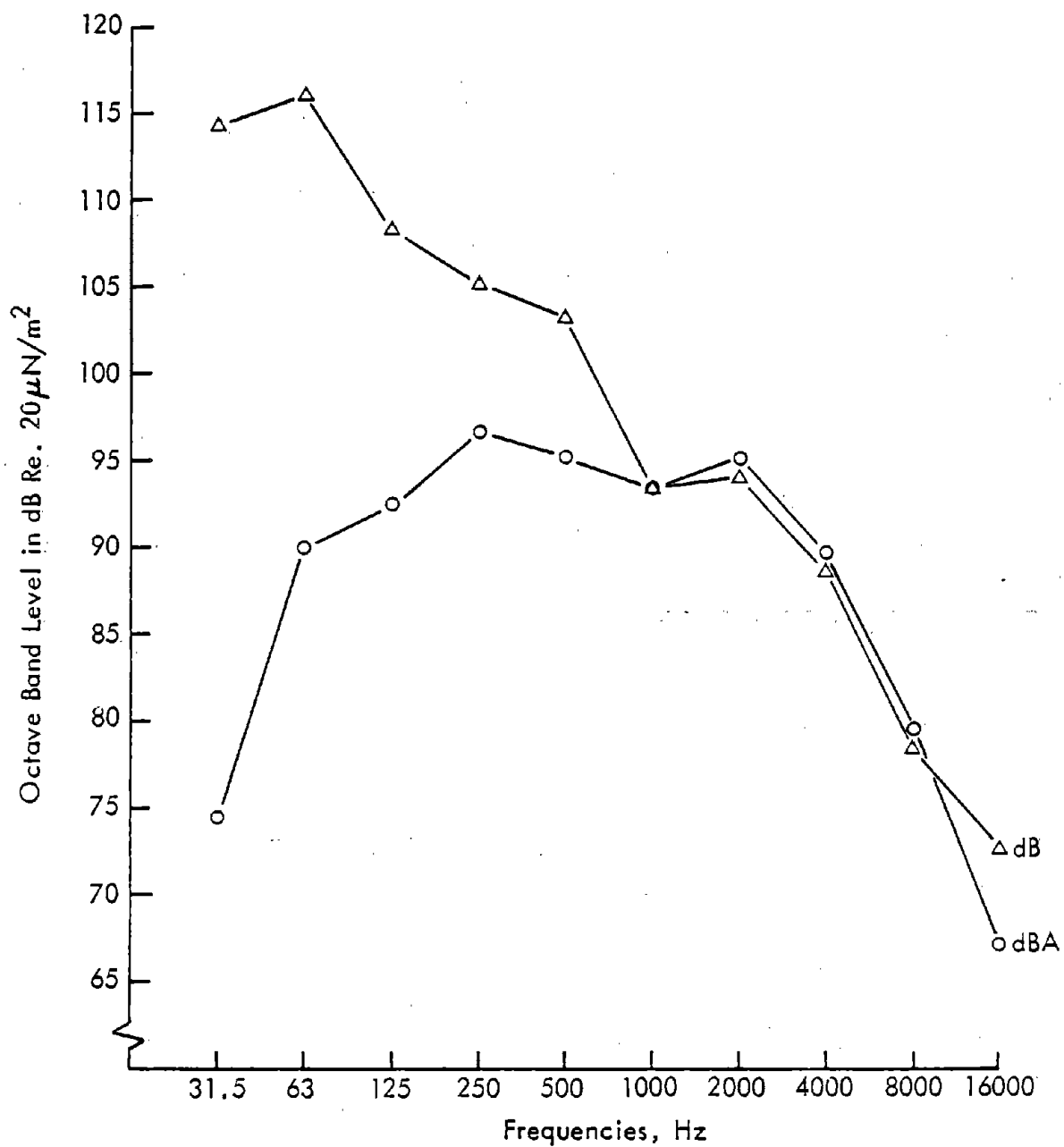


Figure A-36. Maximum noise levels for Plant A Station 1 at 10 octave band center frequencies.

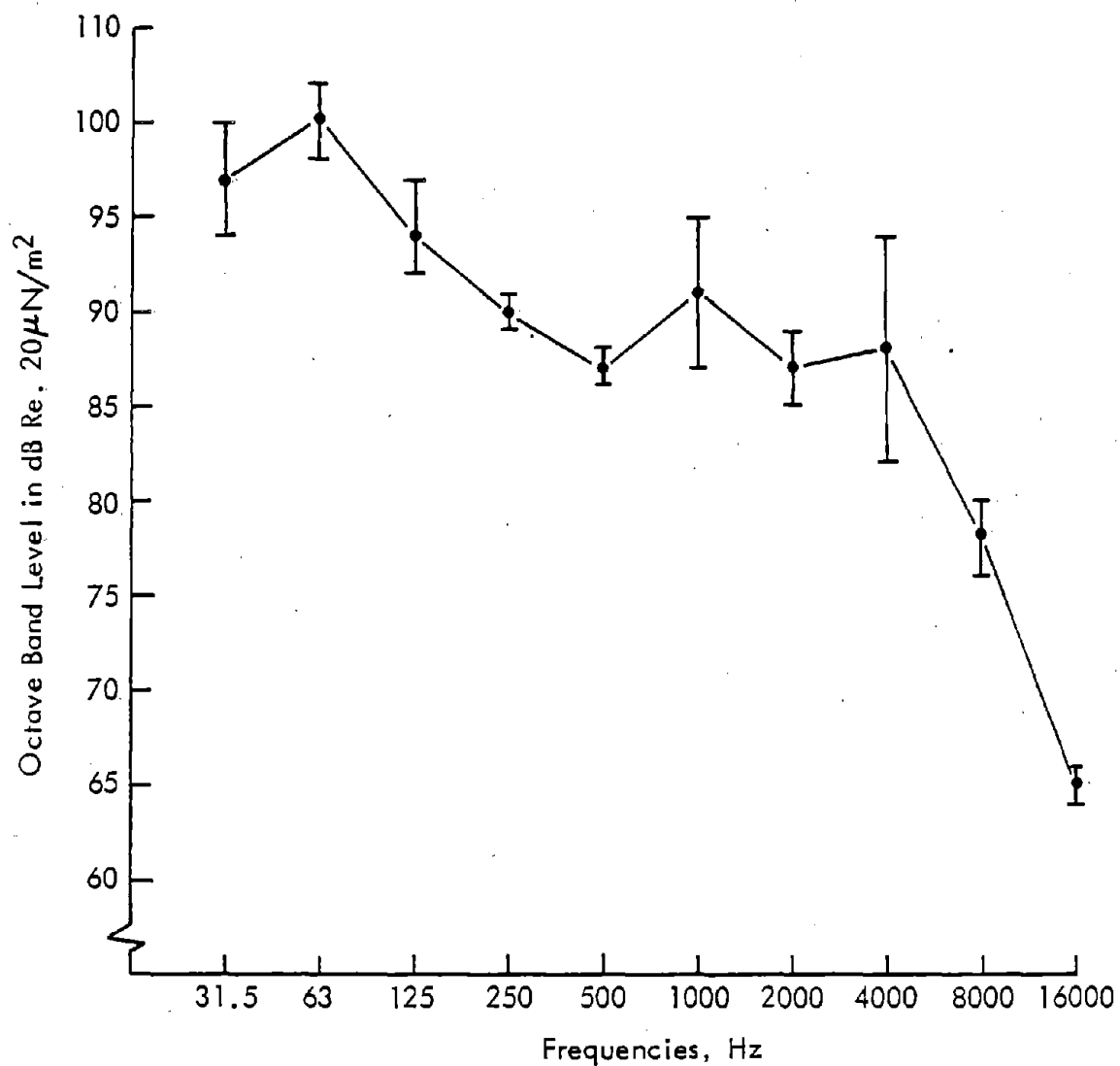


Figure A-37. Mean noise levels for Plant A Station 1 at 10 octave band center frequencies (5-min trials).

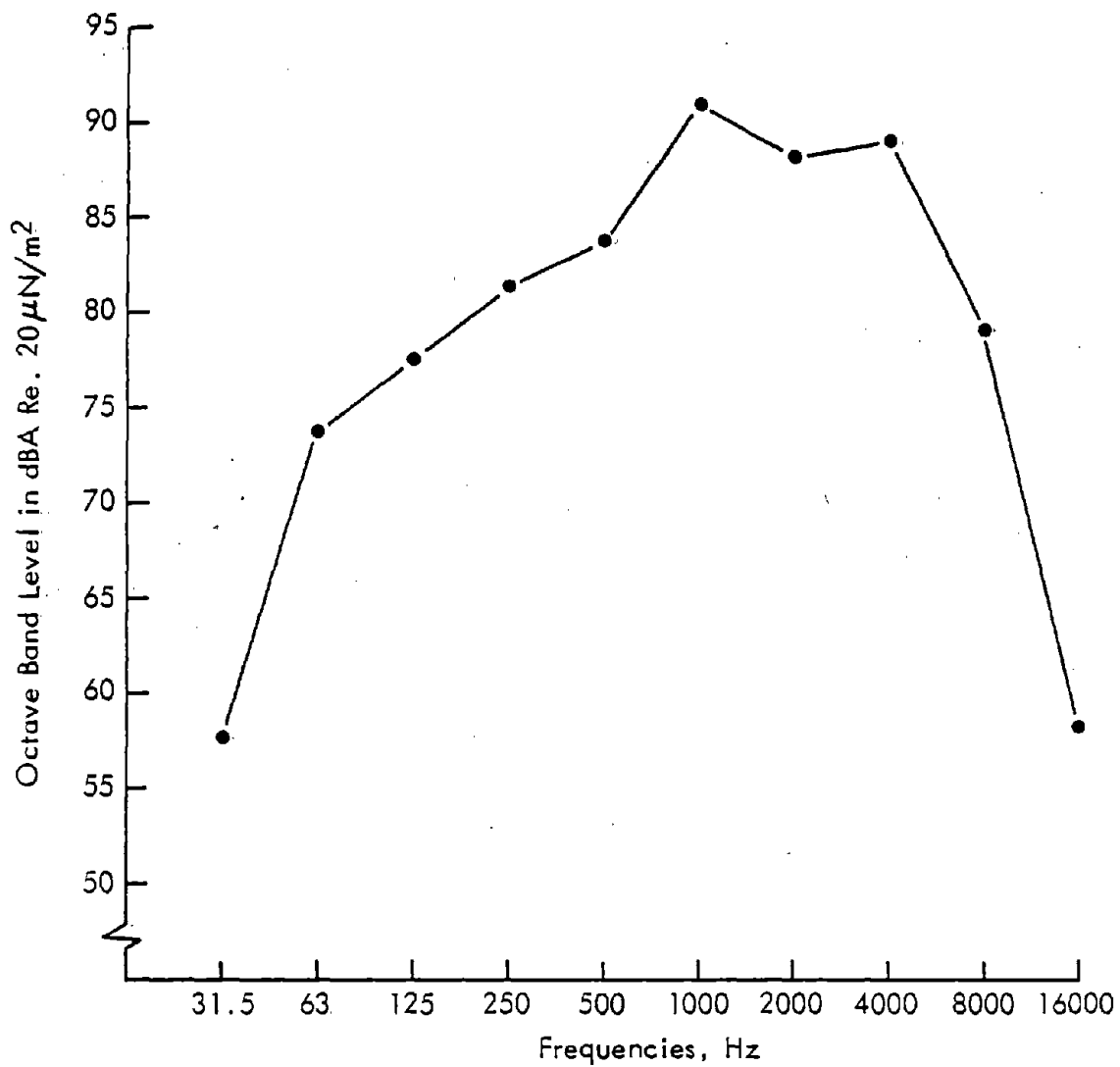


Figure A-38. Mean noise levels for Plant A Station 1 at 10 octave band center frequencies corrected to A weighting (5-min trials).

Average noise levels on the picking platform were 85 to 86 dBA during the measurement period on the first survey day. Noise levels at various locations are shown in Figure A-39. Values shown in parentheses are peak noise readings at locations where the peak values were more than 1 dBA greater than the average.

Sound level readings obtained on the third survey day (second day of plant operation) were very similar to those measured on the first day. The overall range was 83 to 95 dBA and on the main floor, 83 to 90 dBA. Levels at the picking station again averaged 85 to 86 dBA. Results from this part of the survey are shown in Figure A-40.

Background noise level measurements taken on the second survey day when the plant was not operating indicated a background range of 60 to 65 dBA. Readings up to 79 dBA were obtained at locations near operating air compressors in the plant.

Peak/impulse noise measurements were made near two particularly loud and fluctuating noise sources. A peak/impulse sound level of 123 dBA was recorded on the main floor directly in front of the air classifier (approximately 4 in. or 10.2 cm away) while near the ferrous metal separator discharge, the highest reading was 118 dBA.

During operation of the processing plant, two totally enclosed areas within the plant, the welding shed and the machine shop, had noise levels of 83 and 73 dBA, respectively. The machine shop and maintenance office is an area where many of the employees congregate when they are not in the processing area.

Personal noise dosimeters (B&K 4425) were worn by the front-end loader operator and five workers at the picking station during the 2 days of plant operation. Recorded doses are shown in Table A-34.

All readings obtained from the dosimeters worn by the pickers showed low daily noise exposures, ranging from 11 to 26% of the OSHA allowable dose. This finding was anticipated since no high noise sources are adjacent to the picking station and the workers are shielded from the noise of the shredders. However, in nearly every case, the 115-dBA ceiling was exceeded as noted by the upper limit warning light on each dosimeter. The cause of these excursions is not readily apparent and is somewhat confusing since the total noise doses were so low. It is possible that the plant's loudspeaker system could have briefly exceeded the 115-dBA level, since it must be loud enough to be heard above the high background noise levels (one speaker is located just above the picking station beneath the control room).

Even more unexpected were the noise doses recorded for the front-end loader operator, who sits in a heated, enclosed cab and should be reasonably sheltered from the noise of the front-end loader engine and that of the incoming trucks. The extremely high level measured on the first day (equivalent to a continuous exposure of 98.3 dBA) leads one to speculate that the dosimeter and microphone may have been tampered with.

Figure A-39. Plant B noise survey results: day 1.

[illegible]

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TABLE A-34. RESULTS OF PERSONNEL NOISE
DOSIMETRY--PLANT B

Job category	Percent of allowable dose ^a	
	1/28/80	1/30/81
Front-end loader operator	313 (98.3) ^b	149 (92.9)
Picker No. 1	19 (77.4)	16 (76.8)
Picker No. 2	11 (74.0)	-
Picker No. 3	20 (76.3)	-
Picker No. 4	-	19 (77.4)
Picker No. 5	-	26 (80.2)

^a Based on 90 dBA for 8 hr.

^b Values in parentheses are equivalent sound pressure levels.

The loader operator communicates with the control room supervisor via a two-way radio and such a noise level would severely restrict any such communication. It is also possible that vibrations from the loader's engine could have biased the reading. Nonetheless, it was our recommendation that the front loader operator be remonitored by the plant to determine the validity of the first measurement.

Evaluations of four of the noisiest plant areas were conducted using an octave band analyzer. The areas monitored included a location just outside the entrance to the employee locker room between two I.D. fans, a location next to an open-top truck being loaded with ferrous metal, the area just in front of an air classifier, and a location on the main floor adjacent to the picking station near the primary shredders.

Results of these measurements are displayed graphically in Figures A-41 through A-48. Readings were taken in two modes: as a mean value of 5-min observations at each band setting and as a peak value for each setting. Figures A-41, A-43, A-45, and A-47 represent the mean octave band readings, and Figures A-42, A-44, A-46, and A-48 show the peak readings obtained at 10 octave band center frequencies with a correction to "A" weighting.

The significance of the octave band studies is the apparent major contribution of frequencies below 1,000 Hz and the significance of the noise levels in the range of 1,000 to 4,000 Hz after correction to the dBA scale. Thus, low frequency vibration control would be essential to reduce the overall noise generation of this equipment, and some form of ear protection would be desirable for employees working in these areas.

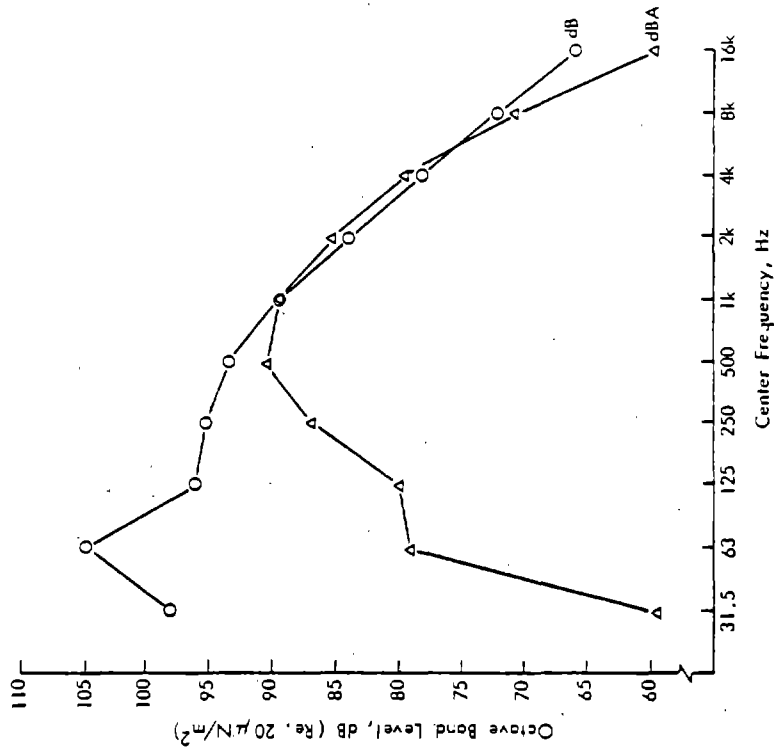


Figure A-42. Maximum noise levels near the Plant B picking station at 10 octave band center frequencies.

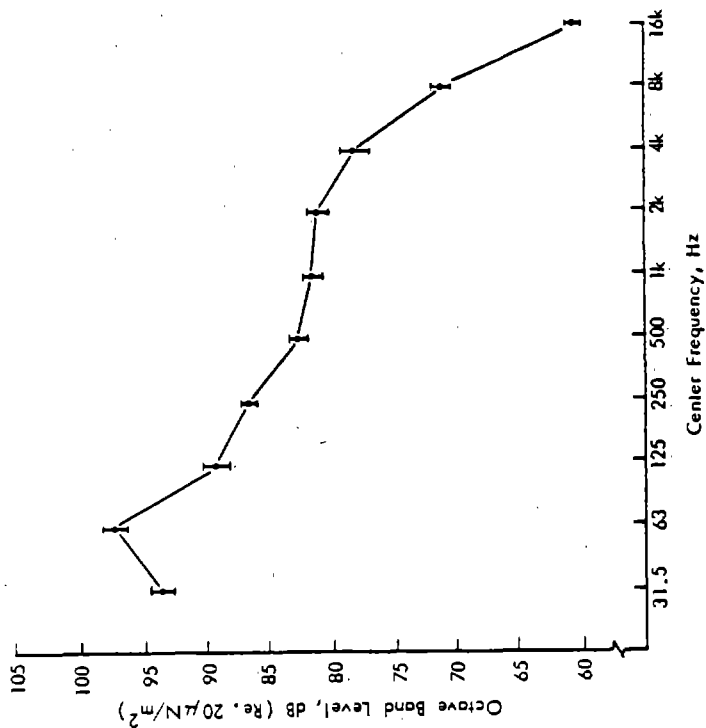


Figure A-41. Mean noise levels near the Plant B picking station at 10 octave band center frequencies.

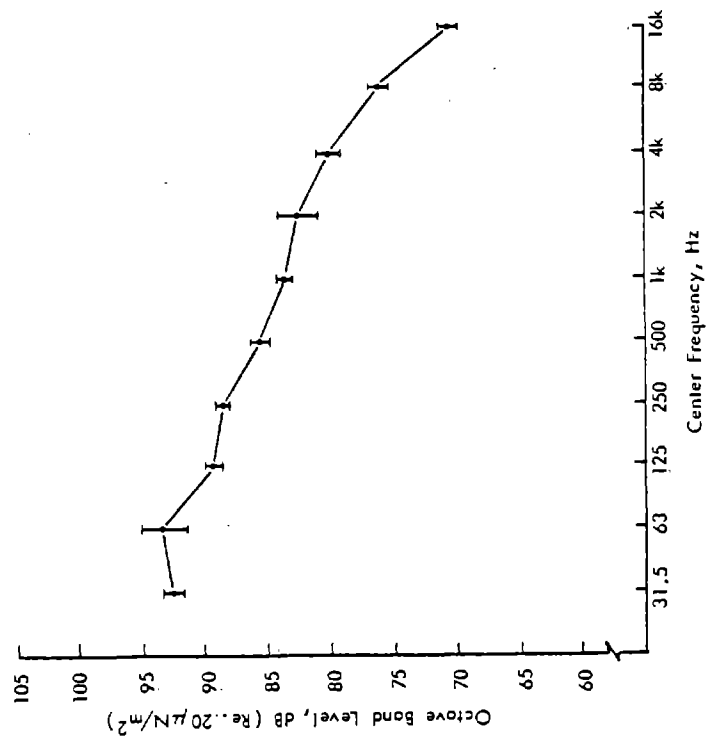


Figure A-43. Mean noise levels near the Plant B air classifier at 10 octave band center frequencies.

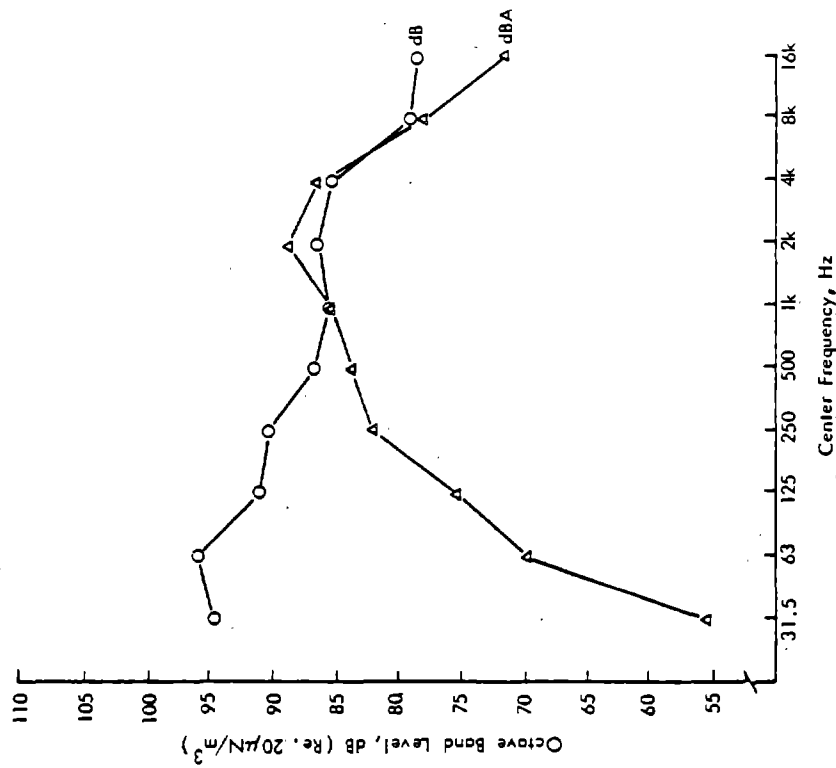


Figure A-44. Maximum noise levels near the Plant B air classifier at 10 octave band center frequencies.

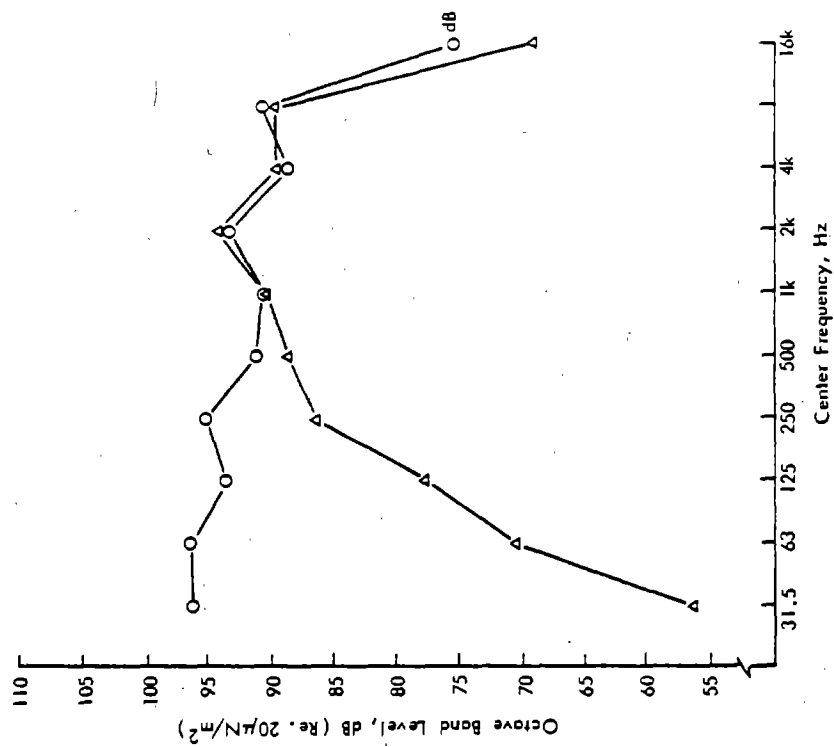


Figure A-46. Maximum noise levels at Plant B near ferrous metal load-out truck at 10 octave band center frequencies.

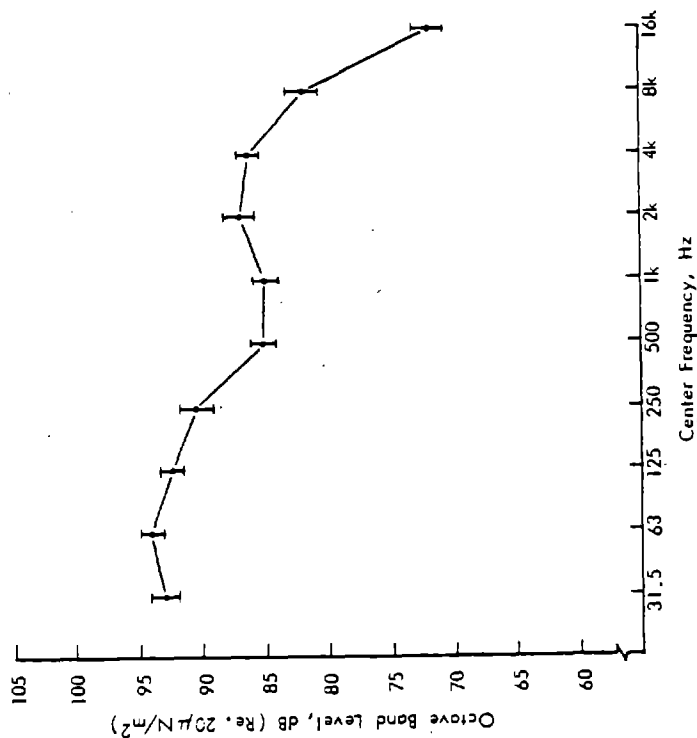


Figure A-45. Mean noise levels at Plant B near ferrous metal load-out truck at 10 octave band center frequencies.

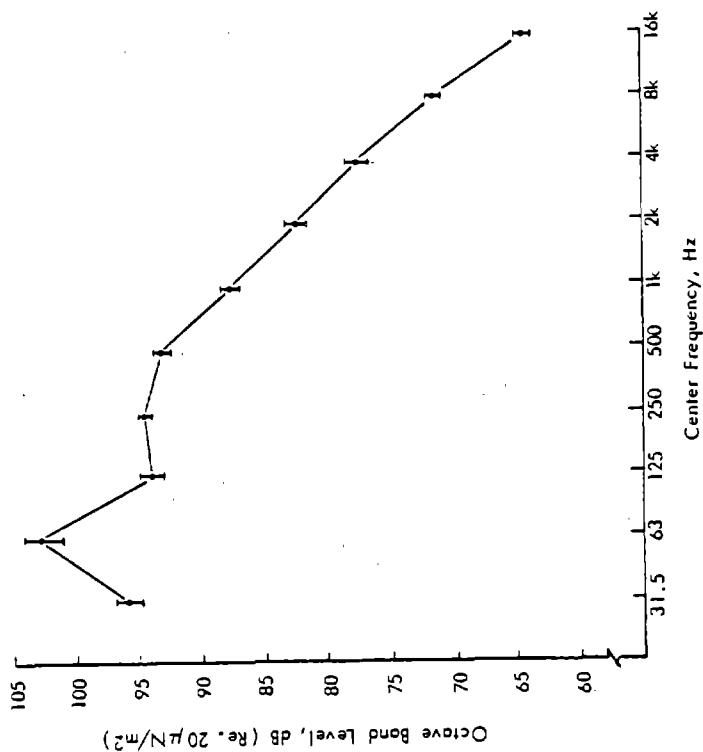


Figure A-47. Mean noise levels at Plant B baghouse exhaust stack at 10 octave band center frequencies.

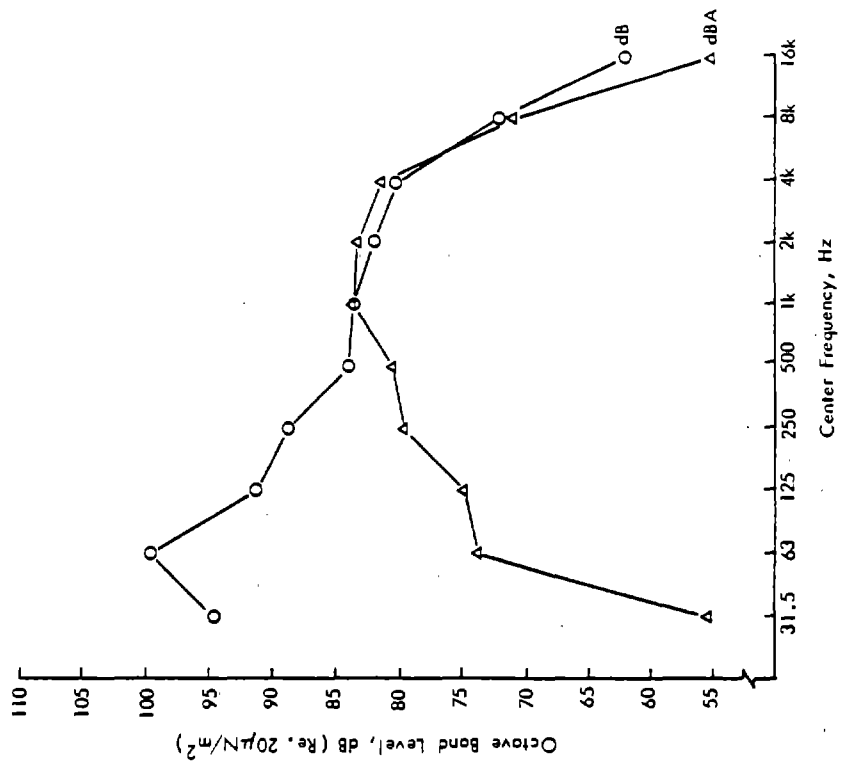


Figure A-48. Maximum noise levels near Plant B baghouse exhaust stack at 10 octave band center frequencies.

Plant C Results

Noise levels throughout Plant C were determined on two separate days of the MRI survey. A wide range of readings (70 to 100 dBA) were recorded, reflecting heavy equipment and nonequipment areas of the facility. Individual readings are shown in Figure A-49.

The highest continuous sound levels were recorded in the shredder area. Readings there consistently ranged from 96 to 98 dBA. The receiving pit area yielded ratings of up to 100 dBA but were the result of noise produced by incoming garbage trucks and thus were intermittent. Other readings at Plant C were primarily between 80 and 90 dBA.

Peak noise measurements were made near two particularly loud and fluctuating noise sources. A peak sound level of 119 dBA was recorded approximately 10 ft (3 m) from the south shredder while under load, and a level of 105 dBA was measured near the pelletizer in the fuel processing area.

To ascertain actual employee noise exposures, personal dosimeters (B&K 4425) were worn by workers in each major area of the plant, including the scale house. Results are presented in Table A-35.

Dosimetry readings did not indicate any overexposed personnel based on the OSHA standard. Worker exposures are moderated by the fact that the employees do not have stationary work locations, but move about the plant according to their duties and have opportunities to take breaks in the control rooms, locker rooms, shop, etc., where there is negligible noise exposure.

An evaluation of two primary noise sources, a shredder and the fuel pelletizer was conducted using an octave band analyzer. Readings were taken in two modes: as a mean value of 5-min (300-s) observations at each band setting and as the peak value for each setting.

Results of these measurements are presented graphically in Figures A-50 through A-53. Figures A-50 and A-51 shown both the mean and maximum readings obtained near the shredder, while Figures A-52 and A-53 show only the mean octave band readings.

Each noise source evaluation showed a major noise contribution in the frequencies below 1,000 Hz, the result of heavy equipment vibration. This is shown in Figure A-50 where the maximum readings have been corrected for "A" weighting. Thus, there is a component of this noise source which is potentially harmful to the human ear.

Plant E Results

Average noise levels throughout the plant were measured with a handheld General Radio sound level meter on the second day of the MRI survey. Readings were taken in all major areas of concern. Results are presented in the diagram shown in Figure A-54.

TABLE A-35. RESULTS OF PERSONNEL NOISE DOSIMETRY-PLANT C

Job category	3/25/80		3/26/80	
	Percent allowable dose ^a	Calculated equivalent SPL	Percent allowable dose ^b	Calculated equivalent SPL
Weighmaster. (scalehouse)	2	-	-	-
Shredder operator (control pod)	3	-	-	-
Utility person (push pit area)	-	-	13	73.5
Shredder (area)	50	85.0	45	84.2
Staging/loading operator	36	82.5	27	80.4
Control room fuel process	-	-	0	-
Pelletizer operator/ maintenance	-	-	71 ^b	87.5 ^b
Packer operator fuel process	38	83.2	-	-

^a Based on 90 dBA for 8 hr.

^b 5-hr sampling time; not a TWA.

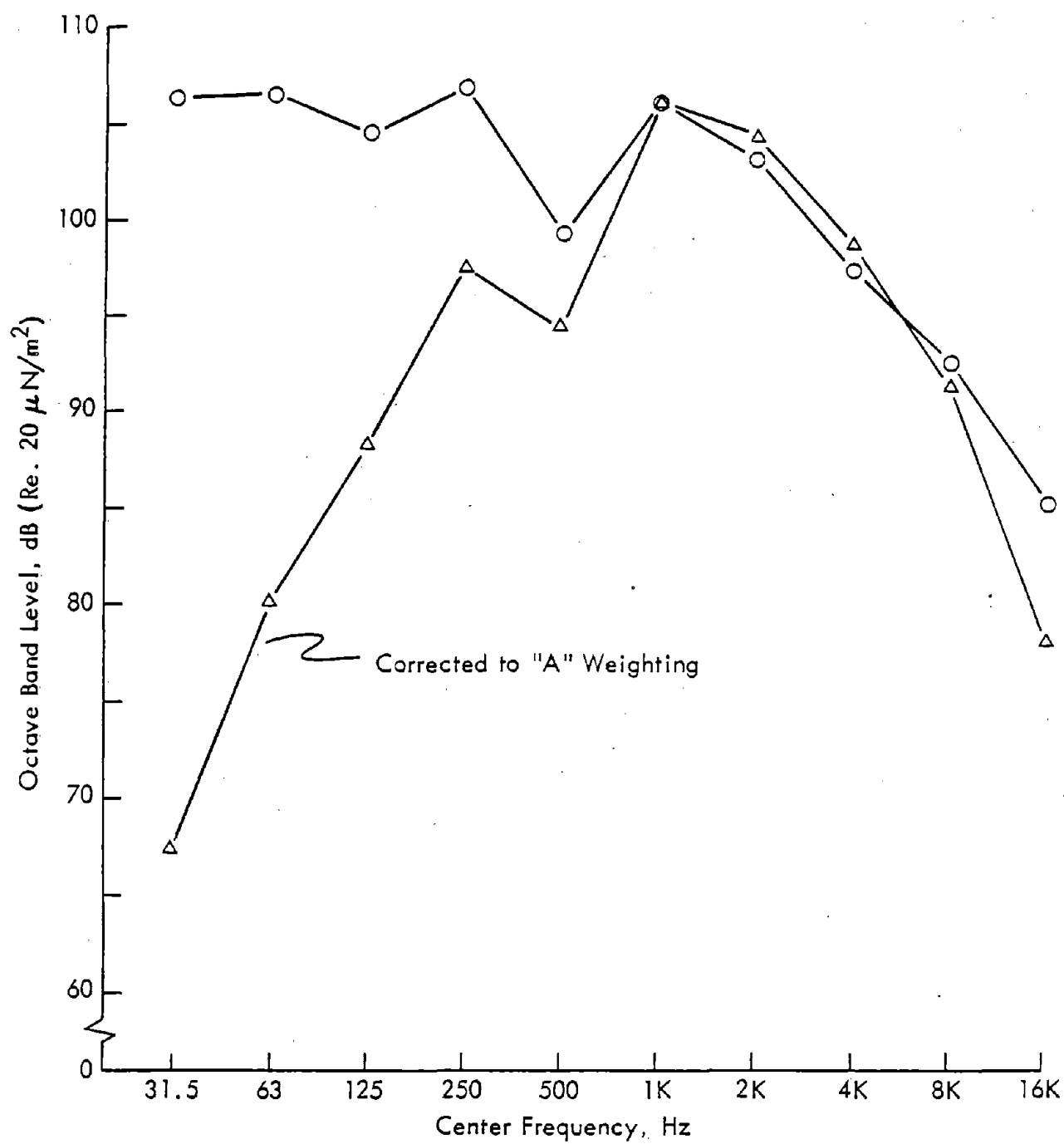


Figure A-50. Maximum noise levels near Plant C shredder at 10 octave band center frequencies.

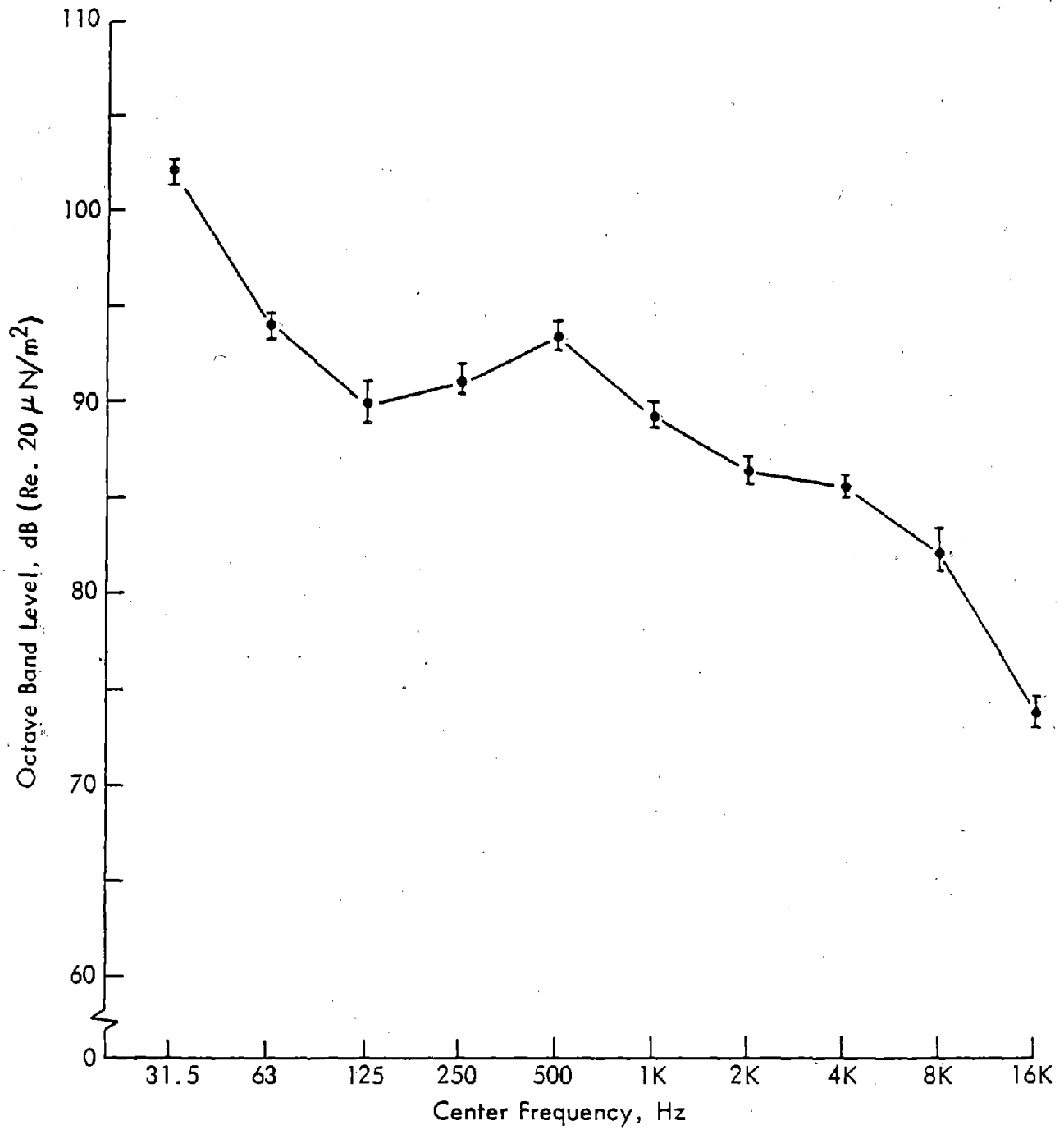


Figure A-51. Mean noise levels near Plant C secondary shredder in fuel process area at 10 octave band center frequencies.

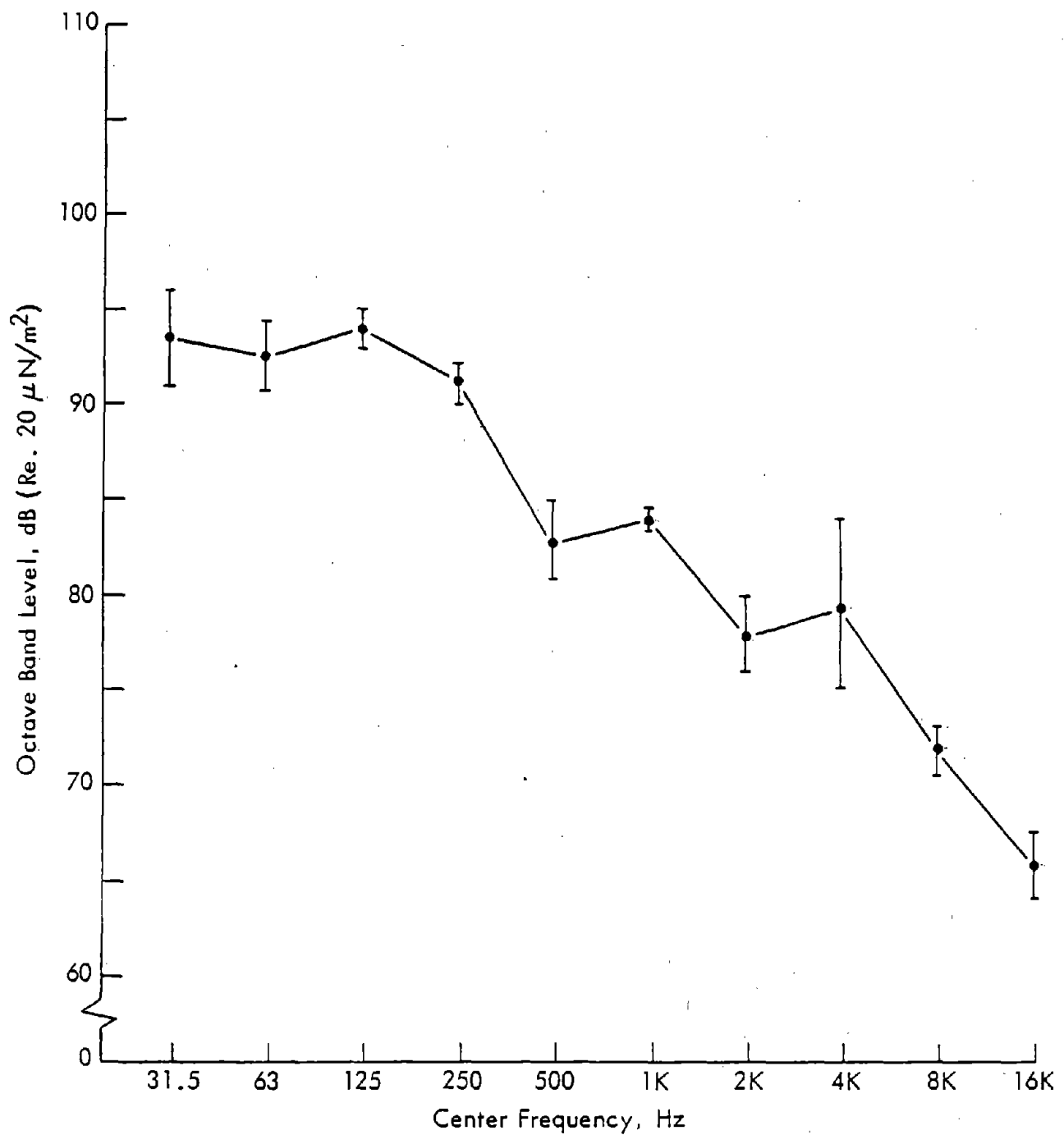


Figure A-53. Mean noise levels near Plant C shredder at 10 octave band center frequencies.

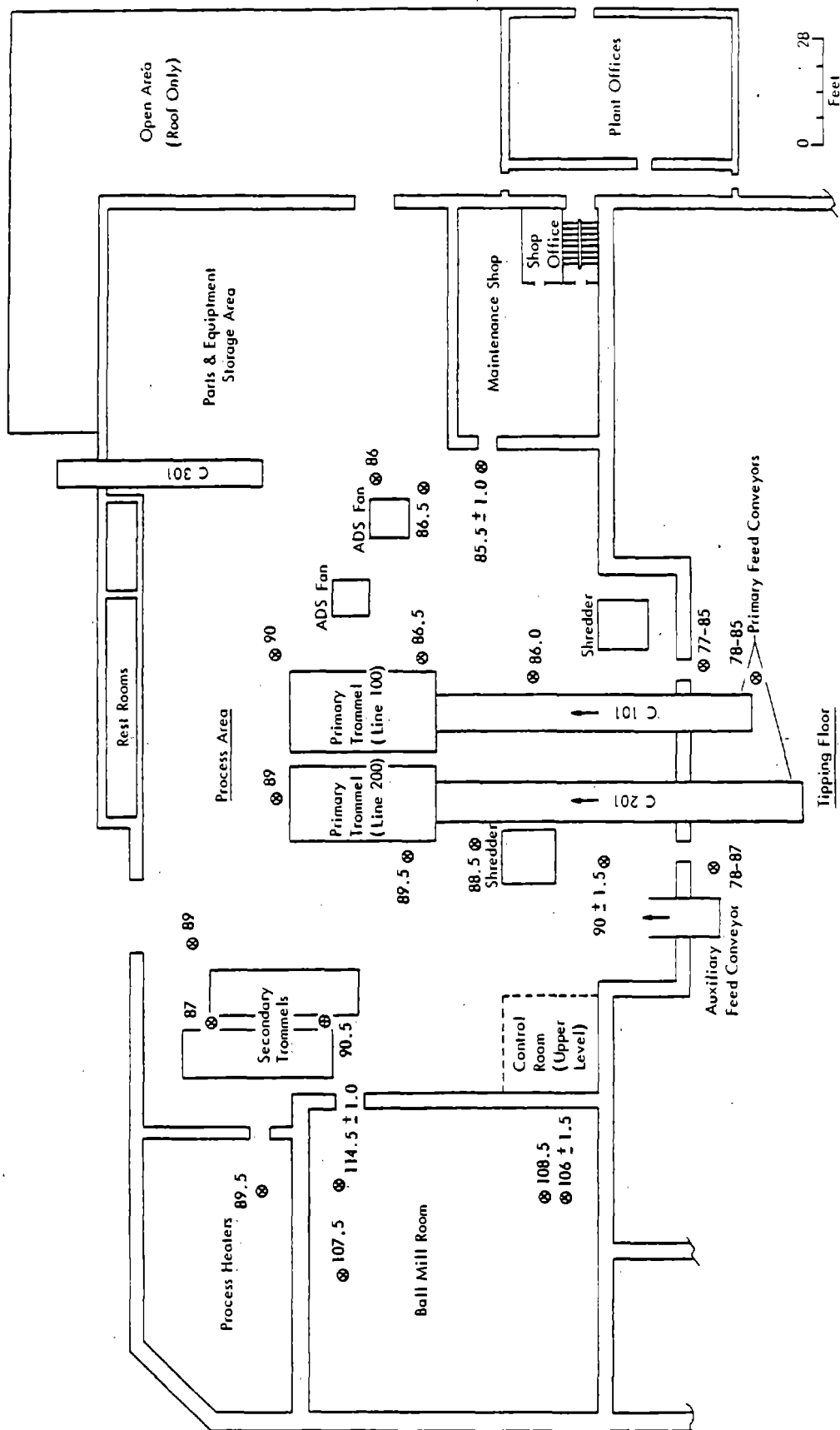


Figure A-54. Results of Plant E area noise survey (readings in dBA).

In the tipping floor area, noise levels varied from 77 to 87 dBA, depending upon the movement of the single payloader operating at the time. No other noise sources were present in the area during the measurements. The operation of a second payloader and the activity of refuse trucks unloading from the truck balcony would raise the average noise levels on the tipping floor above those determined by the survey team. This would likely be the situation when Plant E operates at closer to full capacity.

In the processing area, sound level readings of 86 to 90.5 dBA were obtained. No single segment of the area was significantly worse than the rest, although certain locations near particularly noisy pieces of equipment (e.g., shredder) yielded the highest readings. It should be noted that sound level readings were taken only on the ground floor. No attempt was made to measure noise at any of the elevated catwalk locations since workers normally remained on the ground level.

By far the highest noise levels were measured in the ball mill room. Readings within this area were consistently above 100 dBA, and peaked at 116 dBA. However, the ball mill room is a special restricted area and is segregated from the rest of the facility. According to the plant safety manager, entry to this area requires hearing protection and special permission from the plant control room personnel. Noise levels were determined at both the discharge end (106 ± 1.5 dBA) and at the feed end (114.5 ± 1.0 dBA) of the one operating ball mill (on the middle elevation catwalk). A reading was also taken on the lower level of the room where the balls are discharged from the mill into a bucket elevator (108.5 dBA).

The actual noise exposures of the workers at Plant E differ from the general area noise levels since their job activities require movement within and outside the facility. To determine their actual noise dosages, personal noise dosimeters were worn by several employees for their full work shift during the survey. Results of this monitoring are shown in Table A-36.

Of the eight workers monitored, three had noise exposures in excess of the OSHA limitation of 90 dBA for 8 hr. However, two of the employees, the payloader operator and the ball mill room operator, wore ear muffs with two-way radio headsets incorporated into them. The third employee, a utility worker, was not observed to be wearing a hearing protection device. The other five employees were exposed to noise dosages ranging from 86.4 to 89.8 dBA (cumulative).

The plant experienced extended downtime periods coupled with erratic production which precluded octave band analysis of the major noise producing equipment.

The next section describes the process and sampling results from the incineration facilities.

TABLE A-36. RESULTS OF PERSONNEL NOISE DOSIMETRY--PLANT E

Job category	Cumulative exposure ^a dBA	
	9/16/80	9/17/80
Payloader operator	90.9	89.5
Ball mill room operator		99.5
Picker	86.4	
Picker	88.5	
Utility	89.5	
Utility	86.9	
Utility		92.3
Utility		89.8

^a As recorded by Metrosonics, Model 301 dosimeters.

APPENDIX B

INCINERATION FACILITIES

The following subsections detail plant operations, personnel descriptions, and survey results. The survey results are presented for general air contaminants, microbiological aerosols, and noise exposures at plants designated as D and G, both "mass burn," waterwall incineration facilities.

DESCRIPTION OF PLANT OPERATIONS AND PERSONNEL

Plant D Facilities

Plant D is a privately owned and operated resource recovery facility which has been in operation since November 1975. It converts residential, commercial, and industrial solid wastes into process steam, recyclable ferrous metal, and a residual ash. Full capacity of the facility is 1,200 tons (1,088 Mg) per day (tpd). The plant has entered into long-term, base tonnage arrangements with many of the surrounding municipalities and accepts all types of solid waste except hazardous materials and unusually large or heavy objects. This facility has operated very successfully and consistently since start-up and is established as one of the industry's most reliable systems. A schematic diagram of the process at Plant D is shown in Figure B-1.

Incoming refuse trucks first stop at the entrance weigh station to determine their disposal charges and then proceed to the tipping area. There are 16 dumping bays on the tipping floor along the face of a 200- by 40-ft (61- by 12-m) refuse pit. Normal storage capacity is about 2,700 tons (2,449 Mg), or enough to maintain incinerator operation for approximately 2-1/2 days. Since the back wall of the refuse pit is 85 ft (26 m) high, refuse can be stored above the level of the tipping floor to give a maximum storage capacity of about 6,700 tons (6,078 Mg).

Two overhead traveling cranes with tine-type grapples are used to mix and stockpile the refuse and also to feed each furnace. Each crane bucket can lift up to 3 tons (2.7 Mg) of refuse per bite. The cranes are equipped with air-conditioned cabs for operator protection and comfort. Material is lifted from the pit and over the high back wall to the furnace feed hoppers located on the charging floor. A relatively constant level of refuse is maintained in the hoppers, creating a seal so the proper furnace draft is maintained and also preventing flame flashbacks. An electronic monitor installed on each hopper sounds a warning to the crane operator should the refuse level fall to a critically low point.

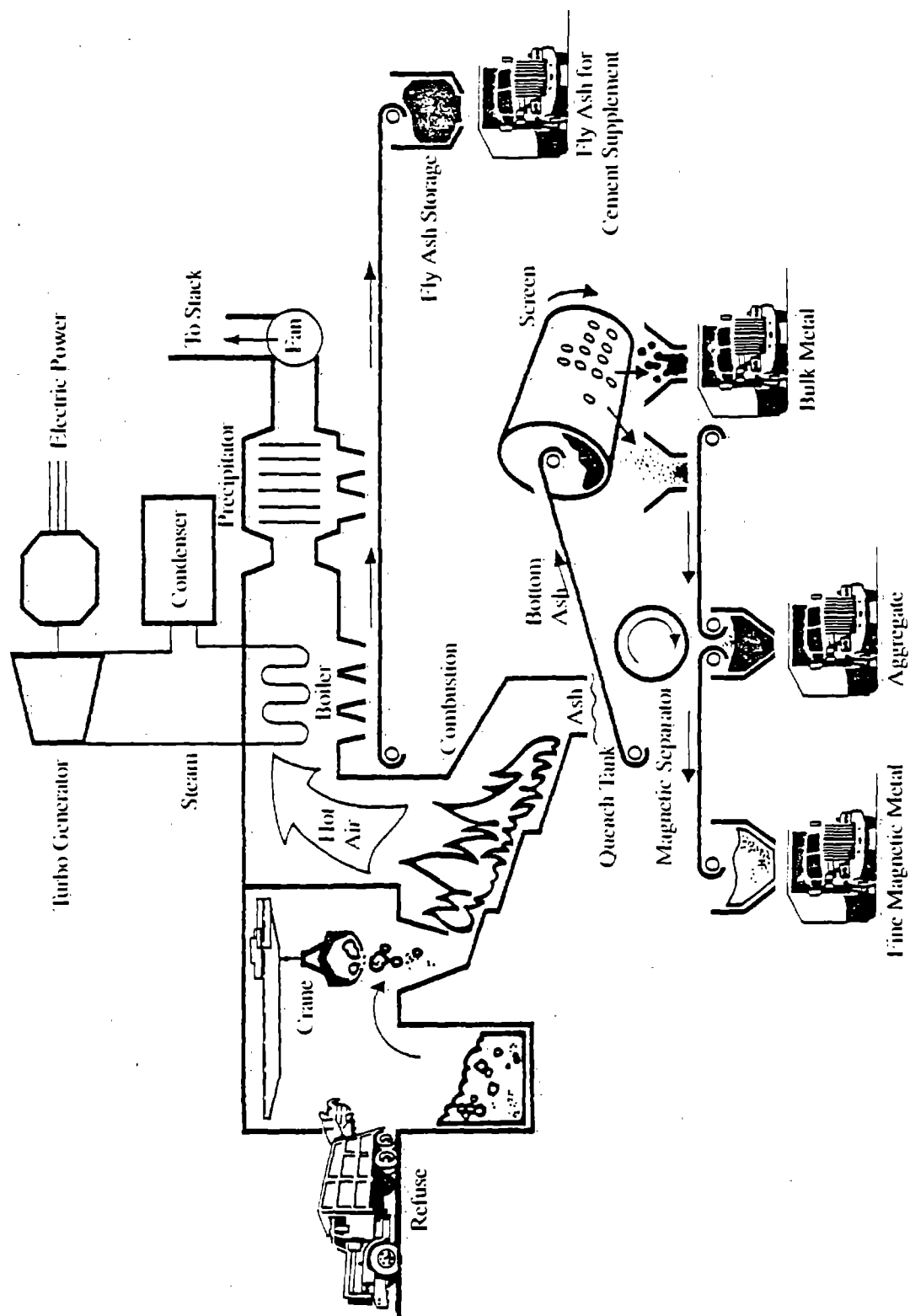


Figure B-1. Plant D process flow diagram.

The two 750-tpd (680 Mg/d) incinerators are capable of producing 185,000 lb/hr of 690 psig (4,757 kPa), 875°F (468°C) steam each. Full load operation is currently about 600 tpd (544 Mg/d), with a resulting steam output of 150,000 to 175,000 lb/hr. To ensure that steam production is always available, two water-tube package boilers are available as back-up. Supplemental oil burners are located in each refuse incinerator but are used only for start-up purposes.

Each furnace has a three-section, inclined, reciprocating grate system. Refuse entering the incinerator from the feed hopper is first deposited on the feed grate, where it dries and the combustion process starts. The burning refuse then drops onto the second grate, where combustion is nearly completed. This is accomplished through the reciprocating action of the grate which tumbles the refuse and moves it down the incline. Final burnout occurs on the last grate section, and the remaining noncombustible ash is discharged into a water-sealed hopper for quenching and subsequent removal.

Primary combustion air is supplied through underfire ports located in the lower two grate sections. The intake for the forced draft fan which supplies this air is located on the charging floor near the furnace feed hoppers. Secondary air is introduced above the grates through overfire ports located on the front and back walls of the combustion chamber. The boilers are operated under a slight negative pressure and the air velocity through each unit is about 3 to 4 ft/sec (0.9 to 1.2 m/s).

Hot gases generated by combustion of the refuse pass by boiler tubes arranged in three sections: a steam superheater section, a steam production section, and an economizer section. This tube panel design allows a mechanical rapping system to be used for cleaning the tubes rather than a conventional soot-blowing arrangement; this results in cleaner tubes and better heat transfer. After leaving the economizer section, the combustion gases pass through a Wheelabrator-Lurgi electrostatic precipitator (ESP) for removal of particulate matter. These units are designed with a removal efficiency of 97.5%. An induced draft fan discharges the cleaned gases through a 178-ft (54-m) concrete common stack.

Bottom ash from the quench troughs beneath the boilers is removed by drag conveyor to an ash-handling system located adjacent to the main building. The ash is first processed through a rotating drum (trommel) screen to remove bulky items (mostly metal), and the undersized material is then passed beneath a magnetic drum to remove ferrous metal. The remaining material is landfilled. One complete ash-handling system is provided for each quench trough. Captured fly ash from the hoppers beneath the boiler tube sections and the ESP is conveyed to a separate storage bin and later sold as a cement supplement.

In addition to the main facility, auxiliary structures on the plant grounds include two small buildings which house the boiler feed water treatment system, the semienclosed ash-handling system, an office building, and the weigh station booth. The main building has five distinct levels, each separated by concrete floors. The plant's control room as well as the employees'

locker and shower room and lunch room are located on the second level. Supervisory offices are also located on this level. The machine shop and stock room are on the bottom level beneath the offices and locker room.

The tipping floor is partially sheltered by an extended overhang, but the dumping bays do not have overhead doors to enclose the refuse pit during nonoperating periods or inclement weather.

Plant Personnel

Employees at Plant D are organized into four basic categories: operations, maintenance, general labor and administrative. Sixty-one of the total staff are involved in operation and maintenance of the plant, and the remaining 10 are administrative personnel. The specific job classifications for these workers are shown in Table B-1. According to the plant management, employee turnover rates are very low, averaging about 2 to 3% per year.

Approximately seven key operations personnel are assigned to each work shift to maintain plant operations. Shift times for these workers are 7 AM to 3 PM, 3 PM to 11 PM, and 11 PM to 7 AM. All other employees, including management, maintenance, general labor, and administrative, work from 7 AM to 3:30 PM. Most job classifications do not require personnel to remain in the process areas for the majority of the work shift. Exceptions are general laborers who are assigned to cleanup duties and maintenance workers solving major equipment problems. The other employees may spend significant portions of their daily work time in the control room, maintenance shop, locker room, lunch room, or offices.

Plant G Facilities

Plant G is a mass-burn incineration facility which began operations in 1971. This municipally owned and operated system processes about 20% of the city's residential solid waste, with outputs of steam, metal fragments, and residual ash. The facility houses four 400-tpd (363 Mg/d) refuse burning units that represent a total capacity of 1,600 tpd (1,452 Mg/d). However, one boiler is usually off-line for scheduled maintenance at any given time, so that the plant normally functions at a 1,200-tpd (1,089 Mg/d) capacity. Each boiler produces an average of about 2 million lb of steam per 24-hr period. Plant G operates 24hr/day, 7 days/week. A section view illustrating the location of equipment is shown in Figure B-2.

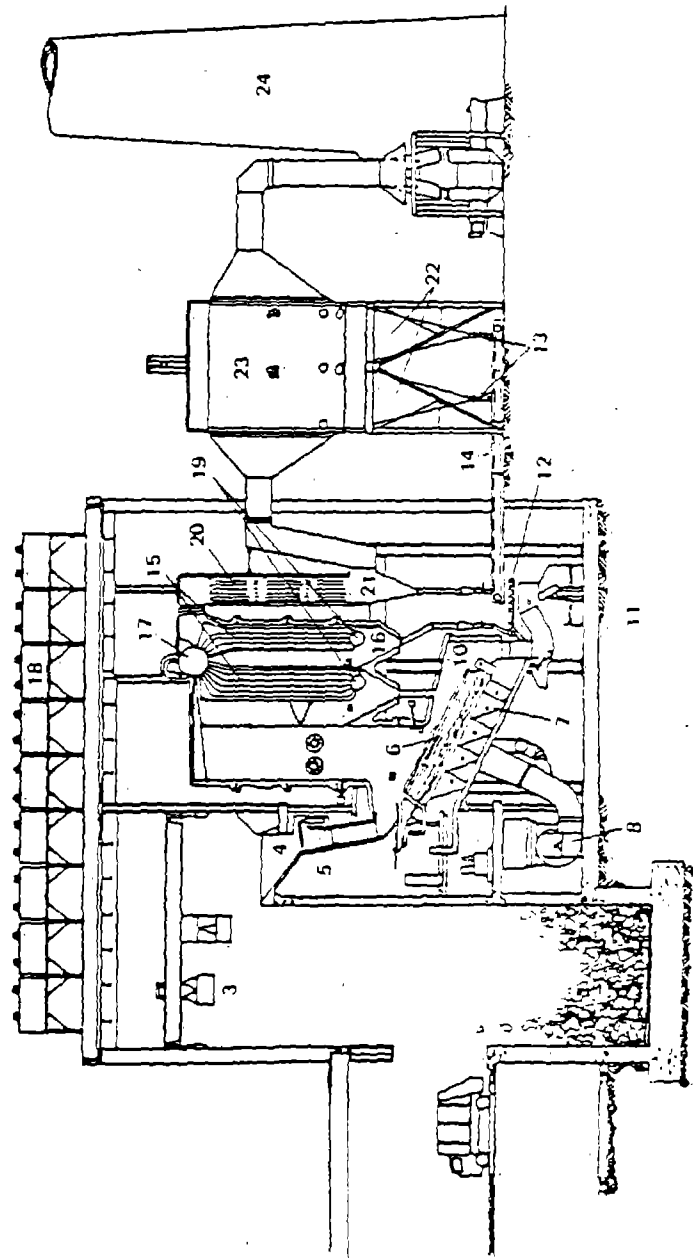
Municipal waste is delivered to the plant by city collection vehicles and is dumped into a 2,000-ton (1,814-Mg) (9,700-cu yd or 7,416 m³) capacity pit. Three overhead cranes are available to stockpile the refuse at the ends of the pit and to feed the operating furnaces. Typically, only one or two cranes are needed to do this. Each furnace feed hopper is equipped with a hydraulically operated damper plate that can be closed when the unit is out of service to prevent air infiltration. During operation, the level of refuse is kept sufficient to form an air seal across the feed chute. The length of this chute between the hopper and the furnace is water cooled to protect it in the event of a back-draft and flame flashbacks.

TABLE B-1. PLANT D WORKER CLASSIFICATIONS

Category	Job classification	No.
Operations	Chief engineer	1
	Assistant chief engineer	1
	Shift supervisor	4
	Boiler operators	4
	Boiler operator assistant	8
	Furnace feeder	8
	Ash-handling operator	4
	Water treatment technician	1
Maintenance	Plant engineer	1
	Maintenance superintendent	1
	Pipefitter	1
	Assistant pipefitter	1
	Electrician	2
	Apprentice electrician	1
	Mechanic	2
	Mechanic's helper	1
	Plant oiler	1
	Maintenance fireman	1
	Welder	2
	Instrument contractor	1
General labor	Labor supervisor	1
	Traffic controller	1
	Carpenter	1
	Laborer	12
Administration	General manager	1
	Controller	1
	Accountant	1
	Secretary	1
	Secretary/payroll	1
	Revenue clerk	1
	Scale operator	2
	Buyer	1
	Stock clerk	1
Total		71

INCINERATOR EQUIPMENT

1. DUMPING AREA	13. AUTOMATIC ROTARY VALVES FOR FLY ASH
2. STORAGE PIT	14. FLY ASH CONVEYOR
3. REUSE CHANES	15. MEMBRANE WATER WALLS
4. FEED HOPPER	16. BOILER HOPPERS
5. WATER COOLED FUEL CIRCUIT	17. STEAM DRUMS
6. STOKER GRATE AREA	18. AIR COOLED CONDENSERS
7. UNDERFIRE GRATE AIR PLENUMS MS	19. MUD DRUM
8. FORCED DRAFT FAN	20. ECONOMIZER
9. AUTOMATIC SIFTINGS REMOVAL SYSTEM	21. ECONOMIZER HOPPER
10. RESIDUE DISCHARGE ROLLER	22. FLY ASH HOPPER
11. ASH DISCHARGER	23. ELECTRIC PRECIPITATOR
12. RESIDUE CONVEYORS	24. STACK



Source JACKSON, 1974.

Figure B-2. Section view, location of equipment Plant G.

Once the refuse material reaches the bottom of the feed chute, it is pushed onto the combustion grate by hydraulic rams. The reverse-reciprocating stoker grate tumbles and mixes the refuse as it progresses down the incline, providing slots for the underfire combustion air to supply the bed of burning material. This combined action produces an effective burnout of 95 to 96%. The residence time of refuse in the combustion zone is about 1 hr. Unburned material (residual ash) is discharged at the end of the grate into a quench trough, which forms a water seal at the base of the discharge chute. The ash is continually removed from the quench section by a drag chain conveyor and deposited onto a long pan conveyor leading to the ash house. There, large fragments of metal are separated from the finer ash by means of a trommel screen. The ash is temporarily stored and then sent to a private landfill. Metals are either sold immediately or stored for later sale.

Combustion gases from the furnace section pass over the waterwalls surrounding the upper combustion zone and the boiler tubes, producing an average of approximately 84,000 lb of steam per hour. A portion of the steam is utilized within the plant, some is sold to a nearby industrial user, and the remainder is condensed by units located on the roof. After the gases pass through the boiler section, they are routed through an economizer for further heat extraction and then enter an ESP for particulate removal. Each ESP is designed to operate at 97% removal efficiency for 110,000 acfm (153,886 m³/sec) at 450°F (232°C). A common exhaust stack is provided for each pair of ESPs. Fly ash collected by the ESP is conveyed to the bottom ash quench and is combined into one waste stream.

Table B-2 presents a summary of the plant operating statistics for 1980, showing the extent of service of each boiler.

TABLE B-2. OPERATING STATISTICS FOR 1980

	Hours in service	No. of charges	Total steam generation (lb)	Average lb/hr
Boiler No. 1	5,373	66,230	451,106,850	83,958
Boiler No. 2	6,200	76,898	525,535,650	84,764
Boiler No. 3	7,065	88,769	589,342,800	83,412
Boiler No. 4	927	11,356	66,881,700	72,148

During the survey, only Units 1 and 3 were in service. The number of charges to each furnace is shown in Table B-3 below.

TABLE B-3. BOILER CHARGE RATES DURING MRI SURVEY

	Number of bucket charges	
	Boiler No. 1	Boiler No. 3
5/11/81		
7 AM - 3 PM	99	Not in service
3 PM - 11 PM	112	91
5/12/81		
11 PM - 7 AM	102	104
7 AM - 3 PM	110	112
3 PM - 11 PM	112	114
5/13/81		
11 PM - 7 AM	102	104
7 AM - 3 PM	101	103

Each charge is approximately 2,800 lb (1,270 kg) of refuse, which translates into an hourly feed rate of 17.5 to 20 tons/hr (0.26 to 0.30 Mg/sec).

A site plan Plant G is shown in Figure B-3. For the purposes of the survey, the major areas within the plant are as follows:

- Tipping floor
- Refuse storage pit and charging floor
- Furnace level
- Ash-handling level
- Ash separation building
- Offices and maintenance shops

All but the ash separation equipment, the office area, and the maintenance shops are contained within the main structure. The small building housing

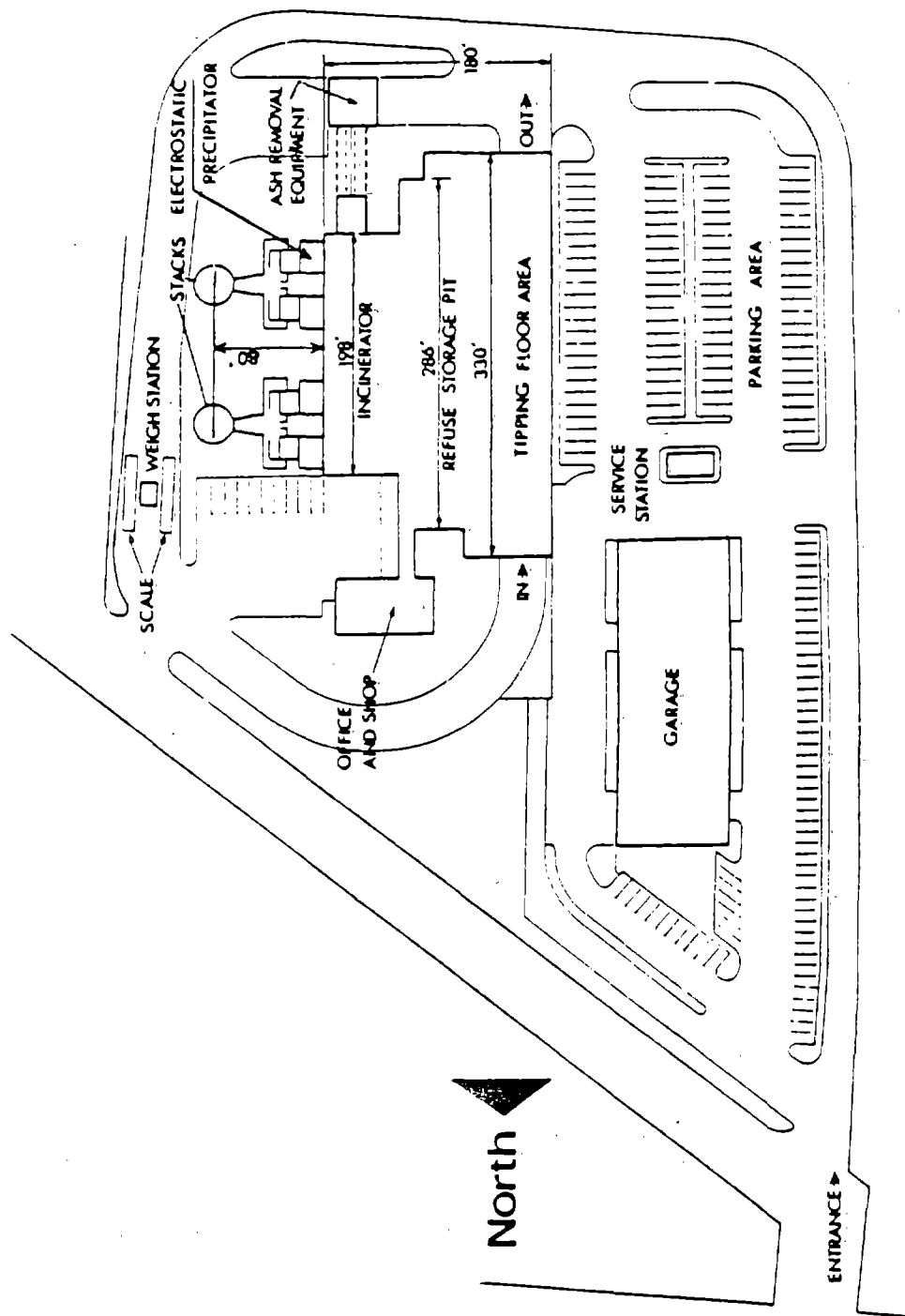


Figure B-3. Plant G site plan.

ash separation equipment is connected to the main structure by a tunnel which contains two inclined ash conveyors. An area is provided beneath the ash house for trucks to park while loading ash.

The plant offices and maintenance shops are located in a building annexed to the north end. Supervisors' offices, employees' lunchroom and locker room, and a laboratory are contained on the upper level, and the shops are located on the lower floor. A narrow passageway connects this annex to the main portion of the plant.

Plant Personnel

The workforce at Plant G consists of 80 employees who operate and maintain the facility, plus four supervisory personnel. Most of the workers are skilled tradesmen who carry union cards from their respective labor union (e.g., pipefitters, heavy equipment, electrical, operating engineers, machinists, boilermakers, etc.). The plant job classification distribution is shown in Table B-4.

A four-watch system is used at the plant to maintain the 24 hr/day operation. One of the watches is off duty on any given day and is rotated back into the schedule after several days. Shift times are 7:00 AM to 3:00 PM, 3:00 PM to 11:00 PM, and 11:00 PM to 7:00 AM. Each watch consists of three engineers, three firemen, two electricians, one maintenance worker, and an assistant watch chief. The majority of the employees in the maintenance category work on the day shift, while the other two shifts are comprised of only a skeleton crew.

RESULTS OF PLANT SURVEYS

Air Contaminants

The following sections detail the results of MRI's survey for air contaminants at Plants D and G, both of which are incineration facilities.

Plant D--

The comprehensive sampling and analysis program conducted during the survey of Plant D is outlined in the survey matrix presented in Table B-5. Table B-6 lists the types and numbers of samples collected in the various plant areas under study. These sampling areas were selected by MRI on the basis of locations of major unit operations and worker positions to yield data corresponding to the greatest potential exposure possibilities.

NIOSH-approved sampling and analytical methods were used throughout this study. Full-shift monitoring was conducted wherever possible in order to characterize 8-hr, time-weighted-average (TWA) exposures. Shorter term sampling was employed where limited collection times were required. These methods were used to estimate the ambient contaminant levels rather than provide TWA comparison data. Personnel sampling was also conducted to assess worker exposures to respirable dust and noise. (All other contaminants were assessed via area sampling.)

TABLE B-4. CLASSIFICATION OF PLANT G EMPLOYEES

Category	Job classification	Number of employees
Supervision	Plant manager	1
	Watch supervisor	1
	Chief electrician	1
	Stockroom clerk	1
Operation	Watch operator	4
	Watch engineer	12
	Fireman	12
	Assistant watch chief	4
	Electrician	8
Maintenance	Maintenance chief	4
	Maintenance engineer	5
	Pipefitter	6
	Machinist	4
	Boilermaker	4
	Laborer	<u>17</u>
Total employees		84

TABLE B-5. SURVEY SAMPLING AND ANALYSIS MATRIX--PLANT D

Substance sampled	No. of samples	Method of sampling	Analysis method
Total dust	8	NIOSH method 29.02/inert or nuisance dust	Gravimetric
Respirable dust	8	NIOSH method 29.02	Gravimetric
Trace metals	1	NIOSH methods: 9.01/Beryllium 22.01/Zinc chloride S312/Cadmium dust S323/Chromium (soluble) S341/Lead	P&CAM 173
Pesticides (organophosphate/ carbamate)	1	NIOSH method 21.01/impinger (distilled water)	Enzyme assay screen
Asbestos	1	NIOSH method 2.02/asbestos	P&CAM 239
Hydrogen chloride	4	Midget impinger 10 ml 0.5 m NaC ₂ H ₃ O ₂	S246
Cyanide	5	Midget impinger 10 ml 0.1 m NaOH	P&CAM 116
PCBs	1	Florisil sorbent collection	P&CAM 244
PNAHs	2	Glass fiber/silver membrane filters, backed by porous polymer tube	HPLC GC/MS
Particulate morphology	2	0.47-µm, 0.1-µm Nucleopore® filter	SEN
Organics	2	Portable IR; charcoal tube	Direct reading, P&CAM 127
Carbon monoxide	2	Interscan COtector	Direct reading
Particle sizing	4	Accu-vol samplers with Sierra impactors	Gravimetric
Noise	-	Sound level meter, octave band analysis	Direct reading
Ventilation	-	Thermoanemometer	Direct reading

TABLE B-6. SAMPLING MATRIX BY PLANT AREA--PLANT D

Sample	Receiving pit	Crane deck	Furnace floor	Ash quench
Total dust	2	3	3	-
Respirable dust	2	1	3	2
Trace metals	-	1	-	-
Asbestos	-	1	-	-
Organics	-	-	1	1
Pesticides	-	-	1	-
PCB	-	-	1	-
PNAH	-	-	1	1
HCl	-	-	2	2
HCN	-	-	3	2
CO	-	1	1	-
Particle size	-	2	2	-
Particle morphology	-	1	-	-
Noise (dosimeter)	2	1	3	1

Table B-7 lists general results of the survey at Plant D. A more complete data table is presented in Appendix D, Table D-4. The data are organized by sampling location. Figures B-4, B-5, and B-6 show the approximate sampling sites in relation to the building confines and the major pieces of equipment. Survey results are discussed in the following sections.

Total and Respirable Dust--Total dust concentrations were evaluated in several areas of Plant D. In all cases, the measured levels were lower than the recommended threshold limit value (TLV) for nuisance dust of 10 mg/m^3 (ACGIH/NIOSH; the OSHA standard for total nuisance dust is 15 mg/m^3). The eight samples collected showed concentrations ranging from 0.1 to 3.9 mg/m^3 . The highest dust levels were measured in the areas adjacent to the receiving pit (tipping level and furnace charging level). All other areas of the facility, which are segregated from the receiving pit by a concrete wall, had minimal dust concentrations.

Respirable dust exposures were characterized via personnel monitoring in the general areas indicated in Table B-7. All measured concentrations were consistently less than 0.5 mg/m^3 (or 1/10 of the recommended TLV). The highest employee exposure (about 0.4 mg/m^3) was recorded in the tipping area when truck activity was high.

Based on MRI's sampling data, worker exposures to airborne nuisance dusts at Plant D do not appear to present an occupational hazard.

Trace Metals--One particulate sample was collected on the crane deck (furnace-charging level) and analyzed by atomic absorption spectroscopy for five trace metals, lead, zinc, cadmium, chromium, and beryllium. Neither cadmium nor beryllium could be detected in the sample, and only very low levels of chromium, lead, and zinc were found.

Only one sample was collected at Plant D and analyzed for trace metal content because data from the previous surveys on this program have consistently indicated negligible concentrations of those trace metals. The crane deck was chosen as the sampling site since it appeared to be the dustiest area within the facility.

Silica--Because no mechanical processing was employed at Plant D and the other incineration facility surveyed, the potential hazard to airborne silica was judged to be negligible. Therefore, no silica sampling was conducted.

Asbestos--As with the trace metal evaluation, a single asbestos sample was collected as a cursory check of the Plant D atmosphere. A total fiber count of 0.16 fibers/cc resulted from microscopic analysis of this sample, which was collected on the crane deck. An asbestos confirmation analysis will be performed by NIOSH. Because the total fiber concentration is less than the recommended NIOSH TLV for asbestos (0.5 fibers/cc), it does not appear likely that asbestos fibers would pose a health hazard (based on our limited survey period).

TABLE B-7. RESULTS OF PLANT D SURVEY BY SAMPLING LOCATION

Substance monitored	Concentration		NIOSH TLV (mg/m ³)
	during sampling (mg/m ³)	TWA (mg/m ³)	
<u>Receiving pit</u>			
Total dust	2.88	2.88	10
	1.88	1.88	10
Respirable dust	0.41	0.37	5
	0.38	0.35	5
<u>Crane deck</u>			
Total dust	3.90	3.90	10
	0.47	0.47	10
	1.20	1.20	10
Respirable dust	0.18	0.16	5
Asbestos	0.16 ^a fibers/cc		0.5 fibers/cc
Trace metals			
Beryllium	ND-LD 0.1 µg ^b	-	0.002
Cadmium	ND-LD 0.3 µg ^b	-	0.05
Chromium	0.0012	0.0012	0.05
Lead	0.0060	0.0057	0.05
Zinc	0.0045	0.0043	5
<u>Furnace level</u>			
Total dust	0.72	0.72	10
	0.16	0.16	10
Respirable dust	0.33	0.30	5
	0.16	0.15	5
	0.09	c	5
Polychlorinated biphenyls (PCBs)			
Aroclor 1242	ND-LD 0.06 µg ^b	-	0.001
Aroclor 1254	ND-LD 0.08 µg ^b	-	0.001
Aroclor 1260	ND-LD 0.15 µg ^b	-	-

(continued)

TABLE B-7. (concluded)

Substance monitored	Concentration during sampling (mg/m ³)	TWA (mg/m ³)	NIOSH TLV (mg/m ³)
Polynuclear aromatic hydrocarbons (PNAH)			
Benzo(a)anthracene	ND-LD 0.010 µg ^b	-	-
Benzo(a)pyrene	ND-LD 0.006 µg ^b	-	-
Chrysene	ND-LD 0.300 µg ^b	-	-
Fluoranthene	ND-LD 0.010 µg ^b	-	-
Pyrene	ND-LD 0.400 µg ^b	-	-
Hydrogen chloride	ND-LD 27 µg ^b 0.67	- c	7 ^d 7 ^d
Hydrogen cyanide	ND-LD 0.1 µg ^b 0.009 ND-LD 0.13 µg ^b	- c -	5 ^e 5 ^e 5 ^e
<u>Ash quench</u>			
Respirable dust	0.08 0.23	c 0.21	5 5
PNAH			
Benzo(a)anthracene	ND-LD 0.010 µg ^b	-	-
Benzo(a)pyrene	ND-LD 0.006 µg ^b	-	-
Chrysene	ND-LD 0.300 µg ^b	-	-
Fluoranthene	ND-LD 0.010 µg ^b	-	-
Pyrene	ND-LD 0.400 µg ^b	-	-
Hydrogen chloride	0.63 ND-LD 33 µg ^b	c -	7 ^d 7 ^d
Hydrogen cyanide	0.0020 0.0067	c c	5 ^e 5 ^e
<u>Ash separation</u>			
Total dust	0.1	0.1	10

a Measured concentration of total fibers. No asbestos confirmed in sample.

b None detected at the limit of detection specified.

c Sampling period was less than 7 hr; extrapolation to TWA not appropriate.

d Ceiling value for 15 min.

e Ceiling value for 10 min.

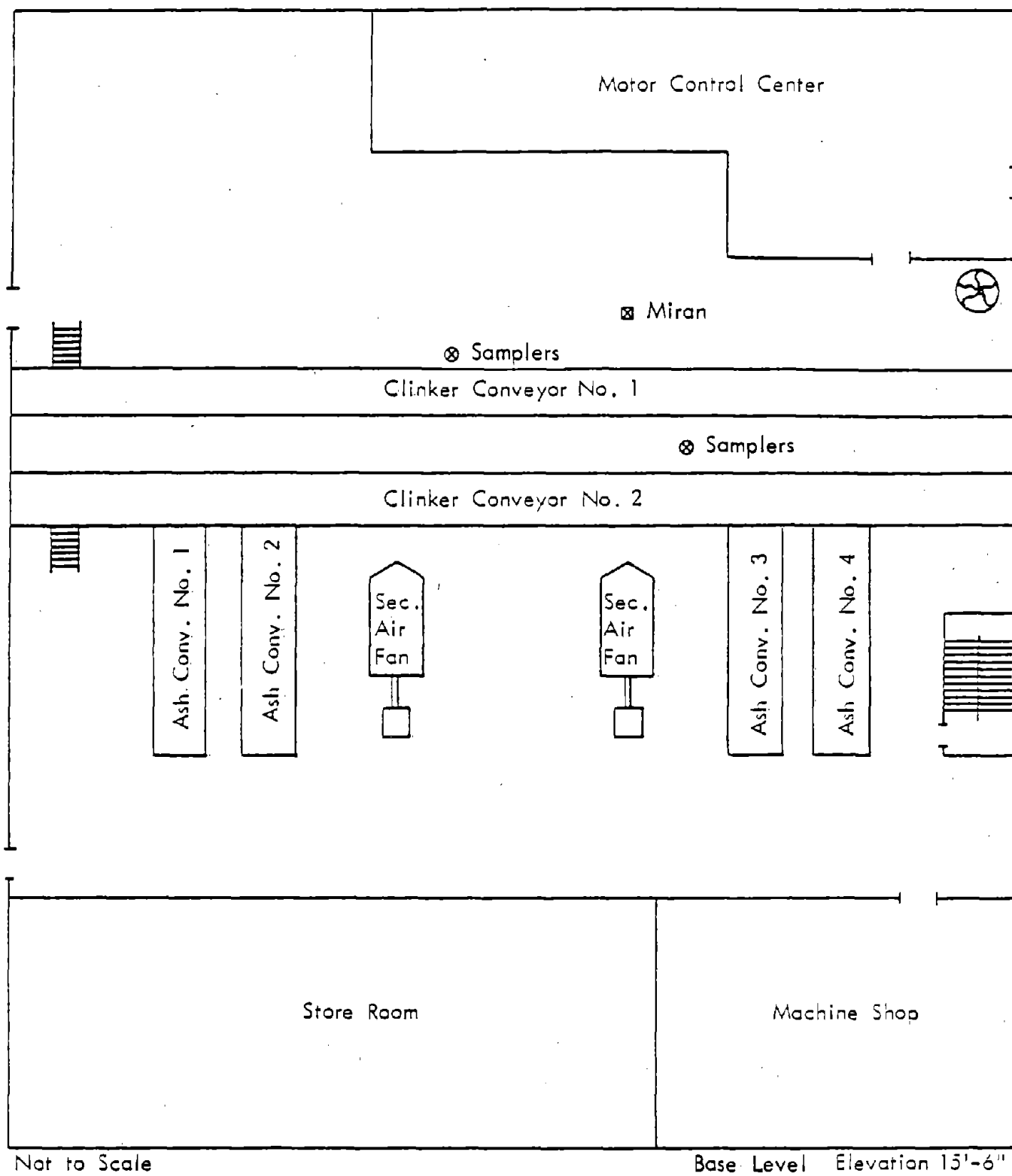
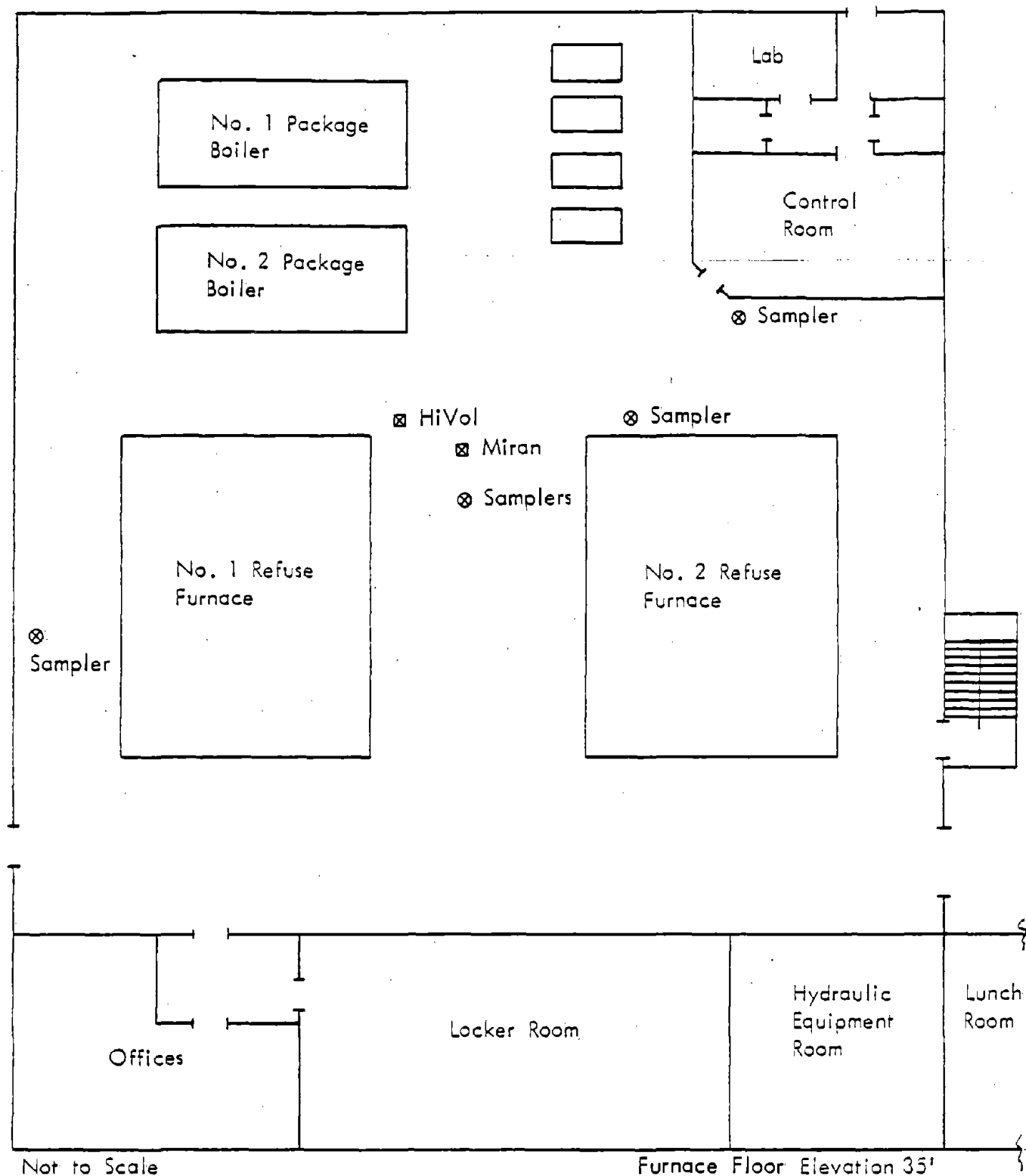


Figure B-4. Sampling locations in ash quench area.



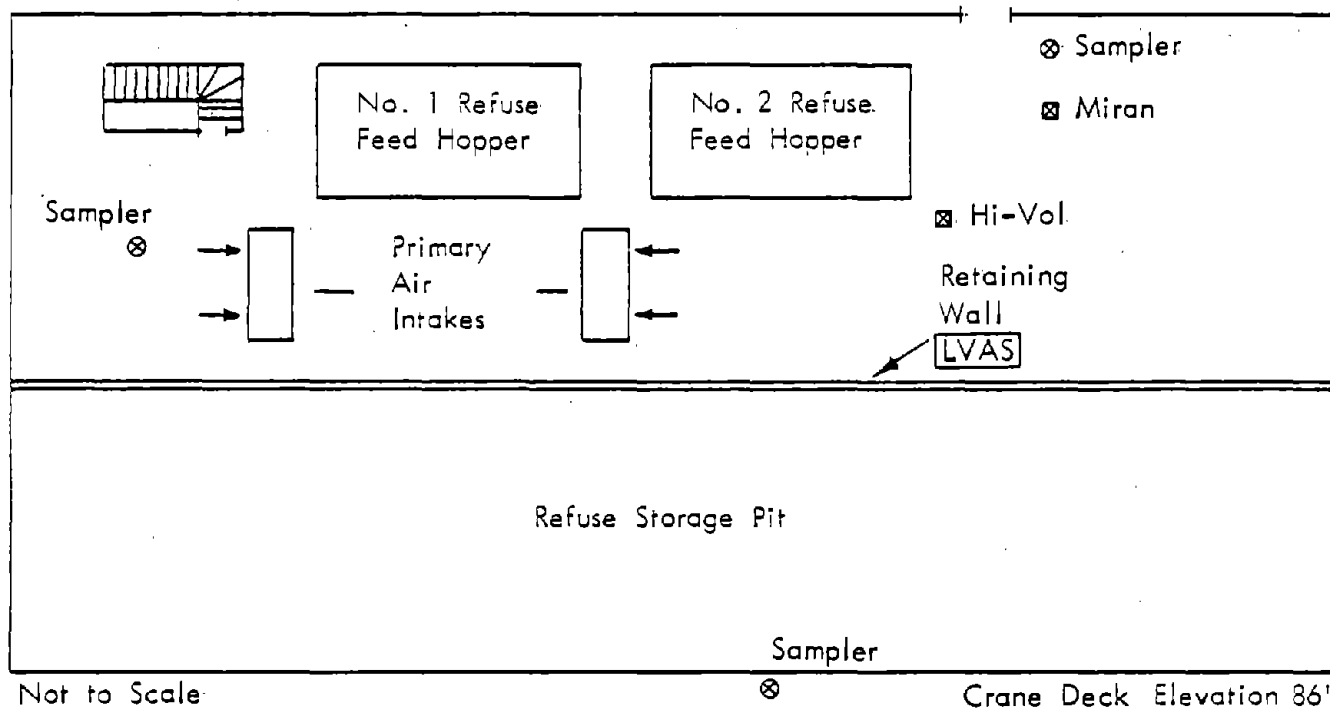
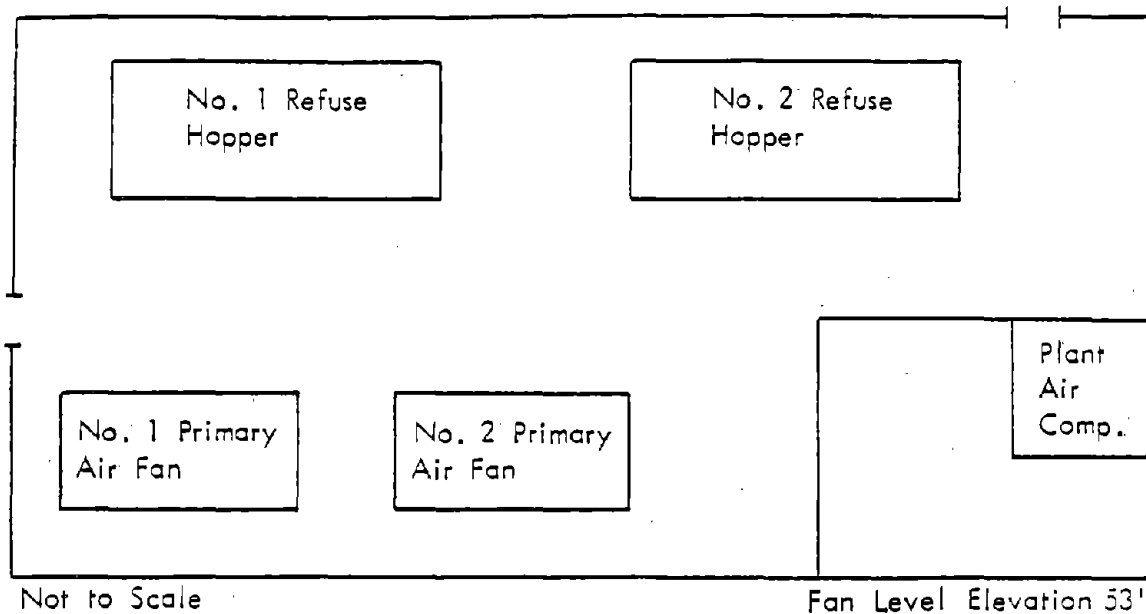


Figure B-6. Sampling locations in the feed hopper area.

Polychlorinated Biphenyls (PCBs)--A solid sorbent tube containing Florisil was used to collect an air sample for PCB analysis. This sample was taken on the furnace level (main level of the plant) between the two incinerator units. Analysis consisted of gas-liquid chromatography assays for Aroclor 1242, Aroclor 1254, and Aroclor 1260. These compounds were not detected in the sample.

Polynuclear Aromatic Hydrocarbons (PNAHs)--Sampling for PNAH compounds was conducted using a combination glass fiber filter/silver membrane filter cassette followed by a porous polymer backup tube. Two samples were collected by this method and were analyzed for the following compounds: benzo(a)-anthracene, benzo(a)pyrene, chrysene, fluoranthene, and pyrene.

Neither sample contained detectable levels of any of the five PNAH compounds.

General Organics--The survey evaluation for organic compounds of a general nature was conducted using direct reading instrumentation (MIRAN 1A analyzer), supported by concurrent charcoal tube sampling. The MIRAN 1A was operated primarily in the scan mode to search for absorbance peaks signifying the presence of organic compound groups. The instrument was also run in specific absorbance wavelengths which were preselected by MRI to correlate with organic compounds that were likely to be evolved during processing of municipal solid waste. The MIRAN 1A was used on the furnace level as well as in the ash quench area, and several scans were run at each location. No significant compound absorbance peaks were observed on the strip chart data tapes at either site.

Charcoal tube samples were collected concurrently with the operation of the MIRAN 1A and were intended as a quantitative backup. Since no significant absorbance peaks were detected by the MIRAN 1A, the charcoal tubes were not submitted for analysis.

Hydrogen Chloride (HCl)--Because the process at Plant D involves the combustion of municipal solid waste (which includes plastics) the work areas were monitored for HCl contamination. Samples were collected on the furnace level and in the ash quench area, using a dilute basic solution.

Laboratory analysis of the samples yielded concentrations near the limit of detection or below. The highest measured level of HCl was 0.67 mg/m^3 , whereas the recommended ceiling TLV is 7 mg/m^3 . Thus, no exposure hazard from hydrogen chloride was evident at Plant D. Because the incinerators are operated under a slight negative pressure, appreciable concentrations of HCl were not anticipated.

Hydrogen Cyanide (HCN)--Similarly, another possible product of combustion, HCN, was included in the sampling program. A dilute solution of sodium hydroxide was used to collect several of these samples, two in the ash quench area and three on the furnace level. Negligible concentrations of HCN were found in all samples. The highest level detected was only 0.0009 mg/m^3 in one of the samples collected in the ash quench area (as compared to the ceiling TLV of 5 mg/m^3). The potential hazard from HCN exposure, therefore, appears to be minimal.

Carbon Monoxide (CO)--Carbon monoxide levels were measured with a direct-reading instrument in major areas of the plant. In the refuse truck bays along the receiving pit, the CO readings ranged from 3 to 5 ppm, while on the crane deck, concentrations of 8 to 11 ppm were measured. This latter area had the highest average levels of CO in the facility, which was probably due to the movement of outside air past the incoming refuse trucks, through the truck bay openings and then up to the crane deck where the intakes for the incinerator primary air fans are located.

Other CO measurements indicated concentrations of 2 to 5 ppm on the furnace level and 2 to 3 ppm on the next higher level (62 ft or 19 m elevation). Since the recommended TLV for CO is 35 ppm, no worker exposure hazard was evident within Plant D.

Airborne Particle Size--High-volume, ambient air samplers equipped with Sierra, five-stage cascade impactors were used to determine the approximate particle size distribution of the airborne dust within the plant. The Sierra impactor aerodynamically segregates particles at five size stages: 10.2, 4.2, 2.1, 1.4, and 0.73 μm .

Four samples were collected during the MRI survey; two on the crane deck and two on the furnace level. Data are presented graphically in Figures B-7 through B-10. The curves designated "actual" were generated by adjusting the "raw" data for a known mass bias on the final filter of the Sierra impactor. It is typical to find an excess of particulate material on the final filter, which indicates that a particle "bounce" phenomenon had occurred as the sample was collected. The applied correction is used to yield the more true size distribution.

The samples collected on the crane deck showed very similar particle size distributions. The median particle diameter was between 4.5 and 6.5 μm . A slightly smaller average particle size was indicated by the samples collected on the furnace level. There, the average particle size was about 3 to 4 μm .

Airborne Particle Morphology--Two air samples were collected on special Nucleopore® filters to determine the morphology of airborne particles, particularly fibers, at Plant D. One of the samples was collected on the crane deck and the other within the ash-handling equipment structure. The morphological analysis was performed by Walter C. McCrone Associates using optical microscopy and scanning electron microscopy methods.

The crane deck sample contained cotton, synthetic, plant and paper fibers. No glass fibers were noted and the total quantity of fibers (versus amorphous particles) was very low. Figure B-11 shows micrographs taken of this sample at two magnifications.

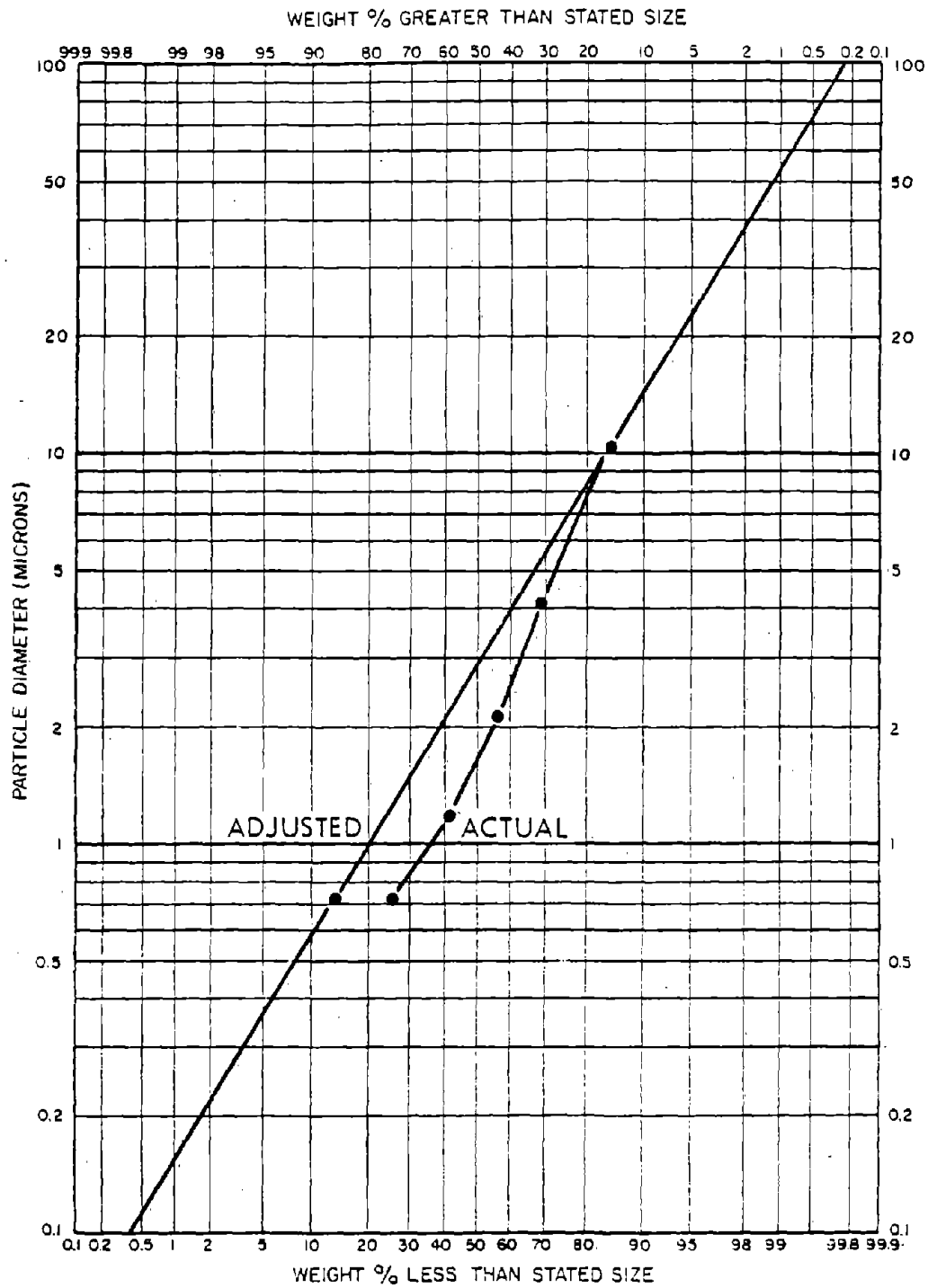


Figure B-7. Particle size distribution on the main incinerator level (7/8/80).

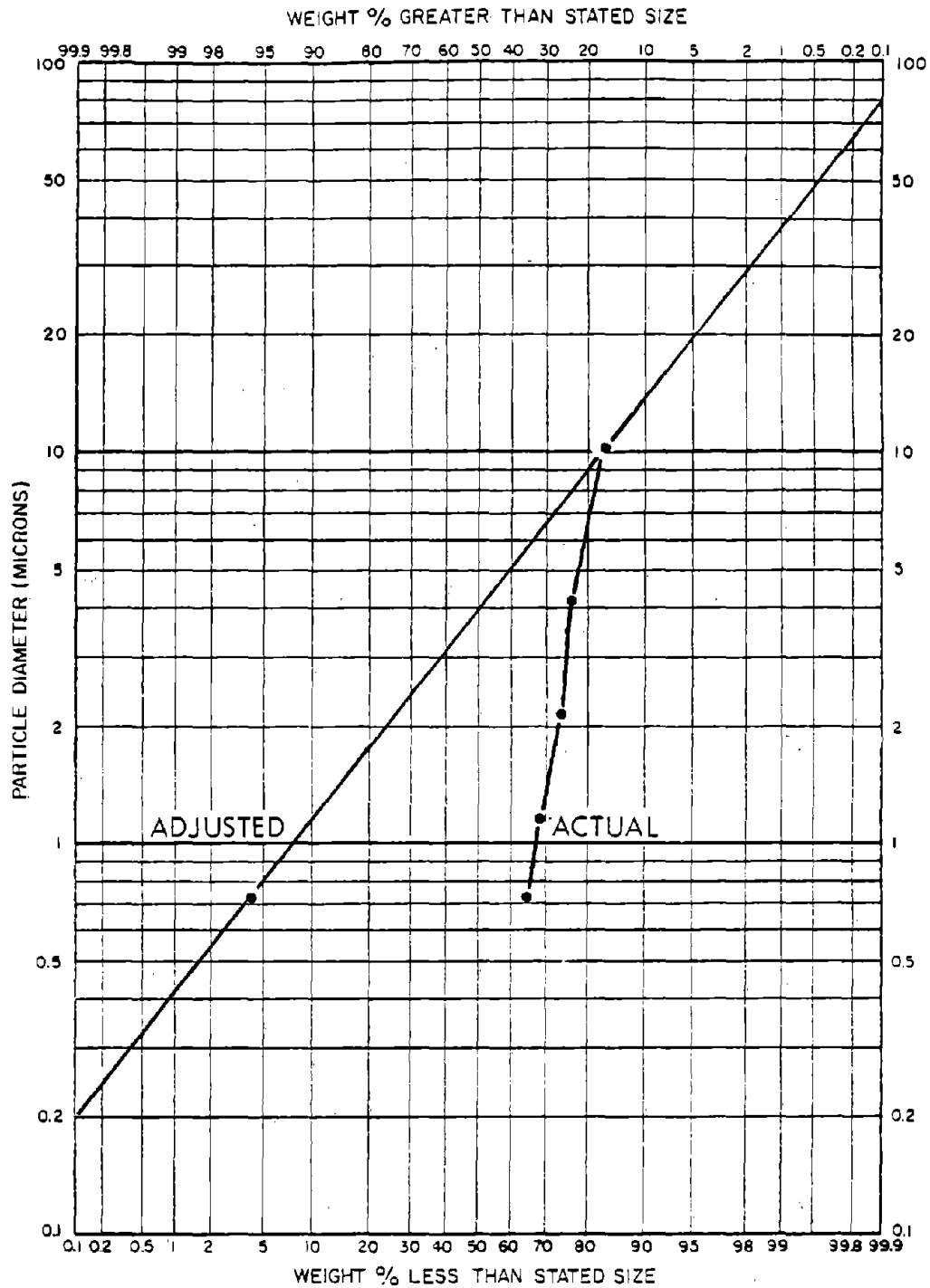


Figure B-8. Particle size distribution on the main incinerator level (7/9/80).

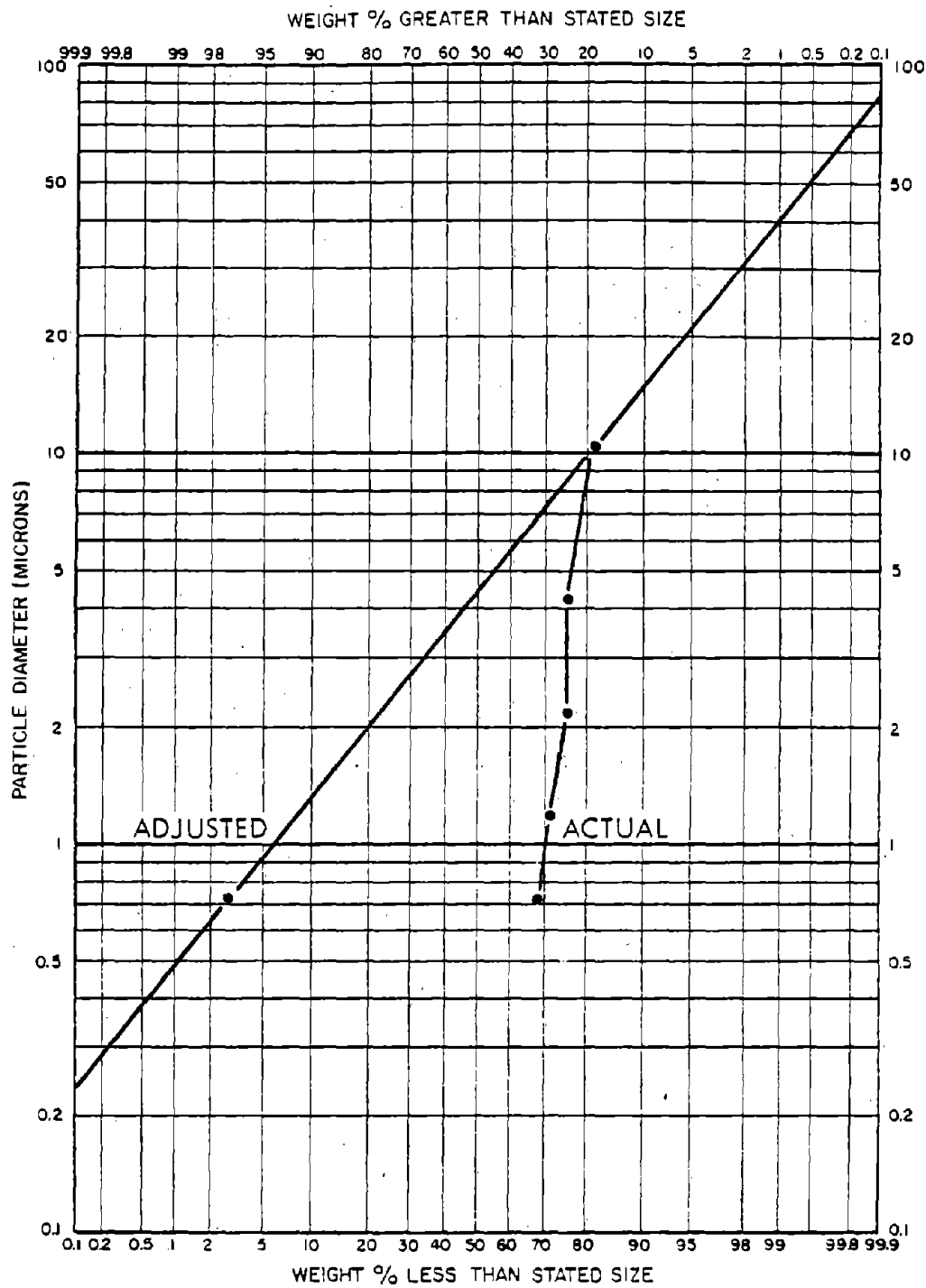


Figure B-9. Particle size distribution on the crane deck level (feed hopper area) (7/8/80).

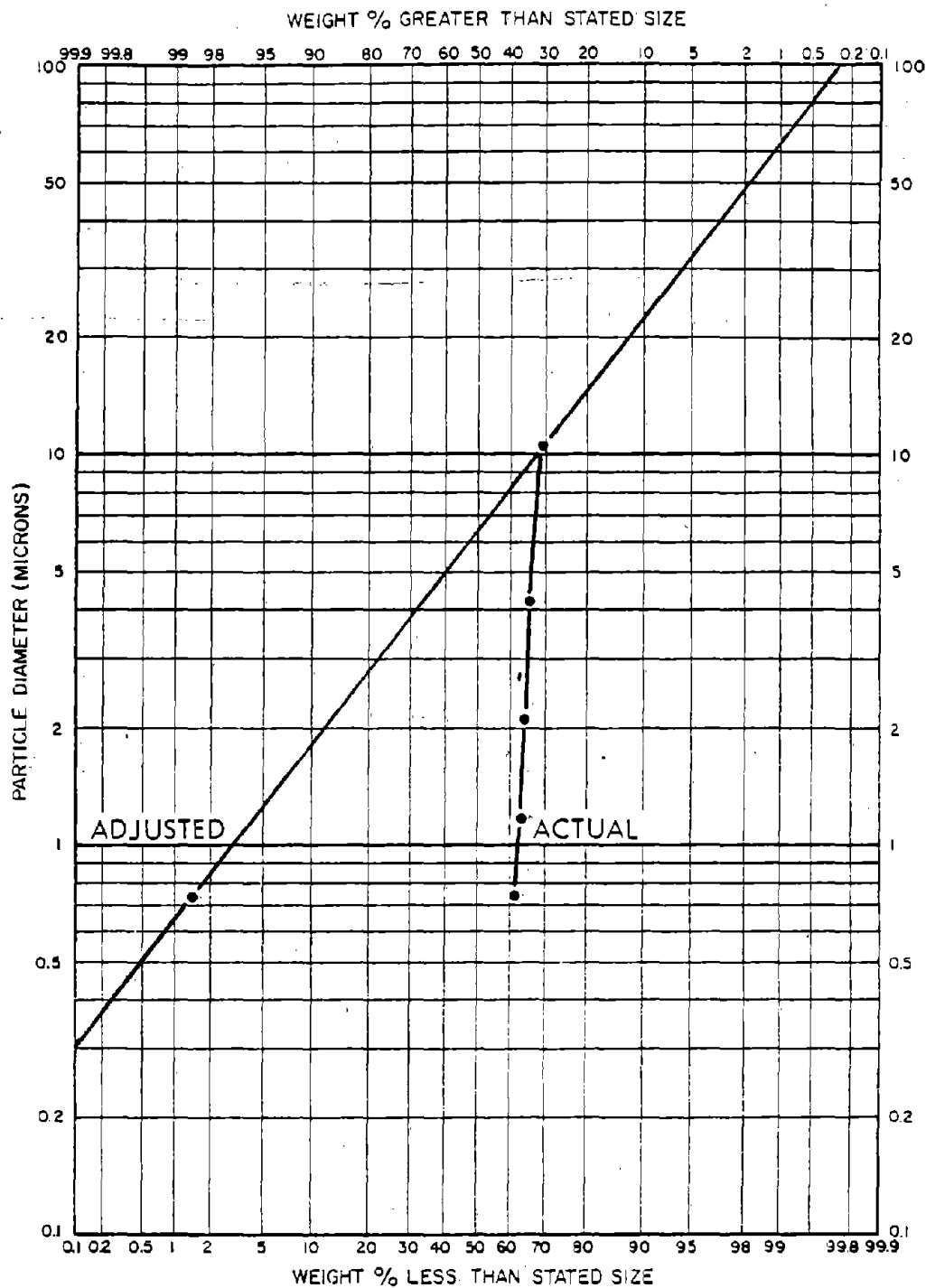


Figure B-10. Particle size distribution on the crane deck level (feed hopper area) (7/9/80).

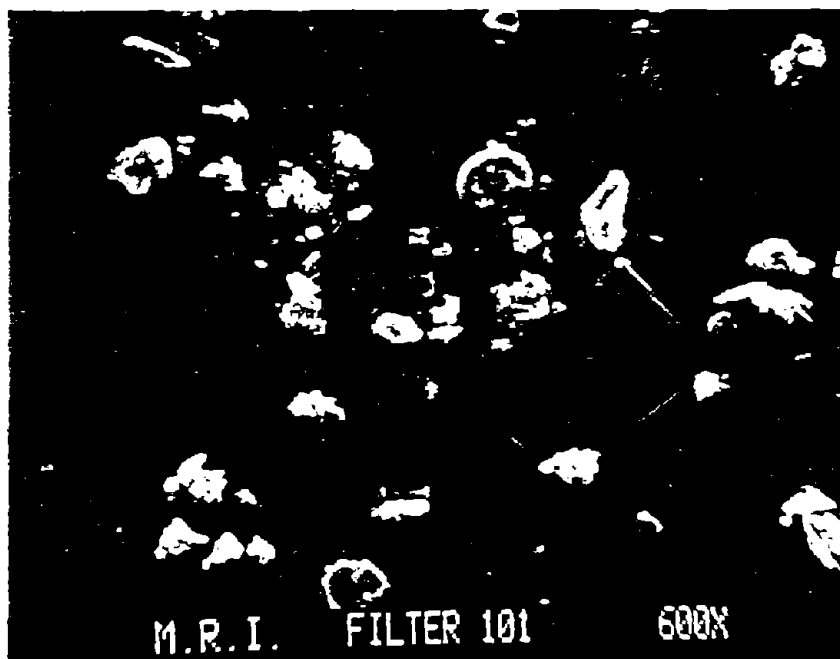
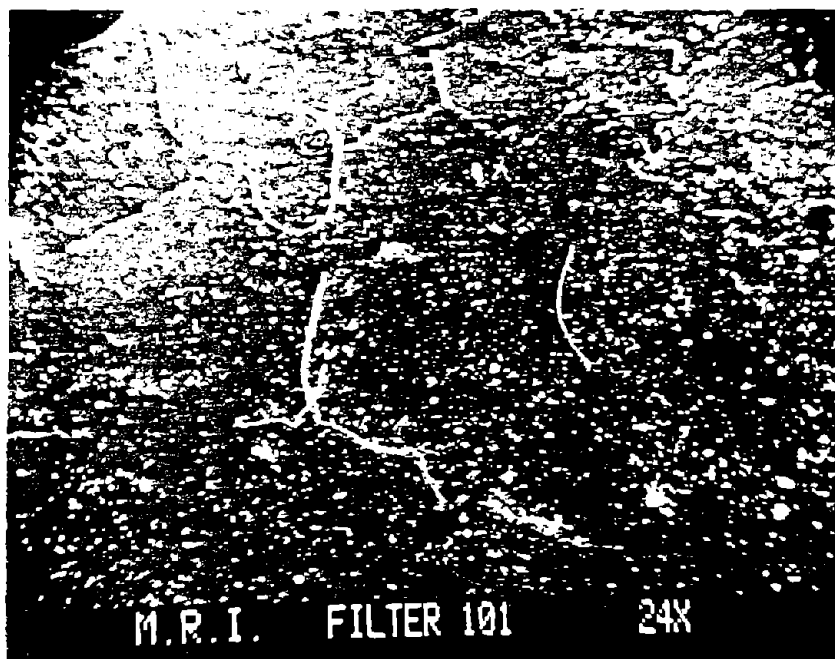


Figure B-11. Photomicrographs of particulate sample collected on the crane deck.

The sample obtained within the ash handling structure contained cotton, paper, and many glass fibers, as well as some wood chips. No synthetic fibers were observed in this sample. Also identified were iron oxide flakes, carbonaceous soot flakes, and various sintered particles of indefinite composition, which indicated the results of incineration. Figure B-12 shows the micrographs for this sample.

Plant G--

The air sampling and analysis program used by MRI to determine chemical contaminant concentrations and worker exposures is outlined in Table B-8. The types and numbers of samples collected in each of the various plant areas under study are shown in Table B-9. Sampling locations were selected by MRI on the basis of the location of the major sources of air contaminants and the locations of workers so as to yield data corresponding to the most significant potential exposures. The sampling sites are shown in Figures B-13, B-14, and B-15.

NIOSH-approved sampling and analytical methods were used throughout this survey. Full-shift monitoring was conducted wherever possible in order to characterize 8-hr, time-weighted-average (TWA) exposures. Shorter term sampling was employed where limited collection times were required and was used to estimate the ambient contaminant levels rather than to provide TWA comparison data. Personnel sampling was also conducted to assess worker exposures to respirable dust and noise. (All other contaminants were assessed via area sampling.)

Table B-10 lists the general results of the sampling at Plant G. For reference, a more complete data table is presented in Appendix D, Table D-7. Data in both tables are organized by sampling location. These survey results are discussed and evaluated in the following sections.

Total and Respirable Dust--Airborne total dust and respirable dust concentrations were determined in all of the major work areas of Plant G (tipping floor, charging floor, furnace levels, and ash house). As indicated in Table 49, all results were well within the recommended permissible exposure limits (ACGIH/NIOSH) of 10 mg/m^3 for total nuisance dust and 5 mg/m^3 for respirable nuisance dust. The highest total dust concentrations (2.4 and 1.7 mg/m^3) were measured on the charging floor, which is consistent with the constant crane activity there versus the activities in the remainder of the plant. Respirable dust levels were found to be less than 1 mg/m^3 in the same area.

With the exception of the area where bottom ash from the boilers drops onto the removal conveyors, all areas of Plant G had total and respirable dust levels below 1 mg/m^3 . The sample collected by the ash dropout points indicated a total dust concentration of 1.3 mg/m^3 . Particulate levels in the remainder of the plant ranged from 0.15 to 0.81 mg/m^3 on an 8-hr, TWA basis. Similarly, the measured respirable dust concentrations were in the range of 0.21 to 0.87 mg/m^3 .

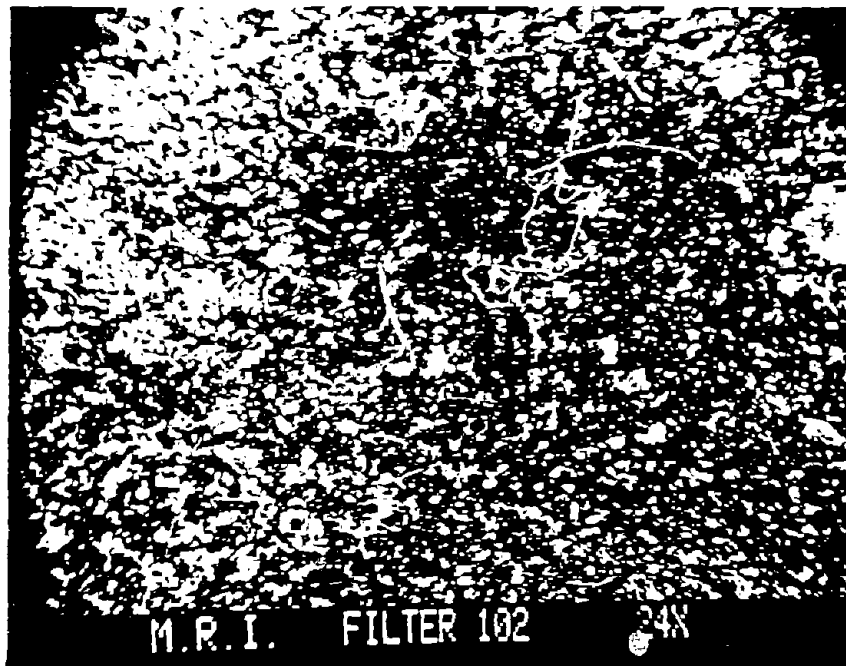


Figure B-12. Photomicrographs of particulate sample collected in the ash handling equipment structure.

TABLE B-8. SURVEY SAMPLING AND ANALYSIS MATRIX--PLANT C

Substance sampled	No. of samples	Method of sampling	Analysis method
Total dust	10	NIOSH method 29.02/inert or nuisance dust	Gravimetric
Respirable dust	8	NIOSH method 29.02	Gravimetric
Trace metals	1	NIOSH methods: 9.01/Beryllium 22.01/Zinc chloride S312/Cadmium dust S323/Chromium (soluble) S341/Lead	P&CAM 173
Asbestos	1	NIOSH method 2.02/asbestos	P&CAM 239
Hydrogen chloride	4	Midget impinger 10 ml 0.5 m NaC ₂ H ₃ O ₂	S246
Cyanide	5	Midget impinger 10 ml 0.1 m NaOH	P&CAM 116
PCBs	1	Florisil sorbent collection	P&CAM 244
PNAHs	2	Glass fiber/silver membrane filters, backed by porous polymer tube	HPLC GC/MS
Organics	2	Portable IR; charcoal tube	Direct reading, P&CAM 127
Carbon monoxide	N/A	Interscan COtector	Direct reading
Particle sizing	4	Accu-vol samplers with Sierra impactors	Gravimetric
Noise	-	Sound level meter with octave band analyzer; personnel dosimeters	Direct reading

TABLE B-9. SAMPLING MATRIX BY PLANT AREA--PLANT G

Substance monitored	Tipping floor	Charging floor	Furnace level	Ash floor/ ash house	Multi- area
Total dust	2	2	2	3	1
Respirable dust	2	3	-	2	1
Trace metals	-	1	-	-	-
Asbestos	-	1	-	-	-
Organics	1	1	1	1	-
Hydrogen chloride	-	-	4	-	-
Hydrogen cyanide	-	-	3	-	-
Particle size	1	1	1	1	-
Carbon monoxide	a	a	a	a	-
Noise (dosimetry)	2	2	-	3	1

^a Walkaround survey using a portable, direct-reading instrument.

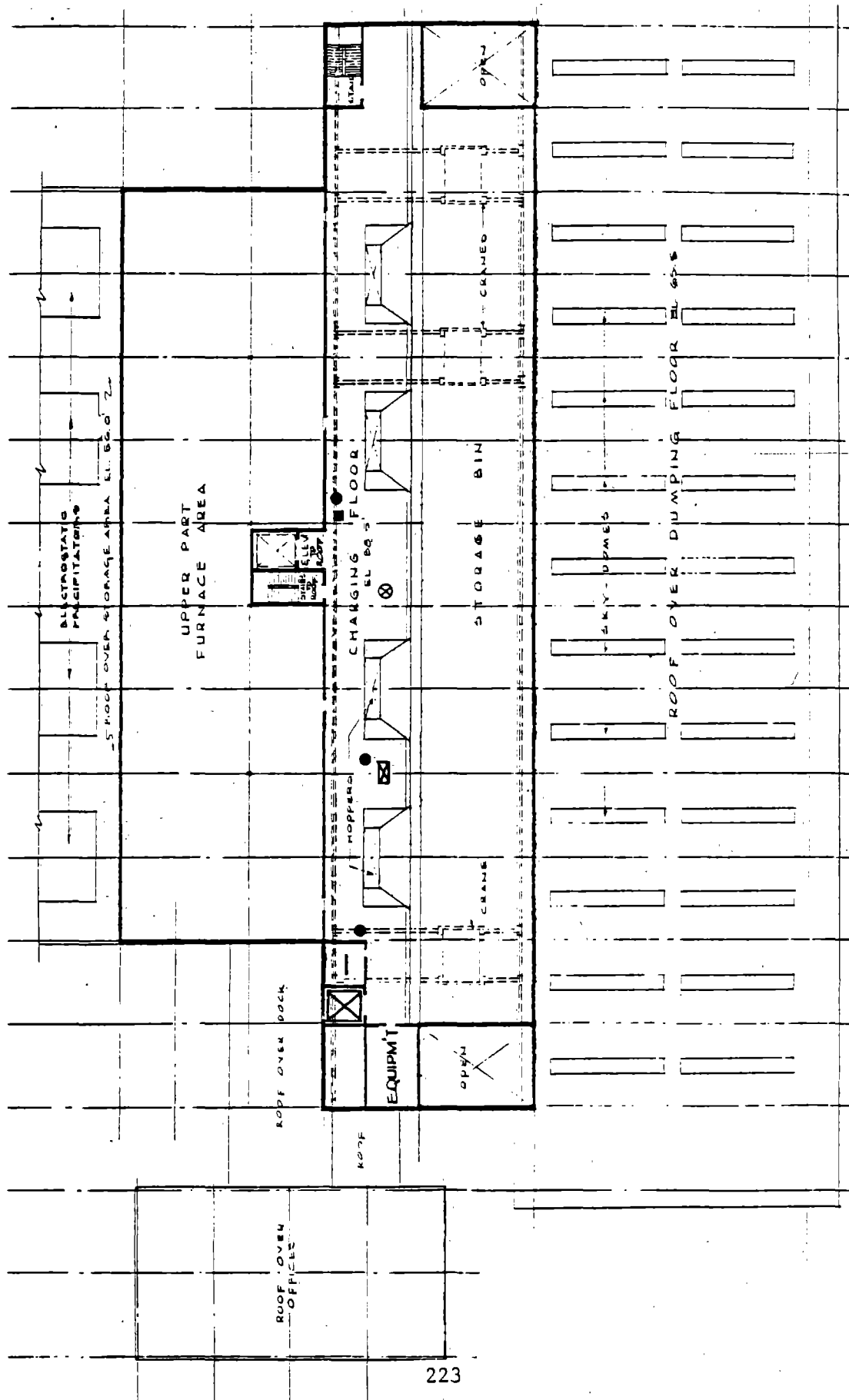


Figure B-13. Sampling locations on the charging floor.

KEY

- Area Samplers
- Particle Sizing (hi-vol)
- ☒ Large Volume Air Samp
(Microbiological)
- ⊗ Miran 1A (Organics)

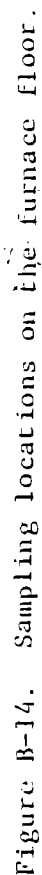


TABLE B-10. RESULTS OF PLANT G SURVEY BY SAMPLING LOCATION

Substance monitored	Concentration during sampling (mg/m ³)	TWA (mg/m ³)	NIOSH TLV (mg/m ³)
<u>Tipping floor</u>			
Total dust	0.56 0.81	0.52 0.81	10 10
Respirable dust	0.46 0.90	a a	5 5
Organics			
Heptane	0.2	0.2	340
Hexane	ND-LD 0.01 mg ^b	-	360
Nonane	ND-LD 0.01 mg ^b	-	-
Octane	ND-LD 0.01 mg ^b	-	350
Pentane	0.4	0.4	350
<u>Charging floor</u>			
Total dust	2.38 1.74	2.35 1.74	10 10
Respirable dust	0.43 0.30 0.90	0.40 0.29 0.87	5 5 5
Trace metals			
Beryllium	ND-LD 0.05 µg ^b	-	0.002
Cadmium	ND-LD 0.2 µg ^b	-	0.05
Chromium	ND-LD 0.6 µg ^b	-	0.05
Lead	0.007	0.007	0.05
Zinc	0.007	0.007	-
Asbestos	ND-LD 2,460 fibers ^c	-	0.5 fibers/cc
Organics			
Heptane	0.4	0.4	340
Hexane	0.4	0.4	360
Nonane	0.6	0.6	-
Octane	ND-LD 0.01 mg ^b	-	350
Pentane	2	2	350

(continued)

TABLE B-10. (concluded)

Substance monitored	Concentration during sampling (mg/m ³)	TWA (mg/m ³)	NIOSH TLV (mg/m ³)
<u>Furnace level</u>			
Total dust	0.35	0.35	10
	0.15	0.15	10
Hydrogen chloride	0.69	a	7 ^d
	0.46	a	7 ^d
	0.84	a	7 ^d
	0.82	a	7 ^d
Hydrogen cyanide	0.001	a	5 ^e
	0.002	a	5 ^e
	ND-LD 0.2 µg ^b	-	5 ^e
<u>Ash house</u>			
Total dust	0.33	0.30	10
	0.22	0.22	10
	1.3 ^f	1.3	10
<u>General maintenance personnel</u>			
Total dust	0.81	0.74	10
Respirable dust	0.21	0.21	5

^a Sampling period was less than 7 hr; extrapolation to 8-hr TWA not appropriate.

^b None detected at limit of detection specified.

^c Total fibers; no asbestos confirmed in sample.

^d Ceiling value for 15-min exposure.

^e Ceiling value for 10-min exposure.

^f Sampler located at head of ash conveyor near dropout point from boiler ash hoppers.

Trace Metals--A single particulate sample was collected on the charging floor near the No. 2 hopper and analyzed by atomic absorption spectroscopy for five trace metals, beryllium, cadmium, chromium, lead, and zinc). The charging floor was selected as the best sampling location since it appeared to be the dustiest work area.

Beryllium, cadmium, and chromium were not detected in the sample. Lead and zinc were detected at very low levels, in each case corresponding to an airborne concentration of 0.007 mg/m³.

Silica--Because no mechanical processing was used at Plant G, the exposure hazard to airborne silica was judged to be negligible. Therefore, no silica sampling was conducted.

Asbestos--A cursory check of the Plant G work environment for asbestos contamination was conducted by obtaining a particulate sample in the charging floor area. Standard NIOSH microscopy analysis showed a total fiber count that was less than the limit of detection. No further analytical work was done to confirm the possible presence of any asbestos fibers since the total fiber content of the sample was so minimal. Based on this limited sample, there appears to be no asbestos exposure hazard at Plant G. This result is consistent with similar samples at other plant sites.

General Organics--The survey evaluation for general organic compounds was conducted using direct reading instrumentation (MIRAN 1A analyzer) supported by concurrent charcoal tube sampling. The MIRAN 1A was operated primarily in the scan mode to search for absorbance peaks signifying the presence of organic compound groups. The instrument was also run at specific absorbance wavelengths which were preselected by MRI to correlate with organic compounds that are likely to be evolved during processing of municipal solid waste. Charcoal tube samples, collected concurrently with the operation of the MIRAN 1A, were intended as a quantitative backup.

The MIRAN 1A was set up at sampling locations on the tipping floor, the charging floor, in the ash loading area, and on the main furnace level between the No. 2 and No. 3 boilers. Very small absorbance peaks were observed on the strip charts collected in the tipping floor and charging floor areas, primarily at a wavelength of 3.4 nm. Absorbance at this wavelength indicates a family of straight-chain hydrocarbon compounds. Thus, the charcoal tube samples collected in these two work areas were analyzed for the compounds shown in Table B-10.

Results of the analysis showed airborne levels of these compounds to be either below or just slightly above the limit of detection. Since the TLV's for these hydrocarbons are relatively high, it is clear that no exposure hazard to these organic chemicals existed at the time of the MRI survey.

Carbon Monoxide (CO)

A walk-around survey of Plant G was conducted to determine work area levels of carbon monoxide. A direct-reading, hand-held detector was used to obtain a number of short-term measurements in each area. Results are summarized in Table B-11 below:

TABLE B-11. SUMMARY OF CO MEASUREMENT DATA

Plant area	CO concentration (ppm)
Tipping floor	2.5 to 4.0
Charging floor	9.0 to 14.0
Furnace floor	2.0 to 4.0
Ash floor	5.0 to 7.0

All areas monitored had CO levels well below the recommended exposure limit of 35 ppm. The highest readings obtained were on the charging floor. This finding is reasonable since the furnace intake fans are located above and behind the charging hoppers, and thus draw air from the tipping floor up and across the charging area. Carbon monoxide levels on the tipping floor itself were measured near the wall opposite the refuse pit and were lower than those recorded near the charge hoppers. From these data, it is concluded that no employee exposure hazard from CO existed at Plant G during the survey period.

Hydrogen Chloride (HCl) and Hydrogen Cyanide (HCN)--Since municipal solid wastes (which include plastics of all types) are incinerated directly at this resource recovery facility, the furnace level area was monitored for the presence of HCl and HCN gases. Samples were collected using midget impingers containing a dilute sodium acetate solution for the capture of HCl, and for HCN, sodium hydroxide.

Analysis of the samples yielded very low amounts of both HCl and HCN. All HCl concentrations were less than 1.0 mg/m^3 , and the calculated HCN concentrations were below 0.01 mg/m^3 . Since the boilers at Plant G are kept under negative pressure, these results validate the assumption that combustion gases should not be escaping into the plant environment.

Airborne Particle Size--High-volume, ambient air samplers equipped with Sierra, five-stage cascade impactors were used to determine the approximate

particle size distribution of the airborne dust within the plant. The Sierra impactor aerodynamically segregates particles at five size stages: 10.2, 4.2, 2.1, 1.4, and 0.73 μm .

Four samples were collected during the MRI survey; two on the crane deck and two on the furnace level. Data are presented graphically in Figures B-16 through B-19. The curves designated "actual" were generated by adjusting the "raw" data for a known mass bias on the final filter of the Sierra impactor. It is typical to find an excess of particulate material on the final filter which indicates that a particle "bounce" phenomenon had occurred as the sample was collected. The applied correction is used to yield the more true size distribution.

The particle size distribution obtained from the sampling of Plant G showed similar results. The median particle diameters ranged from 3.8 μm on the furnace level to 9 μm on the tipping floor. On the charging floor, the median diameter was approximately 6.5 μm , while the sample collected on the ash floor showed a median particle size of about 5.5 μm .

Microbiological Aerosols: Plant D

Analytical results of the microbiological sampling program conducted by MRI at the Plant D resource recovery facility are presented in this section. The microbiological survey included analyses for selected bacterial indicator complexes and infectious agents (see Table 2). These analyses were performed on aerosol and stationary dust samples. It must be kept in mind that ambient environmental microbiology standards have not been established and that any microbiological results must be interpreted with extreme care. Complete descriptions of the sampling and analytical methodologies are included in Appendix A.

Sampling Sites--Microbial aerosol samples were collected at two locations at Plant D. Aerosol samples collected in the building were taken near the center of the charging floor adjacent to the concrete retaining wall separating the charging floor from the refuse storage pit (see Figure 60).

All in-plant aerosol samples except one were taken during normal plant operations. A single sample set consisting of an all-glass impinger (AGI 2-7) and a large volume air sampler (LVAS 2-4) was collected during a period when the cranes were not operating and no solid waste was being received in the storage pit. This in-plant aerosol control sample was taken following a 30-min quiet period to allow the previously generated dust to settle out.

A single outdoor aerosol sample set (AGI and LVAS 3-2) was collected near the southeast corner of the plant building. The plant property line's proximity to the building's east side and the presence of a salt marsh outside that boundary precluded the outdoor sample from being taken at a strict upwind location. During the sampling period, the wind was from the east-northeast at approximately 5 mph (2.2 m/s) as determined with a Wong Portable Weather Station.

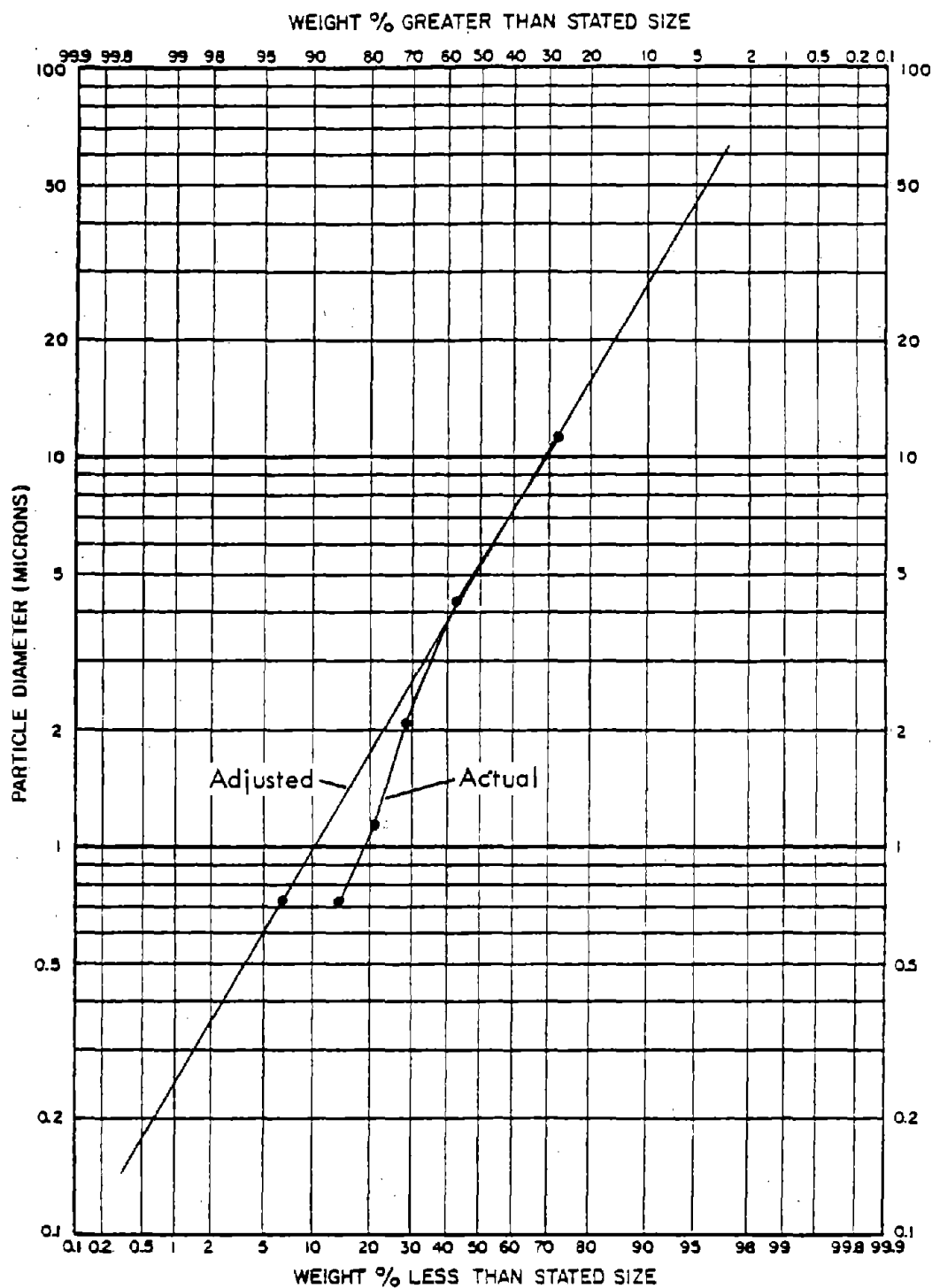


Figure B-16. Particle size distribution at the ash conveyor sampling location (5/13/81).

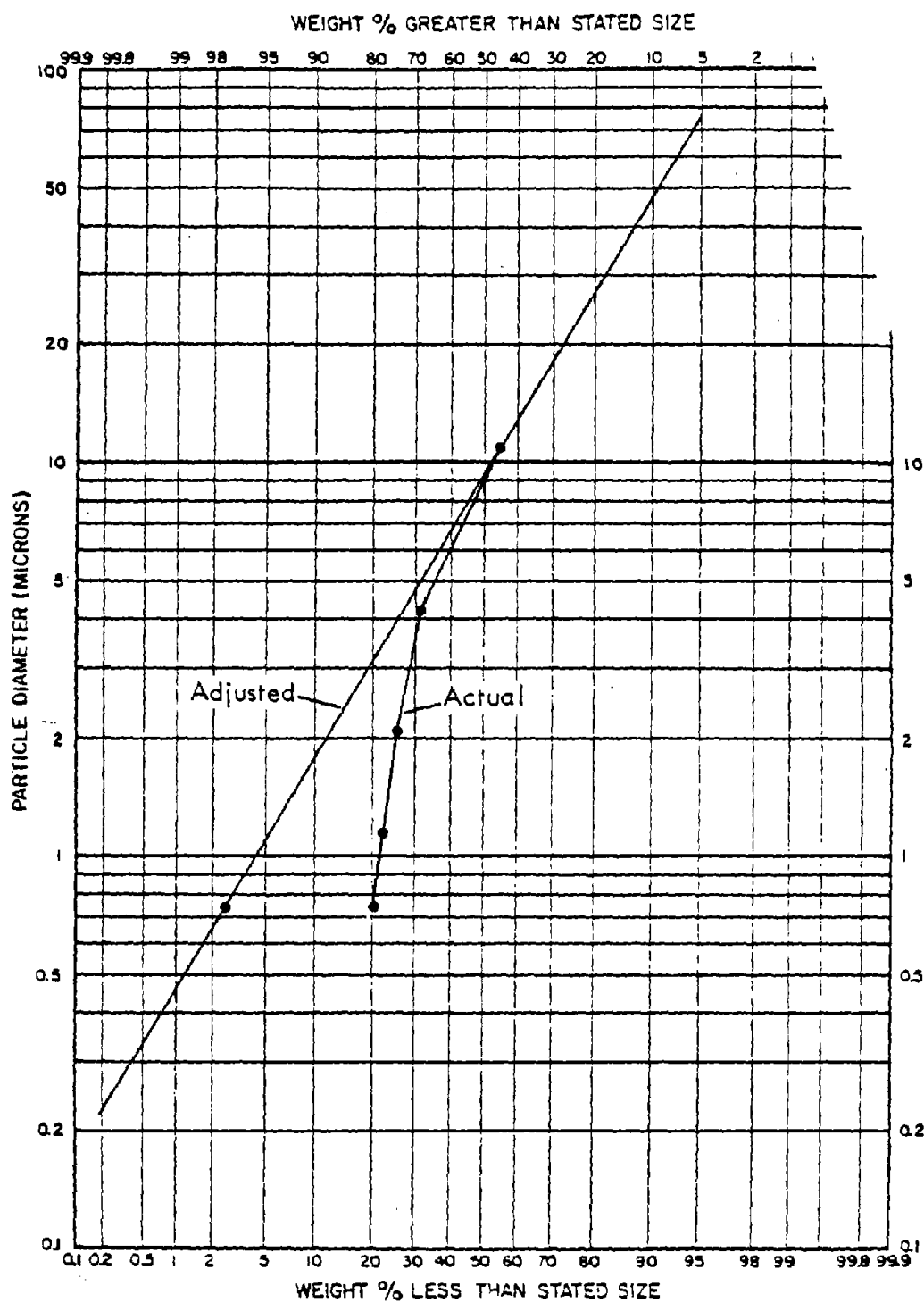


Figure B-17. Particle size distribution at tipping floor sampling location (5/12/81).

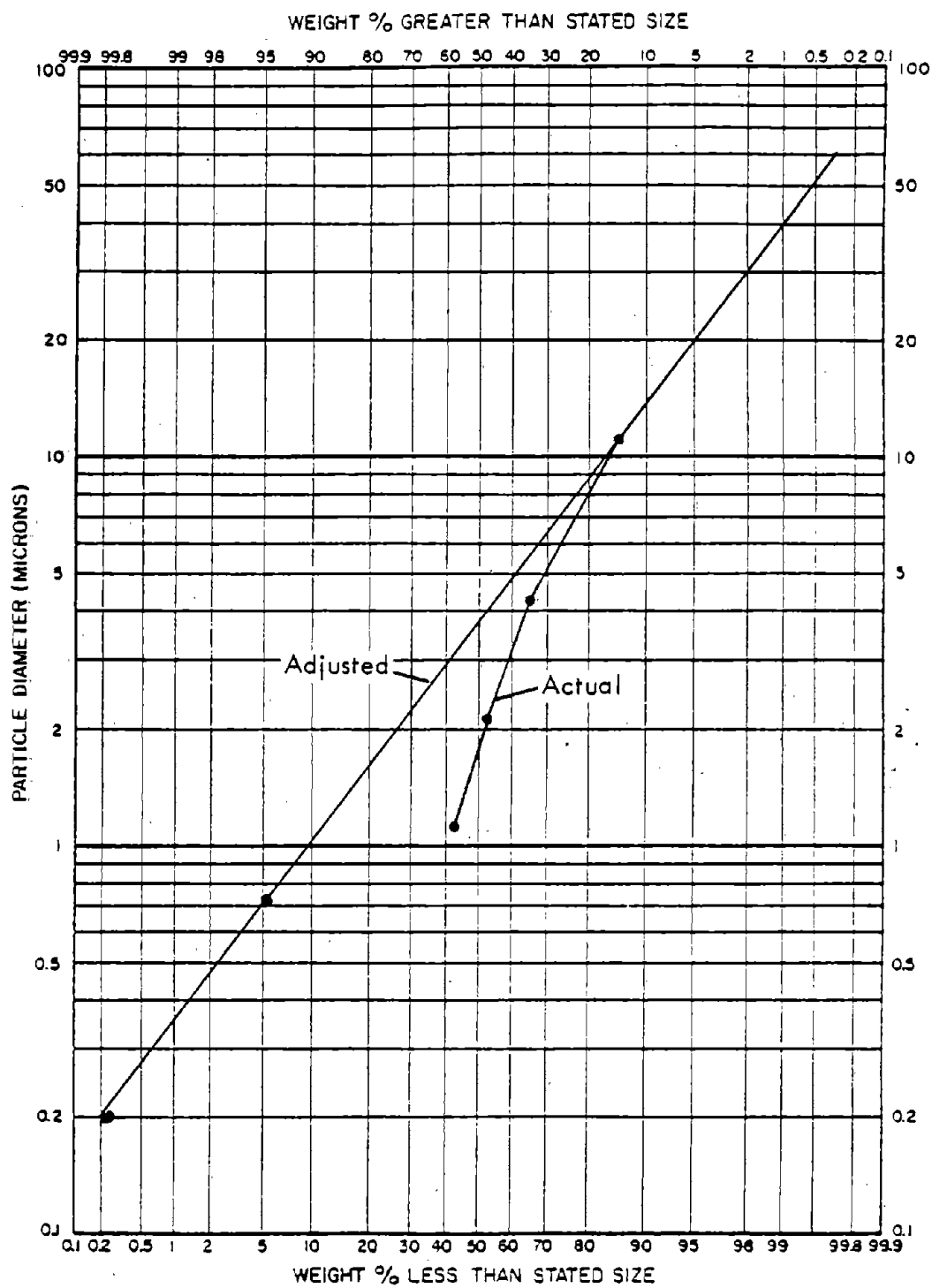


Figure B-18. Particle size distribution at furnace level sampling location (5/13/81).

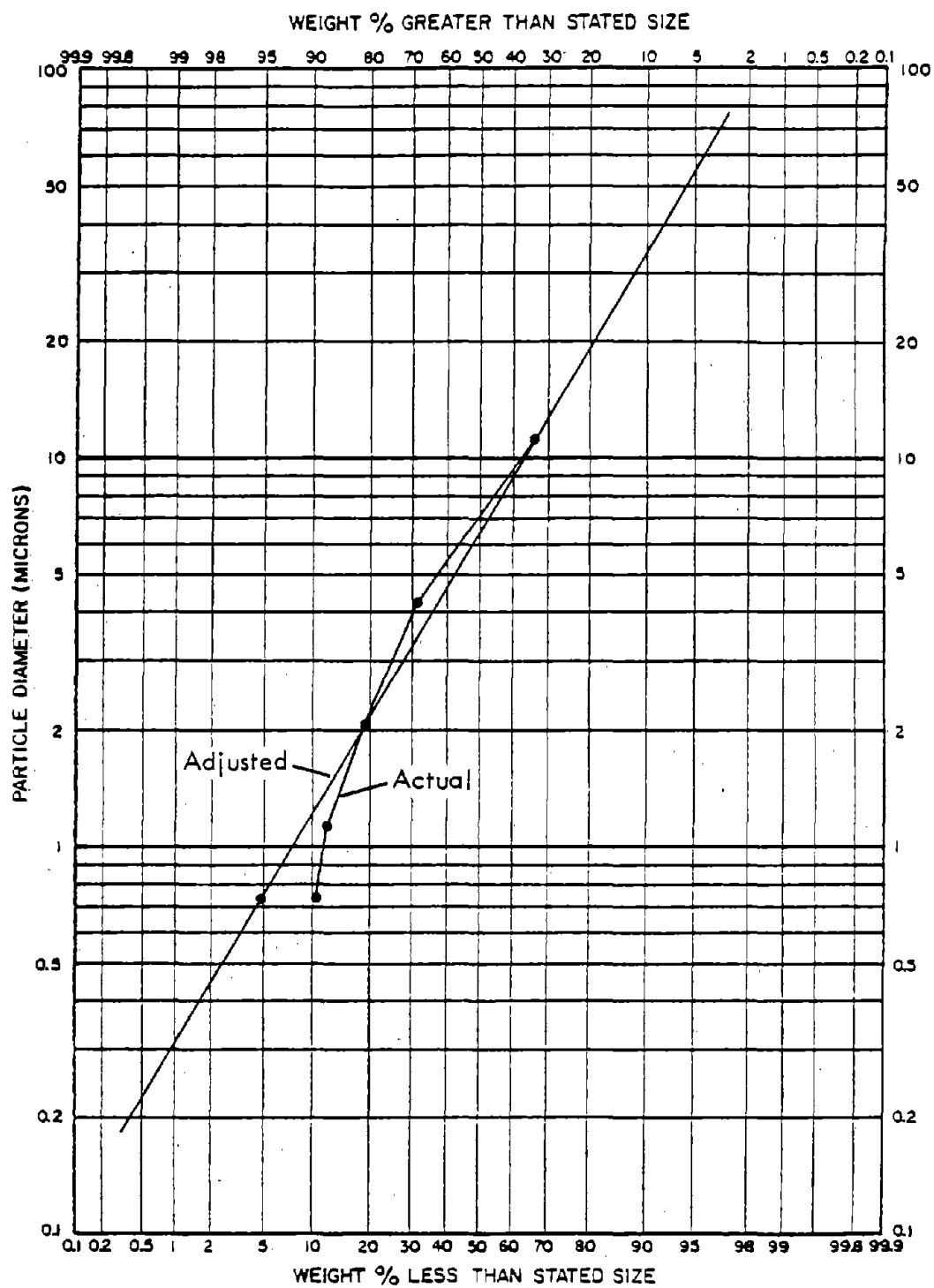


Figure B-19. Particle size distribution at the charging floor sampling location (5/12/81).

Only selected types of solid samples were collected for microbiological analysis because of the plant's mode of converting solid waste to energy. Solid waste samples were not collected because relatively homogeneous samples could not be obtained without an inordinate amount of difficulty. However, stationary dust samples were collected on a random basis from the charging floor, railings, and equipment surfaces.

Sampling Methods--A complete description of the sampling methods is presented in Appendix A.

Analytical Results--

Analytical results of microbiological samples collected at Plant D are presented in this section. The results of the bacteriological analysis of stationary dust samples are presented in Table B-12. The aerosol sample results are found in Tables B-13 and B-14.

Unfortunately, data from some of the samples collected in the field were lost due to a problem with the air carrier during shipment. The missing data included the LVAS indoor control sample (LVAS 2-4) for bacteriological analysis and two aerosol sample sets for virus analysis, i.e., production samples AGI and LVAS 3-1 and outdoor control samples AGI and LVAS 3-2.

Bacteriological--The average ($n = 3$) total bacteria concentration of the stationary dust was 1.3×10^8 bacteria/g with a range from 7.4×10^7 to 1.7×10^8 bacteria/g. Outdoor total bacteria aerosol levels were $< 2.0 \times 10^4$ bacteria/ m^3 (AGI) and 3.5×10^3 bacteria/ m^3 (LVAS). Indoor control total bacteria aerosol levels, which were taken when the plant was not operating, were 3.0×10^5 bacteria/ m^3 (AGI only). During normal plant operations, average total bacteria aerosol levels increased to 1.5×10^6 bacteria/ m^3 (AGI) and 1.2×10^6 bacteria/ m^3 (LVAS).

Stationary dust samples contained an average ($n = 3$) fecal coliform concentration of 17 fecal coliforms/g. Fecal coliform aerosols were not detected outside the plant, i.e., $< 40/m^3$ (AGI) and $< 1/m^3$ (LVAS). Similarly, fecal coliform aerosols were not detected by the AGI during outdoor sampling control (< 40 fecal coliforms/ m^3). During normal plant operations fecal coliform aerosols increased to 3.2×10^3 fecal coliforms/ m^3 (AGI) and 1.0×10^3 fecal coliforms/ m^3 (LVAS).

Salmonella isolates were detected both in a stationary dust and AGI-30 aerosol sample. Salmonella enteritidis, group G, was isolated by enrichment from a single dust sample with an overall concentration $< 2.0 \times 10^2$ cfu/g. Salmonella enteritidis group B was detected from an AGI sample at 2.0×10^3 cfu/ m^3 . The aerosol concentration was not statistically accurate, however.

No Shigella was detected in either solid or aerosol samples.

TABLE B-12. MICROBIOLOGICAL STATIONARY DUST SAMPLE RESULTS
OBTAINED AT PLANT D

Microbial assay	Microbiological results (cfu/g) ^a		
	2-2	3-1	3-2
Total bacteria	1.6×10^8	7.4×10^7	1.7×10^8
Fecal coliform	< 0.4	2.2×10^1	2.8×10^1
Salmonella sp.	< 2.0×10^2	< 2.0×10^2	< 2.0×10^2 ^b
Shigella sp.	< 2.0×10^2	< 2.0×10^2	< 2.0×10^2
Klebsiella sp.:			
pneumoniae	7.8×10^5	2.1×10^5	8.6×10^5
oxytoca	7.8×10^4	4.2×10^4	5.7×10^5
ozaenae	< 2.0×10^2	< 2.0×10^2	< 2.0×10^2
Staphylococcus aureus	< 2.0×10^2	< 2.0×10^2	< 2.0×10^2
Nocardia sp. ^c	6.0×10^3	2.0×10^3	2.0×10^3
Streptomyces sp.	< 2.0×10^2	8.0×10^3	1.2×10^4
Aspergillus fumigatus	< 2.0×10^2	< 2.0×10^2	< 2.0×10^2
Aspergillus flavus	< 2.0×10^2	< 2.0×10^2	< 2.0×10^2
Mycobacterium sp.	< 2.0×10^2	OG ^d	< 2.0×10^2

^a Less-than values, i.e., < 2.0×10^2 , indicate the overall minimum detection limits and that no microorganisms were detected.

^b Salmonella enteritidis group G isolated from enrichment only.

^c Nocardia sp. not asteroides or brasiliensis.

^d OG = Overgrown by molds.

TABLE B-13. MICROBIOLOGICAL COMPOSITION OF AEROSOL SAMPLES COLLECTED BY THE AGI-30 SAMPLER AT PLANT D.

Parameter	AGI-30 samples						Indoor control	Outdoor control
	1-1	1-2	2-1	2-3	2-5	2-7		
Sampling date	7/8/80	7/8/80	7/9/80	7/9/80	7/9/80	7/9/80	7/9/80	7/10/80
Air volume sampled (m ³)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Microbiological analysis (cfu/m ³) ^a								
Total bacteria	3.4 x 10 ⁶	1.4 x 10 ⁶	3.0 x 10 ⁵	1.8 x 10 ⁶	6.0 x 10 ⁵	3.0 x 10 ⁵	< 2.0 x 10 ⁴	< 2.0 x 10 ⁴
Fecal coliforms	4.8 x 10 ³	1.1 x 10 ⁴	4.0 x 10 ³	2.4 x 10 ²	4.0 x 10 ⁴	< 4.0 x 10 ⁴	< 4.0 x 10 ⁴	< 4.0 x 10 ⁴
Salmonella sp.	2.0 x 10 ^{3b,c}	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³
Shigella sp.	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³
Klebsiella sp.:								
K. pneumoniae	4.0 x 10 ^{3c}	1.0 x 10 ^{4c}	< 2.0 x 10 ³	8.0 x 10 ^{3c}	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³
K. oxytoca	2.2 x 10 ^{4c}	4.0 x 10 ^{3c}	2.0 x 10 ^{3c}	4.0 x 10 ^{3c}	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³
K. ozonae	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³
Staphylococcus aureus	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³
Nocardia sp.	< 2.0 x 10 ³	2.0 x 10 ^{3c}	< 2.0 x 10 ³	< 2.0 x 10 ³	2.0 x 10 ^{3c}	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³
Streptomyces sp.	< 2.0 x 10 ³	4.0 x 10 ^{4c}	< 2.0 x 10 ³	2.0 x 10 ^{4c}	2.0 x 10 ^{4c}	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³
Aspergillus fumigatus	< 2.0 x 10 ³	6.0 x 10 ⁴	< 2.0 x 10 ³	< 2.0 x 10 ³	8.0 x 10 ⁴	2.0 x 10 ^{3c}	< 2.0 x 10 ³	< 2.0 x 10 ³
Aspergillus flavus	< 2.0 x 10 ³	< 2.0 x 10 ³	2.0 x 10 ^{3c}	< 2.0 x 10 ³	8.0 x 10 ^{3c}	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³
Mycobacterium sp.	OG ^e	< 2.0 x 10 ²	< 2.0 x 10 ³	< 2.0 x 10 ²	OG	< 2.0 x 10 ²	< 2.0 x 10 ²	< 2.0 x 10 ²

^a Less-than values, i.e., < 2.0 x 10³, indicate the overall minimum detection limits and that no microorganisms were detected.

^b *Salmonella enteritidis*, group B.

^c Concentration based upon statistically unreliable microbial count, i.e., < 30 colonies per plate.

^d *Nocardia* sp. not *asteroides* or *brasiliensis*.

^e OG = Overgrown by molds.



TABLE B-14. MICROBIOLOGICAL COMPOSITION OF AEROSOL SAMPLES COLLECTED BY THE
LARGE VOLUME AIR SAMPLER (LVAS) AT PLANT D

Parameter	LVAS samples						Outdoor control 1-2
	1-1	1-2	2-1	2-2	2-3		
Sampling data							
Sampling date	7/8/80	7/8/80	7/9/80	7/9/80	7/9/80	7/10/80	
Air volume sampled (m ³)	11.5	30.0	62.0	60.0	44.0	46.5	
Microbiological analysis (cfu/m ³) ^a							
Total bacteria	6.6 × 10 ⁵	5.5 × 10 ⁵	2.4 × 10 ⁶	2.1 × 10 ⁶	5.0 × 10 ⁵	3.5 × 10 ³	
Fecal coliforms	> 4.0 × 10 ³	6.8 × 10 ²	7.0	3.0 × 10 ²	4.5	< 1.0	
Salmonella sp.	< 1.7 × 10 ²	< 7.4 × 10 ¹	< 5.8 × 10 ¹	< 5.6 × 10 ¹	< 5.7 × 10 ¹	< 5.0 × 10 ¹	
Shigella sp.	< 1.7 × 10 ²	< 7.4 × 10 ¹	< 5.8 × 10 ¹	< 5.6 × 10 ¹	< 5.7 × 10 ¹	< 5.0 × 10 ¹	
Klebsiella sp.:							
K. pneumoniae	2.0 × 10 ^{3b}	2.3 × 10 ³	4.1 × 10 ^{2b}	2.2 × 10 ³	1.6 × 10 ^{3b}	< 5.0 × 10 ¹	
K. oxytoca	1.3 × 10 ^{3b}	8.9 × 10 ^{2b}	1.2 × 10 ^{3b}	3.4 × 10 ^{2b}	4.0 × 10 ^{2b}	< 5.0 × 10 ¹	
K. ozonae	< 1.7 × 10 ²	3.0 × 10 ²	< 5.8 × 10 ¹	< 5.6 × 10 ¹	< 5.7 × 10 ¹	< 5.0 × 10 ¹	
Staphylococcus aureus	< 1.7 × 10 ²	< 7.4 × 10 ¹	< 5.8 × 10 ^{1b}	< 5.6 × 10 ¹	< 5.7 × 10 ¹	< 5.0 × 10 ¹	
Nocardia sp.†	1.7 × 10 ^{2b}	2.2 × 10 ^{2b}	< 5.8 × 10 ¹	1.1 × 10 ^{3b}	3.4 × 10 ^{2b}	< 5.0 × 10 ¹	
Streptomyces sp.	4.9 × 10 ³	7.4 × 10 ^{2b}	< 5.8 × 10 ¹	< 5.6 × 10 ¹	< 5.7 × 10 ¹	< 5.0 × 10 ¹	
Aspergillus fumigatus	< 1.7 × 10 ²	< 7.4 × 10 ¹	< 5.8 × 10 ¹	< 5.6 × 10 ¹	< 5.7 × 10 ¹	< 5.0 × 10 ¹	
Aspergillus flavus	< 1.7 × 10 ²	< 7.4 × 10 ¹	< 5.8 × 10 ¹	< 5.6 × 10 ¹	< 5.7 × 10 ¹	< 5.0 × 10 ¹	
Mycobacterium sp.	OG ^d	OG	OG	OG	OG	< 5.0 × 10 ¹	

^a Less than values indicate the overall minimum detection limits and that no microorganisms were detected.

^b Concentration based upon statistically unreliable microbial count, i.e., < 30 colonies per plate.

^c Nocardia species not N. asteroides or N. brasiliensis.

^d

The average Klebsiella pneumoniae concentration in stationary dust at Plant D was 6.2×10^5 cfu/g. The concentration of K. oxytoca in the dust was 2.3×10^5 cfu/g, while K. ozaenae was not detected at all, i.e., $< 2.0 \times 10^2$ cfu/g. Klebsiella aerosols were consistently detected during normal plant operations but not in the controls. The average K. pneumoniae aerosol levels were 4.4×10^3 cfu/m³ (AGI) and 1.7×10^3 cfu/m³ (LVAS). K. oxytoca aerosol concentrations were 6.4×10^3 cfu/m³ (AGI) and 8.3×10^2 cfu/m³ (LVAS). K. ozaenae aerosols were detected once with the LVAS at 3.0×10^2 cfu/m³.

Staphylococcus aureus was not detected in the stationary dust samples nor in most of the aerosol samples. Staphylococcus aureus aerosols were detected once with the LVAS at 5.8×10^1 cfu/m³.

Species of Nocardia other than N. asteroides or N. brasiliensis were consistently found in Plant D samples. This was the first plant in which Nocardia isolates were obtained. However, since the isolates were species other than the pathogens N. asteroides or N. brasiliensis, these findings are probably insignificant from an employee health viewpoint. Nocardia concentrations in the dust samples averaged 3.3×10^3 cfu/g. Average aerosolized Nocardia levels during normal plant operations were 3.7×10^2 cfu/m³ (LVAS). The presence of Nocardia aerosols was confirmed twice with the AGI at its detection limit of 2.0×10^3 cfu/m³. Nocardia aerosols were not detected in any of the control samples, i.e., $< 2.0 \times 10^3$ cfu/m³ (AGI) and $< 5.0 \times 10^1$ cfu/m³ (LVAS).

The average Streptomyces concentration of the stationary dust samples was 6.7×10^3 cfu/g. Streptomyces aerosols averaged 1.6×10^4 cfu/m³ with the AGI. Only the two air samples collected on the first sampling day with the LAVAS contained Streptomyces. These levels as detected with the LVAS were 7.4×10^2 and 4.9×10^3 cfu/m³. Streptomyces was not detected during control aerosol sampling.

Aspergillus fumigatus was not found in the stationary dust samples. A. fumigatus aerosols were detected only with AGI-30 during three sampling periods. The AGI-30 control sample taken when the plant was not operating contained a statistically unreliable concentration of A. fumigatus at 2.0×10^3 cfu/m³. In addition, two A. fumigatus aerosol concentrations detected during plant operation were 6.0×10^4 and 8.0×10^4 cfu/m³, respectively.

Aspergillus flavus was found in two AGI-30 aerosol samples taken on the same day. The statistically unreliable counts were 2.0×10^3 and 8.0×10^3 cfu/m³.

Mycobacteria were not found at Plant D within the analytical detection limitations.

Viral--The results of the virus analyses were completely negative within the detection limits specified. No human viruses were isolated in cell culture or in newborn mice. Similarly, viral particles were not observed by electron microscopy.

A summary of the analytical data for Plant D is included in Table B-15.

TABLE B-15. VIRUS COMPOSITION OF SAMPLES COLLECTED AT PLANT D

Sample No.	Date collected	Air volume sampled (m ³)	Virus isolation in cell cultures ^a (PHK, IEL, and MDCK) ^b (viral particles/m ³) ^c								Parainfluenza ^d	Newborn mice inoculation Cox. A.	Electron microscopy Rotavirus, etc.
			Adeno	Rhino	Herpes	Polio	Cox. B	ECHO	Influenza ^d				
AGI-2-2	7/9/80	0.5	< 20	< 20	< 20	< 12	< 12	< 12	< 30	< 30	< 60	< 9,600	
AGI-2-4	7/9/80	0.5	< 20	< 20	< 20	< 12	< 12	< 12	< 30	< 30	< 60	< 9,600	
AGI-2-6	7/9/80	0.5	< 20	< 20	< 20	< 12	< 12	< 12	< 30	< 30	< 60	< 9,600	
AGI-2-8 (Indoor control)	7/9/80	0.5	< 20	< 20	< 20	< 12	< 12	< 12	< 30	< 30	< 60	< 9,600	
LVAS-2-1	7/9/80	44.8	< 0.2	< 0.2	< 0.2	< 0.1	< 0.1	< 0.1	< 0.3	< 0.3	< 0.7	< 107	
LVAS-2-2	7/9/80	44.8	< 0.2	< 0.2	< 0.2	< 0.1	< 0.1	< 0.1	< 0.3	< 0.3	< 0.7	< 107	
LVAS-2-3	7/9/80	29.9	< 0.3	< 0.3	< 0.3	< 0.2	< 0.2	< 0.2	< 0.5	< 0.5	< 1.0	< 160	
LVAS-2-4 (Indoor control)	7/9/80	17.4	< 0.6	< 0.6	< 0.6	< 0.3	< 0.3	< 0.3	< 0.9	< 0.9	< 1.7	< 276	
Dust	7/9/80	-	< 1.1	< 1.1	< 1.1	< 0.7	< 0.7	< 0.7	< 1.7	< 1.7	< 3.4	< 550	

^a All less than values, e.g., < 20, indicate the theoretical minimum detection limits and that no viruses were detected.

^b PHK = Primary monkey (Cynomolgus) kidney; IEL = human embryonic lung; and MDCK = continuous Madin Darby canine kidney.

^c AGI and LVAS results are expressed as viral particles/m³. Dust results are expressed as virus particles/g.

^d Inoculated PHK and MDCK tubes were tested for hemagglutination and hemadsorption for detection of influenza and parainfluenza viruses.

Microbiological Aerosols: Plant G

Analytical results of the microbiological sampling program conducted by MRI at the Plant G resource recovery facility are presented in this section. The microbiological survey included analyses for selected bacterial indicator complexes and infectious agents (see Table 2). These assays were performed on aerosol, solid waste, and settled dust samples. It must be kept in mind that ambient environmental microbiology standards have not been established and that any microbiological results must be interpreted with care.

Sampling Sites--

Microbial aerosol samples were collected on the charging floor of Plant G between feed hoppers 1 and 2. All aerosol samples were collected during normal plant operations.

Two types of solid samples were collected for microbiological analysis: solid waste samples from hopper 1, and settled dust samples from the ledges surrounding the charging floor and hoppers.

Analytical Results--

The results from bacteriological analysis of solid waste and settled dust samples are presented in Table B-16. Aerosol sample results are found in Tables B-17 and B-18.

Total Bacteria--The average total bacteria concentration of solid waste at Plant G was 2.1×10^9 bacteria/g. Settled dust samples contained an average of 6.0×10^8 bacteria/g. Aerosol samples collected at Plant G contained 1.9×10^6 bacteria/m³ by the AGI method, versus 7.0×10^5 bacteria/m³ using the LVAS.

Total Molds--The average total mold concentration of the solid waste at Plant G was 6.2×10^5 molds/g. That stationary dust collected around the hoppers contained 7.7×10^6 molds/g.

Mold aerosols were detected by both the AGI and LVAS sampling methods. The average mold aerosol concentration was 1.2×10^5 molds/m³ when collected with the AGI-30. The aerosol samples collected by the LVAS contained 2.3×10^5 molds/m³.

Fecal Coliforms--Fecal coliforms were found in all of the solids samples. Solid waste samples contained an average of $\geq 2.5 \times 10^6$ fecal coliforms/g. Dust samples contained an average of $\geq 3.7 \times 10^6$ fecal coliforms/g.

Fecal coliforms were also detected in all of the aerosol samples collected at Plant G. AGI aerosol samples contained 2.3×10^2 fecal coliforms/m³. LVAS aerosol samples contained 4.7×10^2 fecal coliforms/m³.

TABLE B-16. MICROBIOLOGICAL SOLID SAMPLE RESULTS OBTAINED AT PLANT G

Parameter	Microbiological results (cfu/g) ^a							
	Solid waste samples				Dust samples			
	1-1	1-2	2-1	2-2	1-1	2-1	2-2	
Total bacteria	7.3 x 10 ⁸	7.2 x 10 ⁸	5.9 x 10 ⁹	9.2 x 10 ⁸	5.7 x 10 ⁸	1.2 x 10 ⁸	1.1 x 10 ⁹	
Total molds	9.6 x 10 ⁵	9.6 x 10 ⁵	3.6 x 10 ^{5b}	2.0 x 10 ^{5b}	2.1 x 10 ⁷	1.6 x 10 ^{5b}	1.9 x 10 ⁶	
Fecal coliforms	> 4.8 x 10 ⁶	> 4.8 x 10 ⁶	3.8 x 10 ⁵	7.0 x 10 ⁴	3.2 x 10 ⁶	3.2 x 10 ⁶	> 4.8 x 10 ⁶	
Salmonella sp.	< 2.0 x 10 ^{2c}	< 2.0 x 10 ²	< 2.0 x 10 ²	< 2.0 x 10 ²	< 2.0 x 10 ²	< 2.0 x 10 ²	< 2.0 x 10 ²	
Shigella sp.	< 2.0 x 10 ²	< 2.0 x 10 ²	< 2.0 x 10 ²	< 2.0 x 10 ²	< 2.0 x 10 ²	< 2.0 x 10 ²	< 2.0 x 10 ²	
Klebsiella sp.:								
K. pneumoniae	1.4 x 10 ⁵	1.6 x 10 ⁵	1.6 x 10 ^{6d}	2.1 x 10 ^{7d}	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	
K. oxytoca	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	
Staphylococcus aureus	1.6 x 10 ⁴	4.0 x 10 ³	< 2.0 x 10 ²	< 2.0 x 10 ²	< 2.0 x 10 ²	< 2.0 x 10 ²	< 2.0 x 10 ²	
Nocardia sp.	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	3.8 x 10 ^{4e}	< 2.0 x 10 ³	
Streptomyces sp.	7.7 x 10 ⁵	9.0 x 10 ³	3.4 x 10 ⁵	1.1 x 10 ⁴	5.0 x 10 ⁵	2.0 x 10 ⁴	< 2.0 x 10 ³	
Aspergillus fumigatus	1.8 x 10 ⁴	< 2.0 x 10 ²	< 2.0 x 10 ²	4.0 x 10 ³	< 2.0 x 10 ²	1.3 x 10 ⁵	6.0 x 10 ³	
Aspergillus flavus	< 2.0 x 10 ²	< 2.0 x 10 ²	< 2.0 x 10 ²	< 2.0 x 10 ²	< 1.0 x 10 ^o	< 2.0 x 10 ²	< 2.0 x 10 ²	
Mycobacterium sp.	< 2.0 x 10 ¹	< 2.0 x 10 ¹	OG ^f	6.0 x 10 ¹⁸	OG	OG	OG	

^a Less-than values, i.e., < 2.0 x 10², indicate the overall minimum detection limits and that no microorganisms were detected.

^b Concentration based upon statistically unreliable microbial count, < 30 colonies per plate.

^c Salmonella enteritidis group B isolated from enrichment broth only at numbers too low to count.

^d Concentrations extrapolated from extremely crowded plates.

^e Nocardia sp. not asteroides or brasiliensis.

^f OG = plates overgrown; data lost.

^g Mycobacterium sp. not tuberculosis. Isolates will be speciated.

TABLE B-17. MICROBIOLOGICAL COMPOSITION OF AEROSOL SAMPLES COLLECTED BY THE AGI-30 SAMPLER AT PLANT G^a

AGI-30 microbiological results (cfu/m ³) ^b						
	1-1	1-2	1-3	2-1	2-2	2-3
Sampling data:						
Sampling date	5/12/81	5/12/81	5/12/81	5/13/81	5/13/81	5/13/81
Air volume samples (m ³)	0.5	0.5	0.5	0.55	0.5	0.5
Microbiological assays:						
Total bacteria	8.6 x 10 ⁶	4.0 x 10 ^{5e}	8.6 x 10 ⁵	5.5 x 10 ⁵	4.8 x 10 ^{5e}	8.0 x 10 ^{5e}
Total molds	2.0 x 10 ^{4e}	N.D. ^c	N.D.	1.3 x 10 ^{5e}	2.2 x 10 ^{5e}	< 2.0 x 10 ^{4e}
Fecal coliforms	4.6 x 10 ²	1.0 x 10 ²	1.6 x 10 ²	2.0 x 10 ²	1.0 x 10 ²	3.4 x 10 ²
Salmonella sp.	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 1.8 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³
Shigella sp.	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 1.8 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³
Klebsiella sp.:						
K. pneumoniae	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 1.8 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³
K. oxytoca	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 1.8 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³
Staphylococcus aureus	< 2.0 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³	< 1.8 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ³
Nocardia sp.	4.0 x 10 ^{3d}	< 2.0 x 10 ³	< 1.8 x 10 ⁴	< 1.8 x 10 ³	< 2.0 x 10 ³	< 2.0 x 10 ^{3d}
Streptomyces sp.	8.0 x 10 ³	3.2 x 10 ⁴	1.3 x 10 ⁵	5.5 x 10 ³	3.0 x 10 ³	< 2.0 x 10 ³
Aspergillus fumigatus	2.0 x 10 ³	< 2.0 x 10 ³	4.4 x 10 ⁴	9.1 x 10 ³	6.0 x 10 ³	< 2.0 x 10 ³
Aspergillus flavus	< 2.0 x 10 ³	< 2.0 x 10 ³	2.0 x 10 ³	1.8 x 10 ³	< 2.0 x 10 ³	2.0 x 10 ³
Mycobacterium sp.	< 2.0 x 10 ²	< 2.0 x 10 ²	< 2.0 x 10 ²	< 1.8 x 10 ²	< 1.0 x 10 ²	< 2.0 x 10 ²

^a Samples were collected during normal plant operations.

^b Less than values, i.e., $< 2.0 \times 10^3$, indicate the overall minimum detection limits and that no microorganisms were detected.

^c N.D. = not done.

d *Nocardia* sp. not *asteroides* or *brasiliensis*.

^e Concentration based upon statistically unreliable microbial count, < 30 colonies per plate.

TABLE B-18. MICROBIOLOGICAL COMPOSITION OF AEROSOL SAMPLES COLLECTED BY THE LVAS AT PLANT G^a

		LVAS microbiological results (cfu/m ³) ^b					
		1-1	1-2	1-3	2-1	2-2	2-3
<u>Sampling data:</u>							
Sampling date	5/12/81	5/12/81	5/12/81	5/12/81	5/13/81	5/13/81	5/13/81
Air volume samples (m ³)	12.2	30.0	37.0	40.0	30.0	42.0	
<u>Microbiological assays:</u>							
Total bacteria	2.4 x 10 ⁶	6.6 x 10 ⁵	3.0 x 10 ⁵	1.9 x 10 ⁵	3.1 x 10 ⁵	3.6 x 10 ⁵	
Total molds	1.1 x 10 ⁵	3.9 x 10 ⁵	1.6 x 10 ⁵	3.1 x 10 ⁵	1.1 x 10 ⁵	3.2 x 10 ⁵	
Fecal coliforms	5.6 x 10 ²	1.0 x 10 ²	2.9 x 10 ²	2.7 x 10 ²	1.4 x 10 ³	2.0 x 10 ²	
Salmonella sp.	< 1.0 x 10 ²	< 7.9 x 10 ¹	< 8.3 x 10 ¹	< 7.7 x 10 ¹	< 8.7 x 10 ¹	< 7.2 x 10 ¹	
Shigella sp.	< 1.0 x 10 ²	< 7.9 x 10 ¹	< 8.3 x 10 ¹	< 7.7 x 10 ¹	< 8.7 x 10 ¹	< 7.2 x 10 ¹	
Klebsiella sp.:							
K. pneumoniae	< 1.0 x 10 ²	< 7.9 x 10 ¹	< 8.3 x 10 ¹	< 7.7 x 10 ¹	< 8.7 x 10 ¹	< 1.4 x 10 ²	
K. oxytoca	< 1.0 x 10 ²	< 7.9 x 10 ¹	< 8.3 x 10 ¹	< 7.7 x 10 ¹	< 8.7 x 10 ¹	< 7.2 x 10 ¹	
Staphylococcus aureus	< 1.0 x 10 ²	< 7.9 x 10 ¹	< 8.3 x 10 ¹	7.7 x 10 ²	< 8.7 x 10 ¹	< 7.2 x 10 ¹	
Nocardia sp.	8.3 x 10 ² c,d	1.1 x 10 ³ c,d	< 8.3 x 10 ¹	7.7 x 10 ² c,d	2.6 x 10 ² c,d	5.1 x 10 ² c,d	
Streptomyces sp.	1.2 x 10 ⁴	2.1 x 10 ⁴	1.2 x 10 ⁴	2.9 x 10 ⁴	1.7 x 10 ⁴	1.4 x 10 ⁴	
Aspergillus fumigatus	< 1.0 x 10 ²	< 7.9 x 10 ¹	7.3 x 10 ⁴	1.2 x 10 ⁴	4.4 x 10 ³	1.6 x 10 ⁴	
Aspergillus flavus	< 1.0 x 10 ²	1.0 x 10 ³ c	8.3 x 10 ² c	6.9 x 10 ² c	2.6 x 10 ² c	5.8 x 10 ² c	
Mycobacterium sp.	OG	OG	OG	OG	OG	OG	

^a Samples were collected during normal plant operations.

^b Less than values, i.e., < 1.0 x 10², indicate the overall minimum detection limits and that no microorganisms were detected.

^c Concentration based upon statistically unreliable microbial count, < 30 colonies per plate.

^d *Nocardia* sp. not *asteroides* or *brasiliensis*.

^e OG = overgrown by molds.

Salmonella sp.--Salmonella enteritidis group B was isolated from a solid waste sample (No. 1-1) collected on May 12, 1981 at Plant G. The Salmonella isolate was obtained from enrichment broth at numbers too low to detect by spread plate methodology ($< 2.0 \times 10^2$ cfu/g). No salmonella sp. were observed in any of the other samples.

Shigella sp.--Microorganisms of the genus Shigella were not detected in any of the samples collected at Plant G.

Klebsiella sp.--Of the Klebsiella sp., only K. pneumoniae were detected at Plant G. Solid waste samples contained an average of 5.7×10^6 K. pneumoniae/g. No Klebsiellae were detected in the dust samples.

Klebsiella pneumoniae aerosols were detected only by the LVAS. K. pneumoniae aerosols were detected in one-third of the LVAS samples at an average concentration of 1.1×10^2 cfu/m³ (when found).

Staphylococcus aureus--Staphylococcus aureus was found in 50% of the solid waste samples collected at Plant G, but in none of the dust samples. In solid waste, the average S. aureus concentration, when found, was 1.0×10^4 cfu/g.

S. aureus aerosols were detected once by the AGI and twice by the LVAS. AGI aerosol concentration of S. aureus was 2.0×10^3 cfu/m³. The average LVAS concentration of S. aureus was 4.3×10^2 cfu/m³.

Nocardia sp.--Nocardia was detected in one of the dust samples at Plant G, but in none of the solid waste samples. The dust sample contained 3.8×10^4 cfu/g solids and were species other than N. asteroides or N. brasiliensis.

Nocardia aerosols were recovered at Plant G quite frequently. Nocardia was recovered in 50% of the AGI samples at an average concentration, when found, of 8.0×10^3 cfu/m³. Similarly, Nocardia was found in over 80% of the LVAS samples with an average concentration of 6.9×10^2 cfu/m³. The Nocardia isolates obtained from the aerosol samples were all species other than N. asteroides and N. brasiliensis.

Streptomyces sp.--Streptomyces was found in most of the solid and aerosol samples collected at Plant G. Solid waste samples contained an average of 2.8×10^5 Streptomyces/g. When present, the Streptomyces content of the settled dust samples averaged 2.6×10^5 cfu/g. Streptomyces aerosols were detected at 3.6×10^4 cfu/g by the AGI method and 1.8×10^4 cfu/g by the LVAS.

Aspergillus fumigatus--Aspergillus fumigatus was found in 50% of the solid waste and 66% of the settled dust samples at Plant G. The average A. fumigatus concentration when present in solid waste was 1.1×10^4 cfu/g, while in the dust samples the concentration averaged 6.8×10^4 cfu/g.

A. fumigatus aerosols were detected in 66% of the AGI and LVAS samples collected. The average A. fumigatus aerosol concentration when detected by the AGI was 1.5×10^4 cfu/m³. The average concentration by the LVAS method was 2.6×10^4 cfu/m³.

Aspergillus flavus--Aspergillus flavus was detected in a majority of the aerosol samples but in none of the solid samples at Plant G. A. flavus aerosols were detected in 66% of the AGI samples at an average concentration of 2.0×10^3 cfu/m³, when detected. The LVAS detected A. flavus aerosols in 83% of the samples at average concentrations of 6.7×10^2 cfu/m³, when detected.

Mycobacterium sp.--Microorganisms of the genus Mycobacterium were isolated in one of the solid waste samples at Plant G. Mycobacterial organisms other than M. tuberculosis were isolated in Sample 2-2 collected on May 13, 1981. The Mycobacterium sp. concentration in the solid waste sample was 60 cfu/g.

Noise Exposures

The following sections detail the noise exposure survey results from plants designated D and G. These noise surveys of work areas were conducted as part of the overall industrial hygiene assessment of the facilities. Three measurement techniques were used for evaluating noise exposures: a general plant survey utilizing a precision (NIOSH type 1) sound level meter, octave band analysis at the most significant noise level locations, and personnel dosimetry of selected, at-risk employees.

OSHA, NIOSH and ACGIH Standards--

The current OSHA standard and the proposed NIOSH and ACGIH standards are presented in Table B-19. However, OSHA and other standards are based on personal noise exposure rather than source generation levels. Therefore, compliance efforts should not be based solely on noise level production by the equipment, but rather on time/motion studies or personnel dosimetry.

Plant D Results--

Average noise levels throughout the plant were measured with the handheld General Radio sound level meter on the second day of the MRI survey. Readings were taken in all major areas of concern. Results are presented in the diagrams shown in Figures B-20 through B-24.

TABLE B-19. OSHA NOISE STANDARDS AND SUGGESTED OR PROPOSED STANDARDS

Exposure (hr/day)	Continuous noise		
	OSHA (dBA)	ACGIH (dBA)	NIOSH proposed (dBA)
16		80	85
8	90	85	85
4	95	90	90
2	100	95	95
1	105	100	100
1/4	115 (max)	110	110
1/8		115 (max)	115 (max)

Impact of impulse noise^a

Sound pressure level (dB)	OSHA	ACGIH
140	Not to exceed	100 ^b
130	140 dB	1,000
120		10,000

^a Impacts at intervals > 500 ms.

^b Maximum number of impacts permitted per 8-hr day.

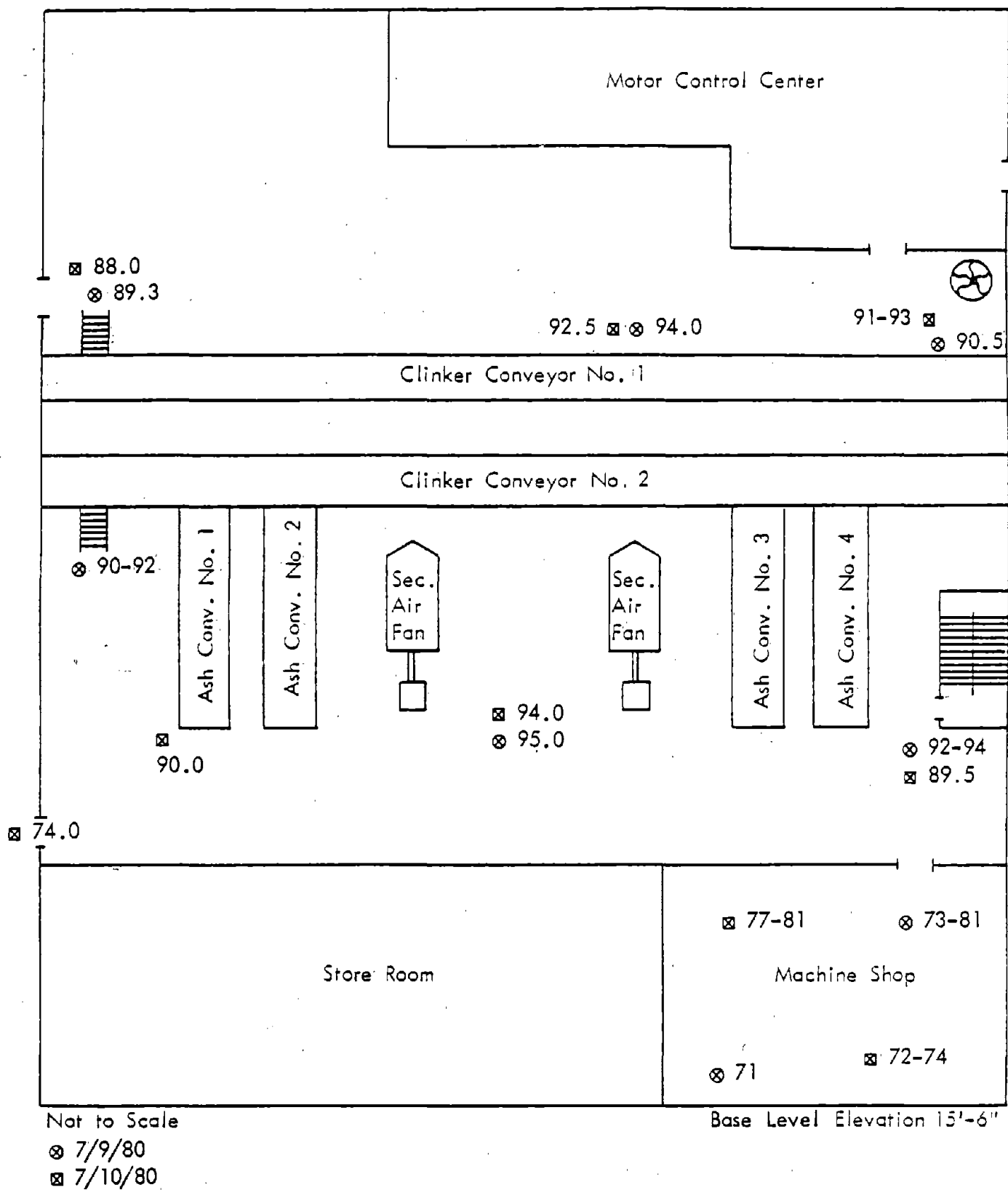
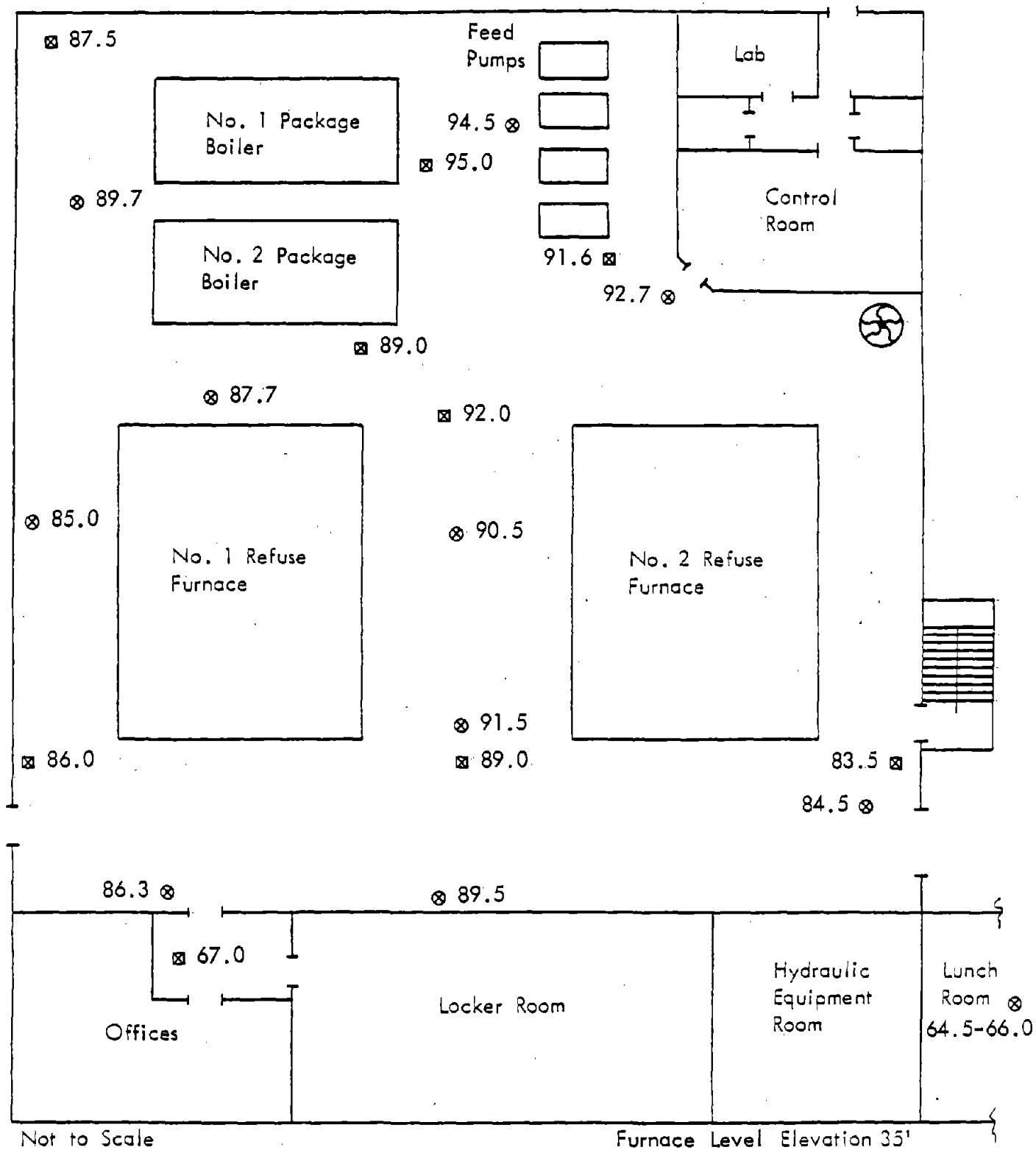


Figure B-20. Noise measurements on base level (ash quench).



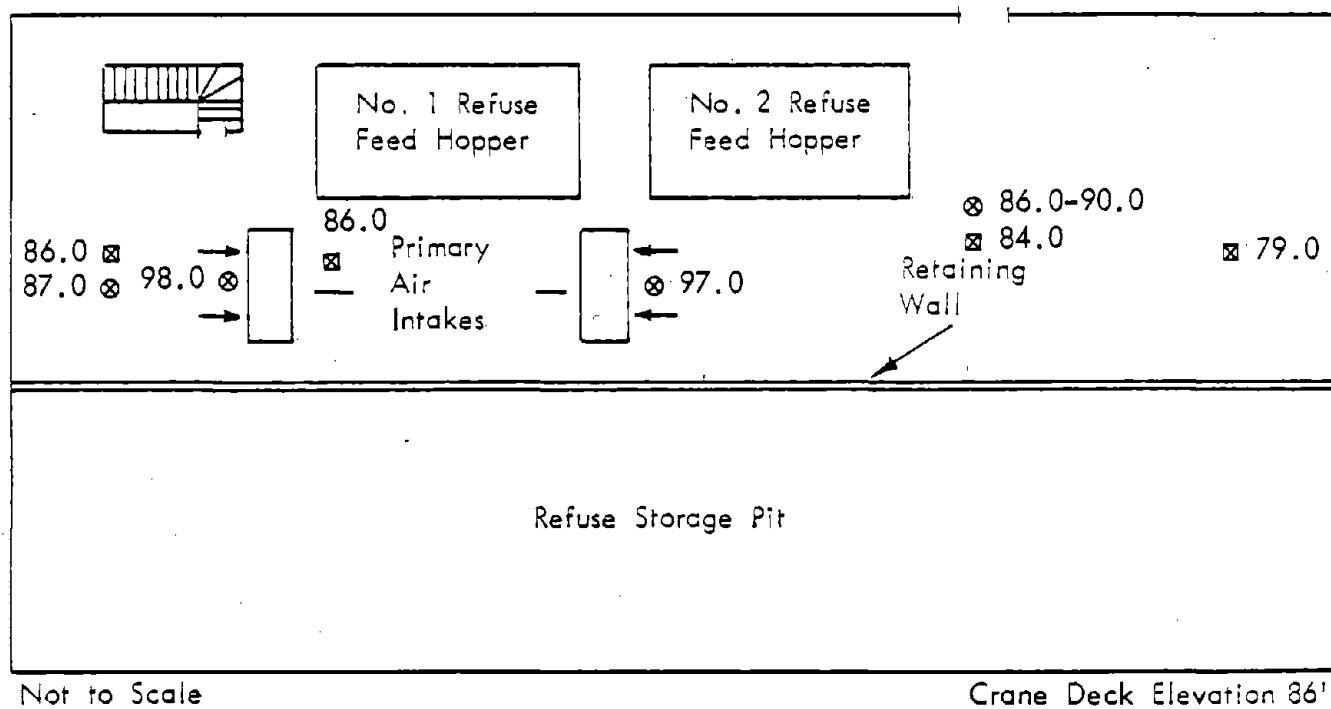
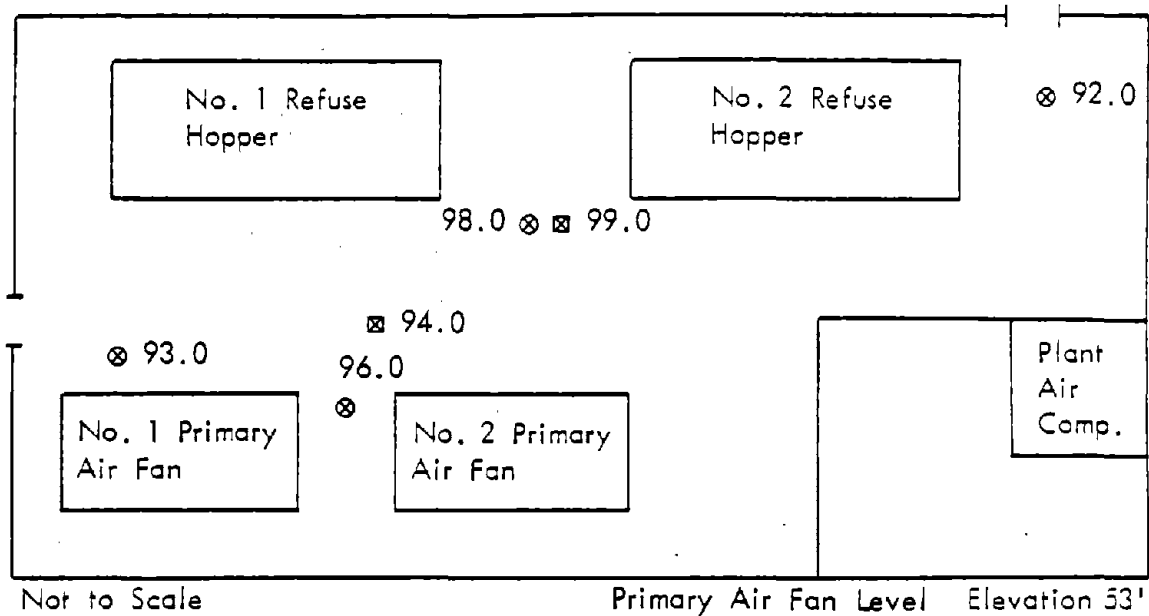
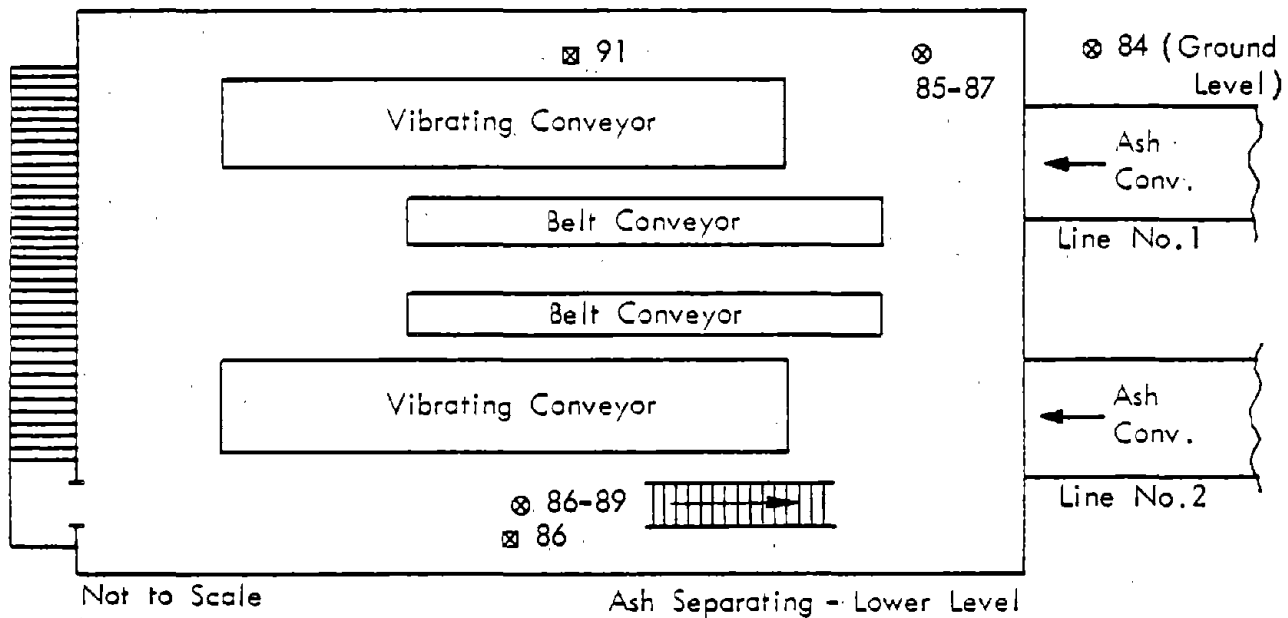
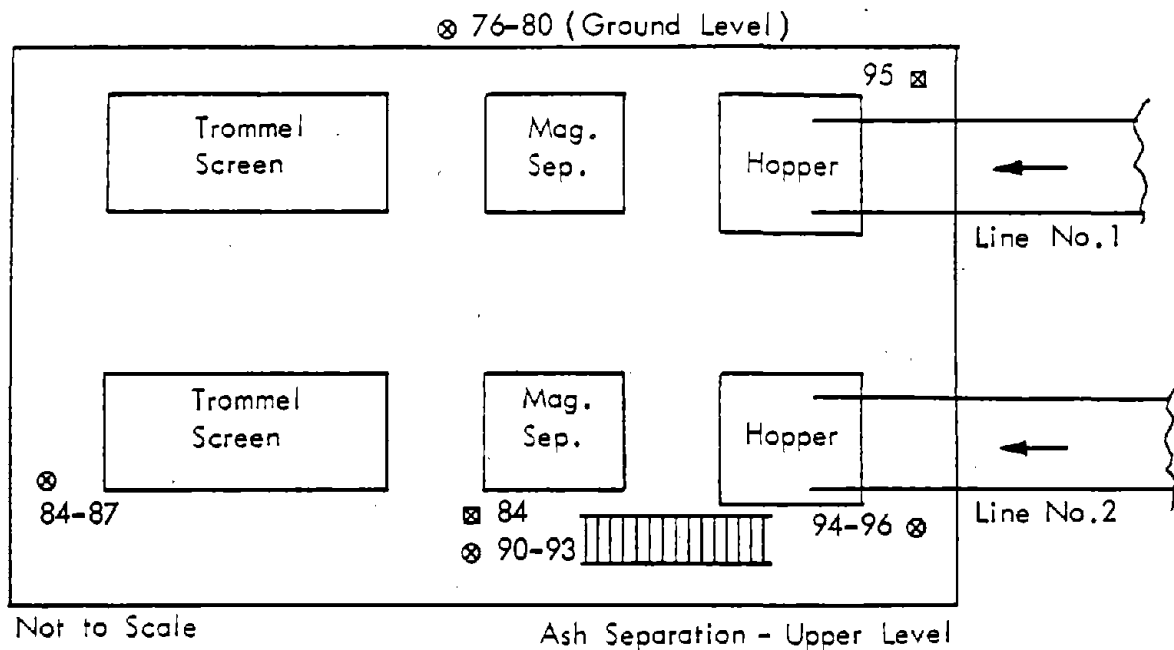


Figure B-22. Noise measurements on the primary air fan level and crane deck.



⊗ 7/9/80: Line No.1 Not Operating
 ⊗ 7/10/80: Line No.2 Not Operating

Figure B-23. Noise measurements in ash separation equipment building.

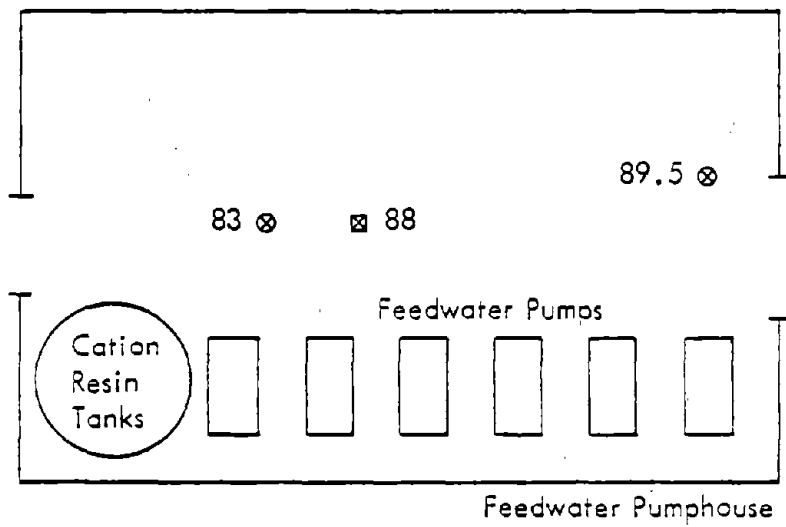
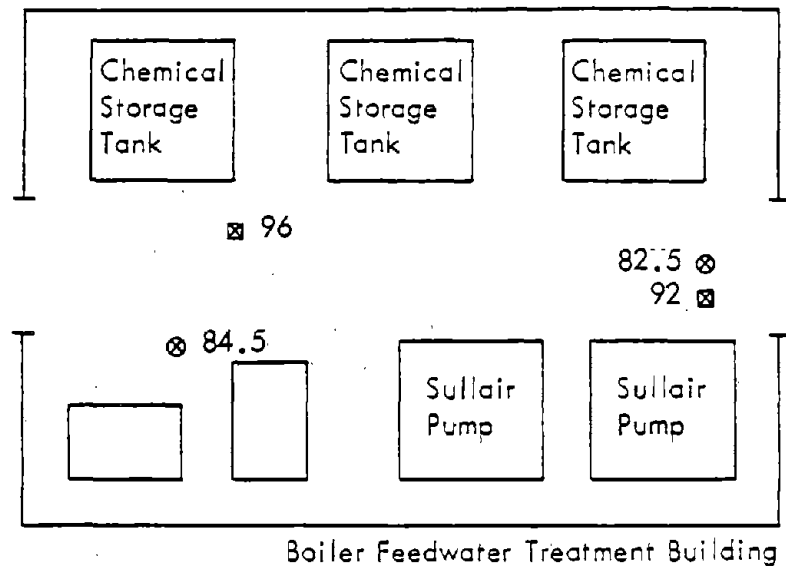


Figure B-24. Noise measurements in boiler feedwater treatment buildings.

Within the confines of the main building, noise levels ranged from 84 to 99 dBA (exclusive of areas such as the machine shop, control room, and lunch room). The highest readings were obtained near the primary and secondary air fans and intakes and near the feed pumps located adjacent to the control room. A summary of the general noise levels by area is given below.

<u>Plant area</u>	<u>Noise levels (dBA)</u>
Base level/ash quench (elevation 15 ft 6 in. (4.7 m))	88 to 95
Main level/furnace and control room (elevation 35 ft (10.7 m))	83.5 to 95
Primary air fan level (elevation 53 ft (16.2 m))	92 to 99
Crane deck (elevation 86 ft (26.2 m))	79 to 98
Ash processing structure	84 to 96
Feedwater treatment building	82.5 to 96
Feedwater pumphouse	83 to 89.5

Noise levels on the crane deck were influenced largely by the activity and number of cranes in operation, whereas the other areas of the plant had relatively constant noise levels. The greatest degree of short-term sound level fluctuation occurred in the ash processing area because of impact noise from falling pieces of metal.

The actual noise exposures of employees varies from the general plant area noise levels according to the degree of employee mobility in and about the facility. To determine actual dosages, noise dosimeters were worn by several of the Plant D workers during the MRI survey. These dosimeters measured the actual noise exposures of these men as they went about their normal duties for their entire work shift. Results are shown in Table B-20.

All of the workers monitored showed noise exposure doses within the limitation set by OSHA (90 dBA for 8 hr) with the exception of the pipefitter. This employee spent the entire work shift repairing one of the feed pumps located next to the plant control room. This is a high noise area as indicated by the sound level readings taken there on two consecutive days, and the employee should have been wearing hearing protection (he was not). Exposures of the other monitored employees were mitigated by their mobility. They moved in and out of the higher noise level areas and spent time in the maintenance shop, control room, or outdoors where the noise exposure is greatly reduced.

The noise characteristics of two major noise sources, the primary air fans and the furnace chambers, were evaluated using an octave band analyzer. Sound level readings were recorded as the mean value at each band setting and also as the peak value for each octave band.

TABLE B-20. RESULTS OF PERSONNEL NOISE DOSIMETRY--PLANT D

Job category	7/9/80		7/10/80	
	Percent allowable dose ^a	Calculated equivalent SPL ^b	Percent allowable dose ^a	Calculated equivalent SPL ^b
Receiving pit sweeper	58	86	47	84.5
Crane deck sweeper	-	-	36	82.5
Pipefitter (furnace Level)	143	92	-	-
Maintenance (ash quench)	67	87	-	-
Laborer (ash quench)	-	-	63	86.5
Assistant operator	-	-	40	83

^a Based on OSHA criteria of 90 dBA for 8 hr.

^b SPL = Sound pressure level (a logarithmic scale that is not proportional to the percent allowable dose).

Results of these measurements are presented graphically in Figures B-25 through B-28. Measurements made near the primary air fans are shown in Figures B-25 and B-26, while Figures B-27 and B-28 represent the sound characteristics determined at the furnace chamber location.

Both noise sources produced higher sound levels at the lower end of the frequency spectrum, particularly below 250 Hz. These findings are what one might expect based on the size of the equipment producing the noise, plus the fan and air speeds involved (relatively slow fan speed and turbulent air movement). When corrected to the dBA scale (see Figures B-26 and B-28), the noise profiles show peak levels to be in the 1,000- to 4,000-Hz range. Thus, these noise sources also produce components which may be harmful from a human exposure standpoint.

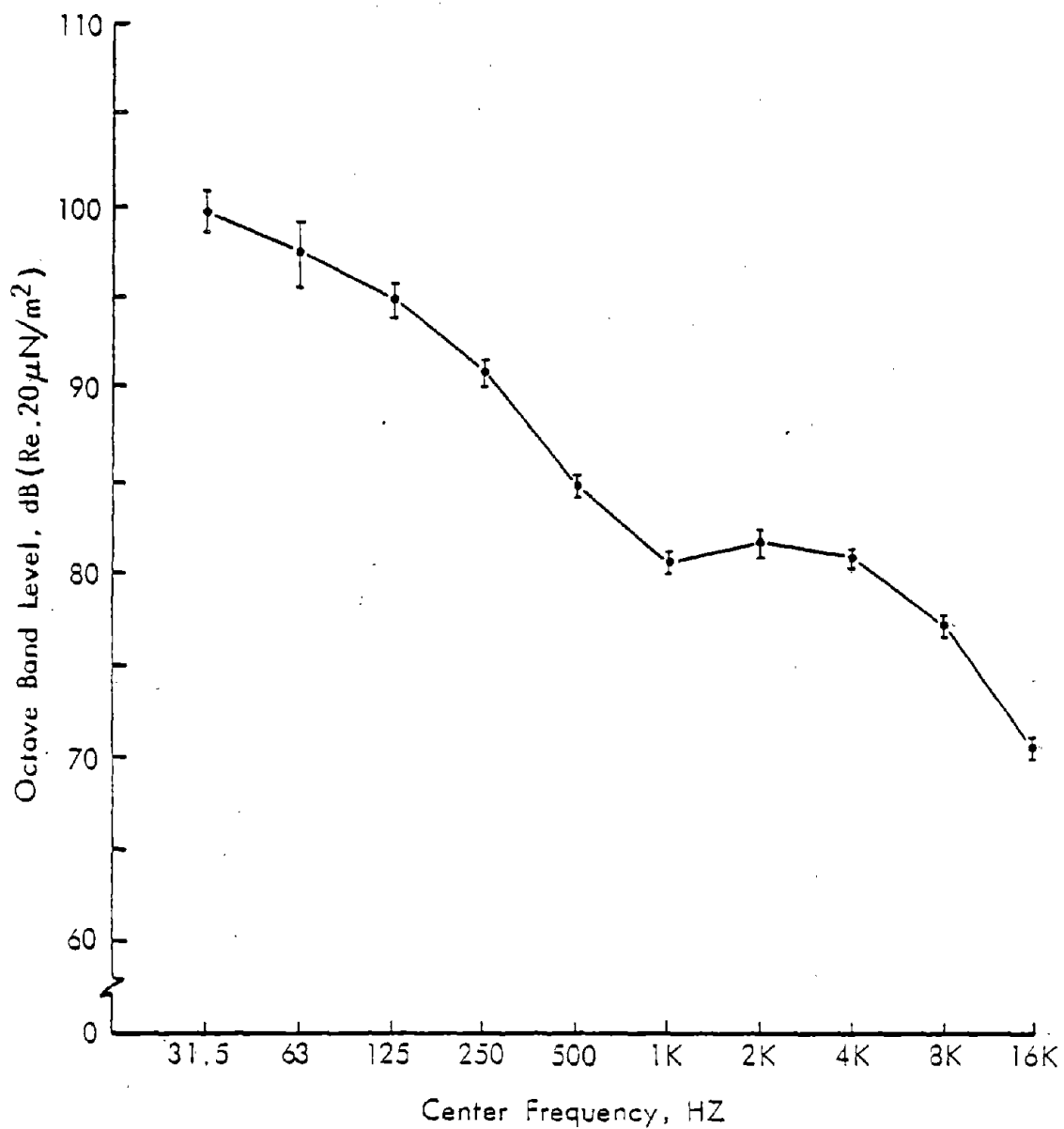


Figure B-25. Mean noise levels on furnace floor at a location midway between No. 1 and No. 2 units at 10 octave band center frequencies.

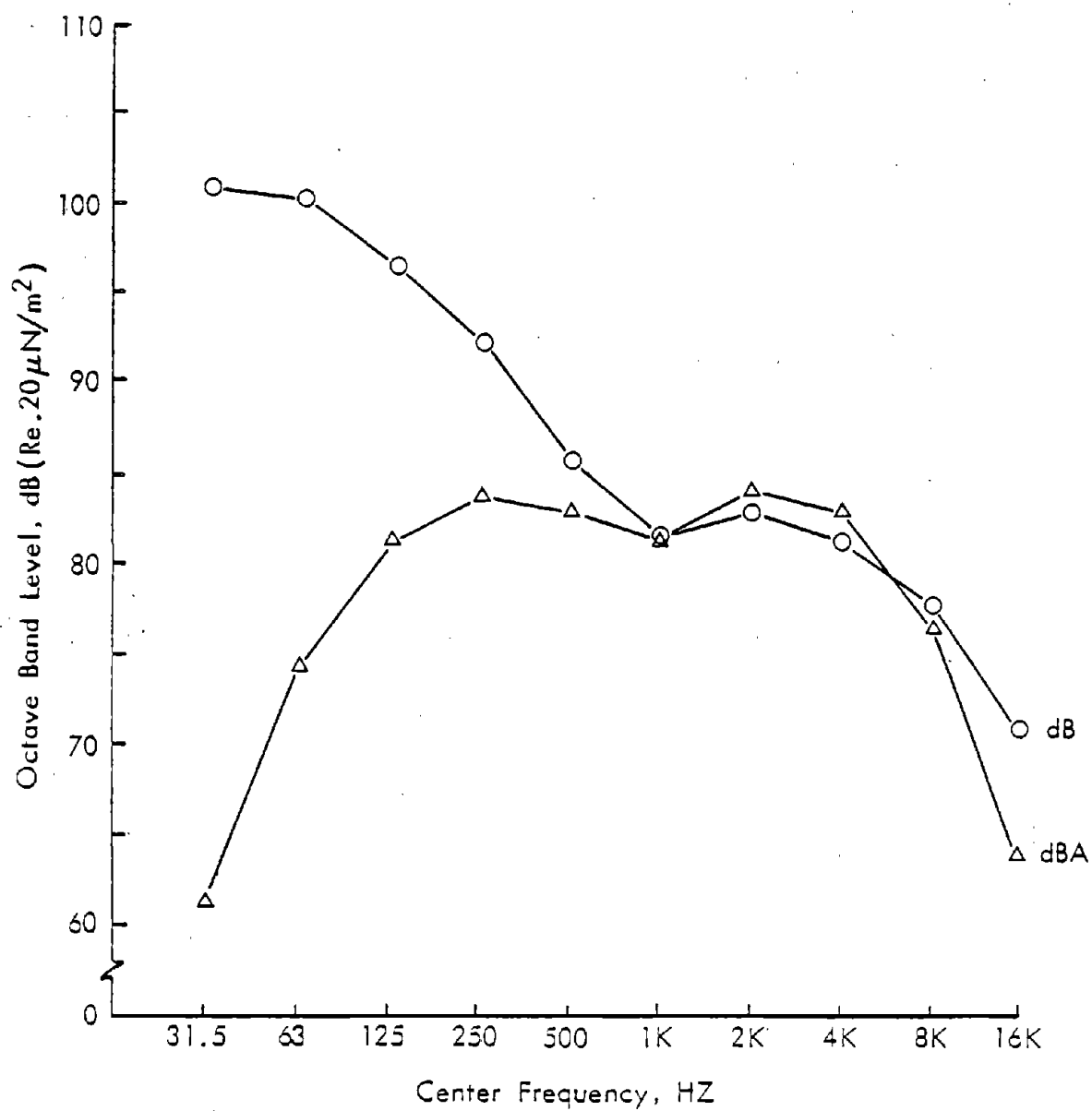


Figure B-26. Maximum noise levels on furnace floor at a location midway between No. 1 and No. 2 units at 10 octave band frequencies.

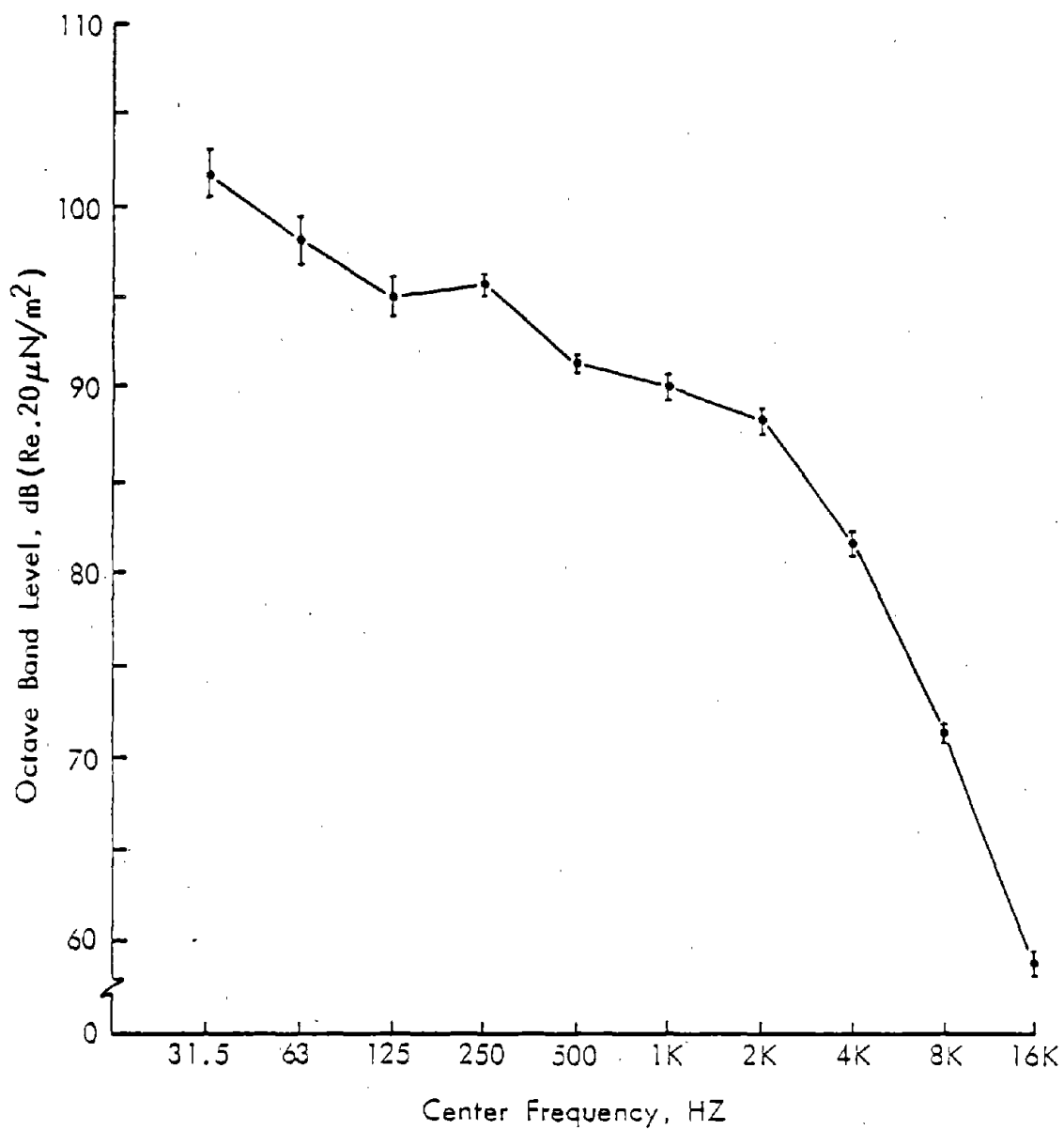


Figure B-27. Mean noise levels near primary air fans at 10 octave band center frequencies.

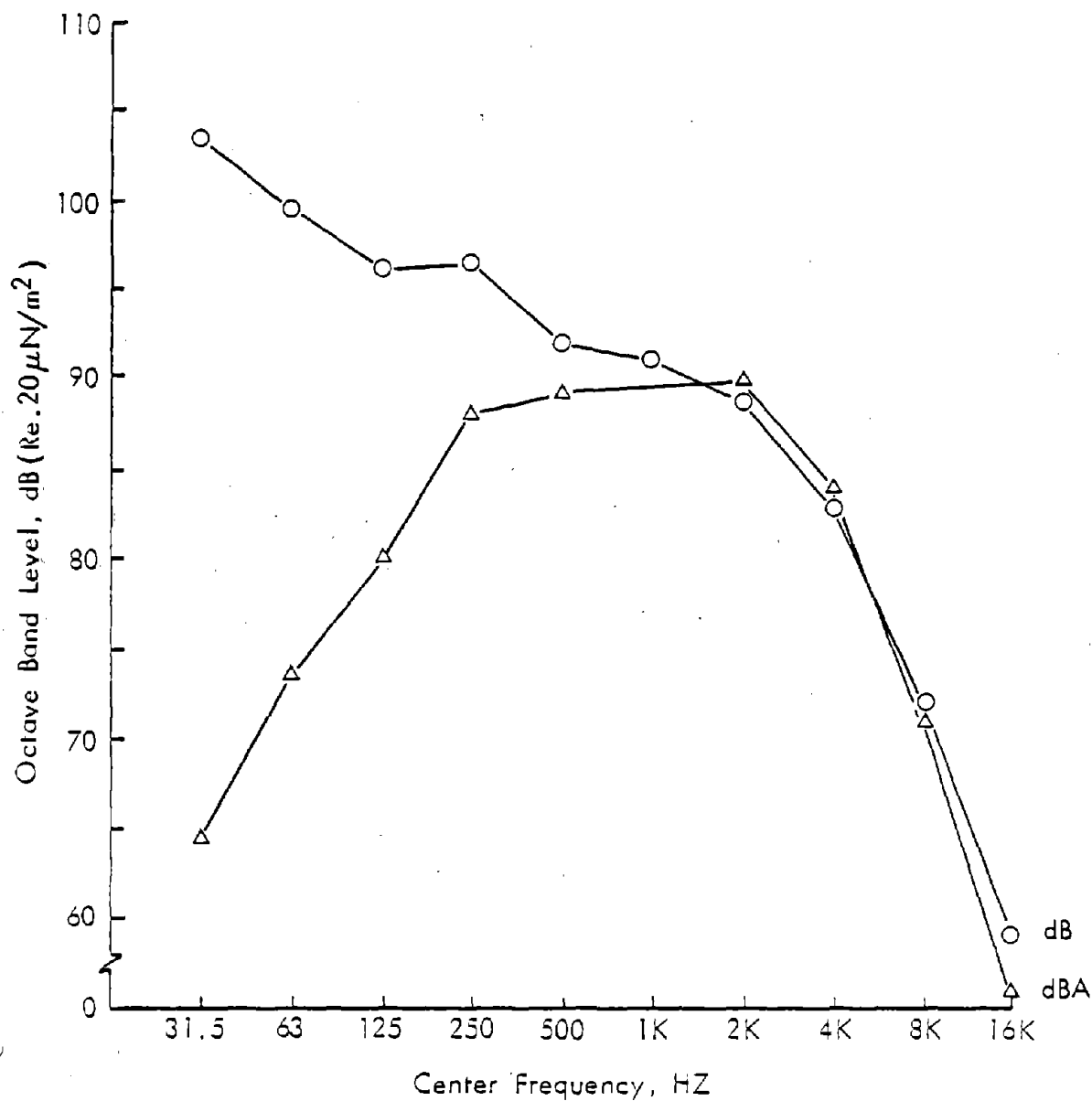


Figure B-28. Maximum noise levels near primary air fans at 10 octave band center frequencies.

Plant G Results--

Average noise levels throughout the plant were measured with the handheld sound level meter on 2 days of the survey. Readings were taken in all major areas of concern and are shown in the diagram in Figures B-29 through B-31.

Noise levels in the tipping floor areas were highly variable, depending upon the number of vehicles within the area and their particular activity, as well as the distance from the noise sources. When no refuse trucks were in the tipping floor area, the sound pressure level readings remained near 80 dBA. When two trucks entered and began unloading, the levels rose from 87 to 92 dBA. With four to six trucks arriving, readings up to 94 dBA were recorded. The maximum observed noise level of 99 dBA was reached when two trucks were in the process of unloading and the plant's front-end loader was in operation nearby. All readings were taken near the traffic monitor's booth along the wall directly opposite the dumping bays.

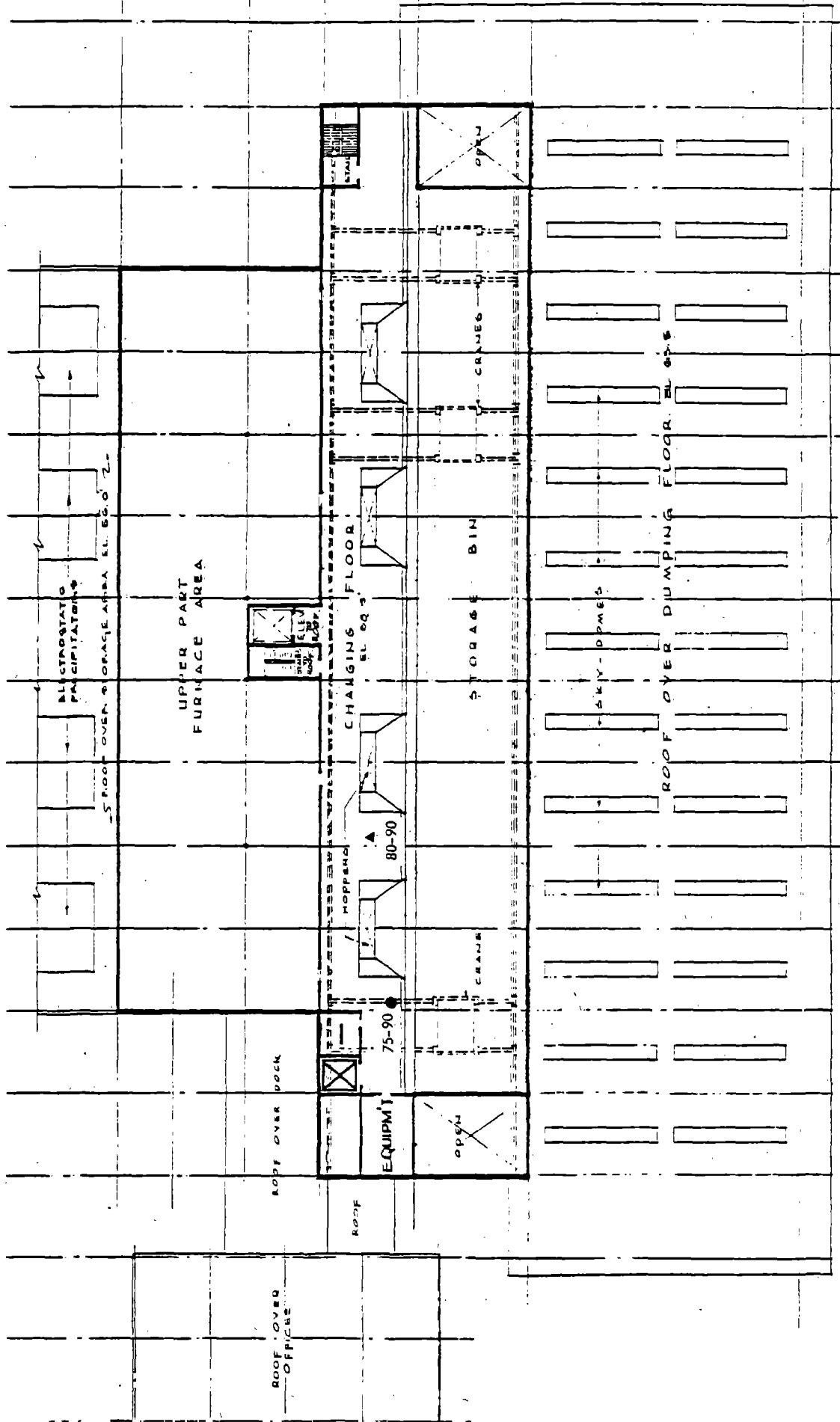
The level of truck activity reaches a peak in the late morning and also in mid-afternoon when most of the collection crews complete their rounds. Although the noise levels generally increase with the number of refuse trucks in the area, the activity of the front-end loader used to help pile the incoming refuse at the ends of the storage pit has the greatest influence on the instantaneous sound level measurements.

Much like the tipping floor, the sound pressure level at a single location on the charging floor is a function of the number of cranes in operation and their level of activity. With no truck activity on the tipping floor and two cranes in operation, readings of 75 to 90 dBA were recorded. The bottom end of the range increased to 80 dBA when trucks began dumping into the pit. The upper end, however, remained at about 90 dBA and occurred whenever a crane passed near the measurement location.

The furnace level of the plant was found to have a lower overall noise level than the other work areas because of the general lack of major noise-producing equipment on the furnace level. The range of noise readings obtained during the MRI survey was 86 to 90 dBA. Only near the two hydraulic pump stations along the west wall did the levels exceed 85 dBA.

Sound pressure level readings varied quite widely in the ash handling areas of Plant G, ranging from 76 to 99 dBA. The major pieces of noise generating equipment on this floor are the four forced-draft combustion fans. At a distance of about 3 ft (0.9 m) from the No. 1 boiler fans, for example, the measured sound pressure levels were 95 to 99 dBA. In the areas adjacent to these fans, the noise levels were generally above 85 dBA and only dropped below that level at an appreciable distance from the operating units. (Only units 1 and 3 were in operation during the MRI survey.)

Noise levels at the point where the ash falls onto the two ash-handling conveyors ranged from 83 to 90 dBA, depending upon the amount of noise generated by the material hitting the conveyor surface. Ash is discharged from the quench troughs above the conveyors in clumps at regular intervals, thus creating fluctuations in the sound pressure levels produced.



(● - on 5/12/81 ; ▲ - on 5/13/81)

Figure B-29. Noise measurement results on charging floor.



Figure B-30. Noise measurement results on furnace floor.

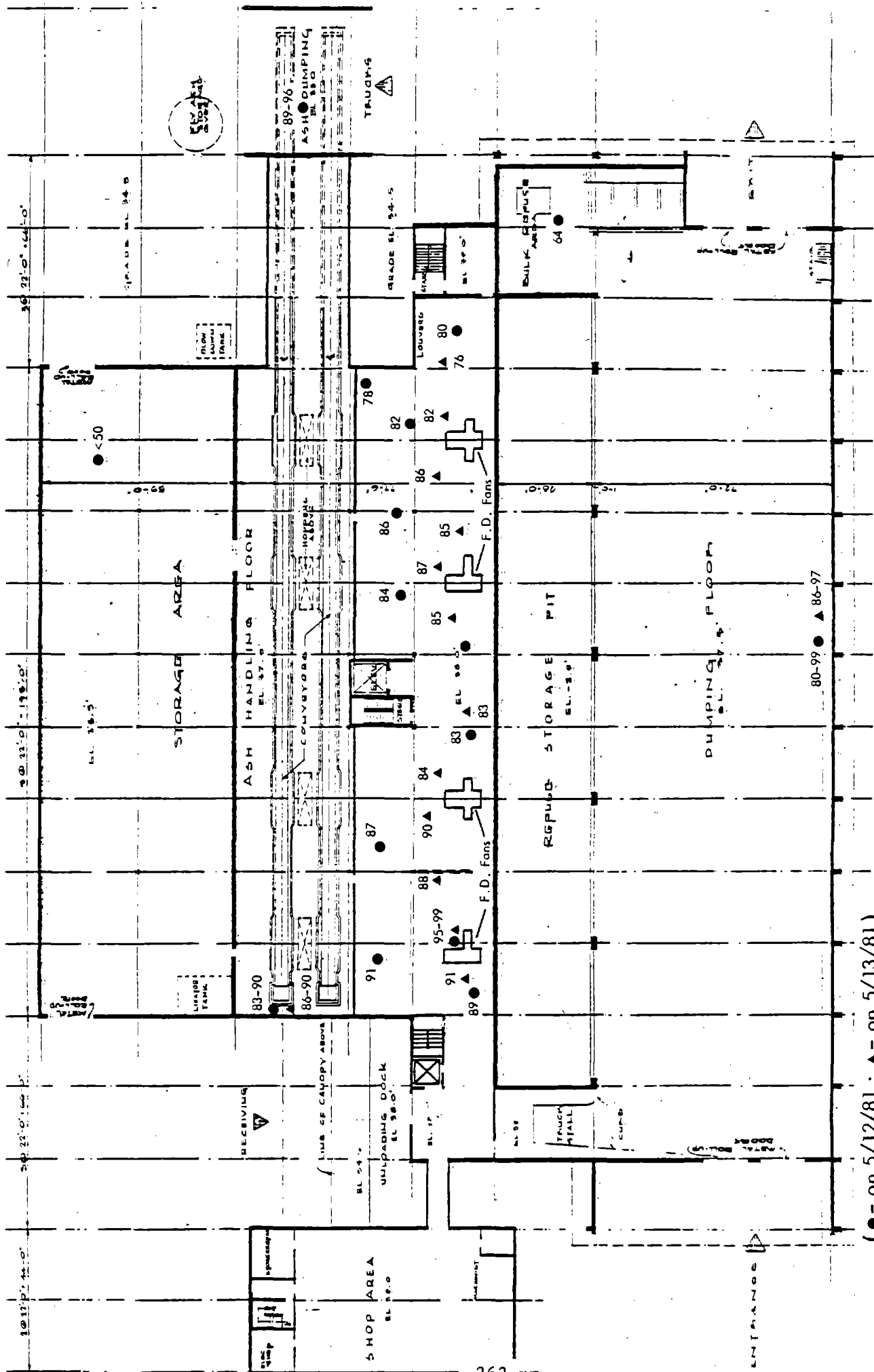


Figure B-31. Noise measurement results on tipping floor and in ash handling areas.

High noise readings were obtained at the ash separation station (ash house). Measurements were made at the ash watchman's location directly above the conveyor discharge into the trommel screens. The recorded levels of 90 to 96 dBA are the results of material tumbling in the rotary screens, as well as other impact noise from falling chunks of metal.

The daily noise exposures of the employees at Plant G are determined by the amount of time they spend in each location having a different noise level. Since their job activities often vary each day, their exposures over an 8-hr period cannot be estimated from the area measurements discussed in the preceding section. Therefore, to determine their actual noise dosages, several workers at Plant G wore noise dosimeters for their full work shifts. These workers were selected for monitoring because they appeared to have the greatest potential for noise overexposure based on the OSHA standard.

The results of the monitoring are shown in Table B-21 below.

TABLE B-21. RESULTS OF PERSONNEL NOISE DOSIMETRY--PLANT G

Job classification	Exposure range (dBA)	Cumulative exposure (dBA)
Tipping floor spotter	62-99	89.0
High lift operator	62-92	84.4
Trommel watch (ash house)	79-98 ^a	92.9 ^a
Crane operator	60-106	89.1
	71-106	86.8
Oiler (maintenance)	60-94 ^b	82.3 ^b
Laborer (ash floor)	60-97 ^b	90.6 ^b

^a Since the workers stationed at the ash house watch post are rotated approximately every 2-1/2 hr, the dosimeter was worn by three different workers. The cumulative exposure value, therefore, is indicative of a single worker's noise dose if he were to be stationed at this location for a full 8-hr shift.

^b Short-term sample; only 3 hr 45 min.

None of the dosimetry measurements indicated a worker exposure in excess of the standard (90 dBA over an 8 hr period). The laborer who was monitored had a cumulative dose of 90.6 dBA, but for a period of only 3 hr and 45 min. A delay in finding an appropriate employee at the start of the work shift who would agree to be monitored led to a shorter monitoring period. The cumulative exposure of 92.9 dBA recorded at the ash house location was the

combined product of three short-term exposures corresponding to each of the workers stationed at the watch post. This was done to assess the full-shift exposure since each worker is relieved after about 2-1/2 hr of duty in the ash house and then is assigned to work in a quieter area.

Two other employees had recorded noise exposures near the regulated limit: the spotter on the tipping floor at 89.0 dBA and a crane operator at 89.1 dBA. The crane operator was monitored on two successive days, and both times showed noise exposures as high as 106 dBA during the first hour of work shift. For the remainder of the shift, exposure was generally below 90 dBA. It is postulated that perhaps a compressed air hose was being used to clean off the crane cab at the start of each shift. An investigation by the Plant G supervisors is needed to ascertain why the noise levels experienced by the crane operator are as high as those measured by MRI.

The relatively high exposure recorded by the tipping floor spotter can be correlated with the level of vehicle activity in the area. This worker's exposure was only moderate until approximately 10:30 AM when refuse trucks began arriving, and it remained high until the noon lunch break.

To determine the sound level frequency characteristics of the most prominent noise sources within Plant G, an octave band analyzer was used for the survey. From the general noise survey of the plant, the forced draft combustion fans on the ash-handling level and the hydraulic pump stations on the furnace level were found to be the highest, consistent noise generators. Octave band analyses were therefore conducted at the No. 1 forced draft fan and the hydraulic pump station which serves the furnaces 3 and 4. The sound level readings were recorded as the 10 second integrated value at each band setting. Results are presented graphically in Figures B-32 and B-33.

As can be seen in Figure B-32, a definite peak in the sound levels is evident at 1,000 to 2,000 Hz, which is in the range of greatest human sensitivity. The noise generated by this fan and motor is very irritating to anyone in its immediate vicinity and could cause potential hearing impairment if a worker were to be exposed to it for long periods of time (> 3 hr).

The hydraulic pump station also exhibited its strongest noise characteristic at 2,000 Hz (89.6 dBA), but at a much less significant level than was the case with the forced draft fan. An employee could be stationed near this source for the entire work shift without risking likely hearing impairment.

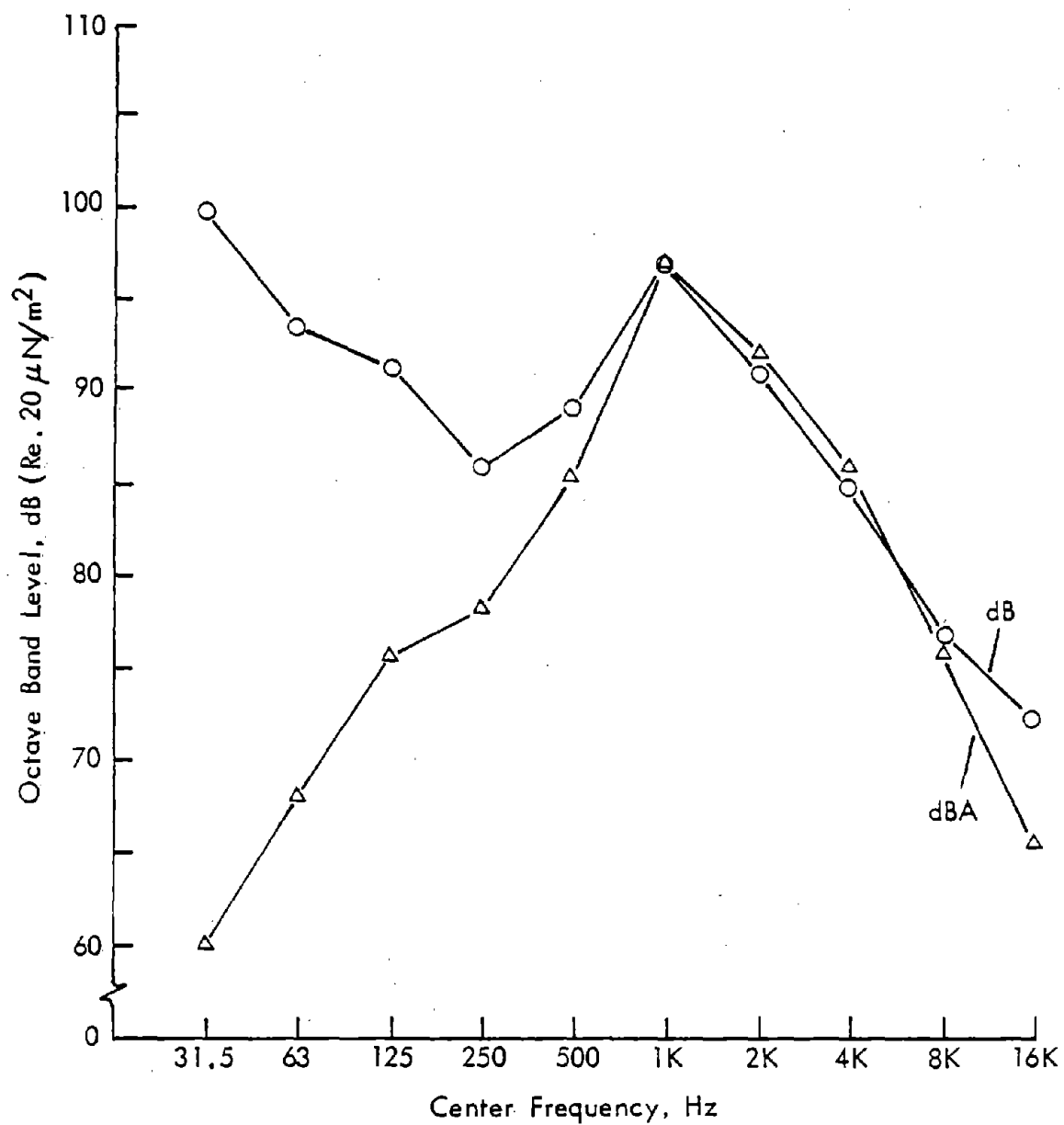


Figure B-32. Average sound pressure levels at 10 octave band center frequencies; No. 1 forced draft fan.

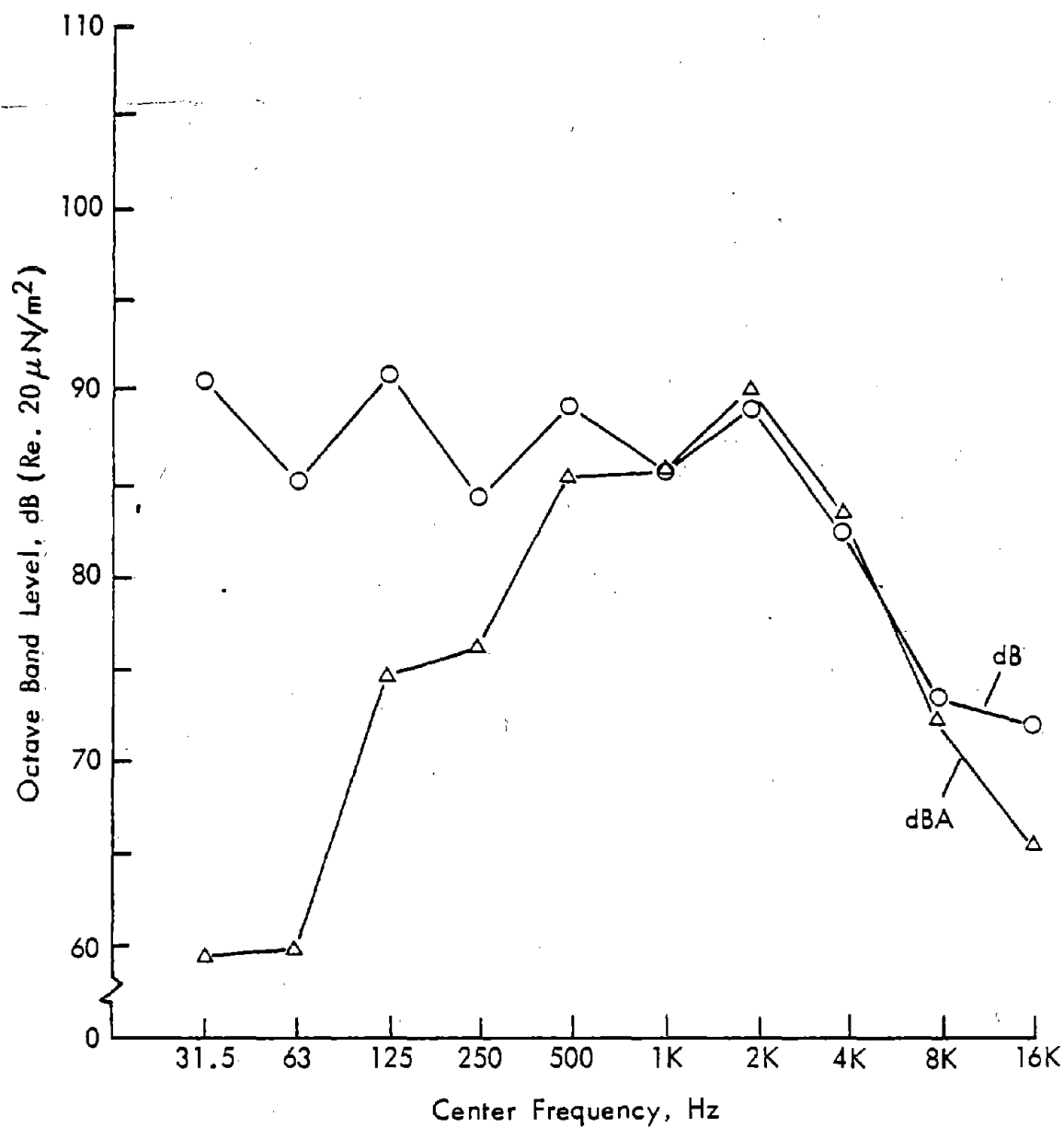


Figure B-33. Average sound pressure levels at 10 octave band center frequencies; hydraulic pump station serving boilers 3 and 4 (furnace level).

APPENDIX C

PRODUCTION OF RDF FOR ON-SITE USE AS A FUEL

The following subsections detail the general scheme of plant operations, personnel descriptions, and survey results. The survey results are presented for general air contaminants, microbiological aerosols, and noise exposures at Plant F, which is a facility for RDF production as well as RDF combustion for steam.

DESCRIPTION OF PLANT OPERATIONS AND PERSONNEL

Process Description

The Plant F resource recovery facility was put into operation in August 1979 but has yet to attain a consistent, reliable record of production. According to plant personnel, many of the current problems can be traced back to the original facility design, which was done by an architectural engineering firm whose experience with resource recovery plants was limited. Plant F is now operated by an engineering firm that specializes in solid waste processing.

The facility consists of two parallel processing lines, a fuel storage and retrieval system, and three conventional suspension-fired boilers. Each processing line is rated at 60 tons/hr (tph) (151 Mg/ks), but actual material throughput is estimated to be about 45 tons/hr (113 Mg/ks). The boilers are fired with refuse derived fuel (RDF) from the storage bin or with No. 2 fuel oil or gas if the RDF is not available. A schematic diagram of the system is shown in Figure C-1.

Vehicles bringing refuse to Plant F enter an enclosed tipping floor area through one of two large doors and unload their material into openings along the floor centerline. The refuse falls into a two-section pit below which has a storage capacity of approximately 1,700 tons (1.5 Gg). The material at the bottom of the pit is moved slowly forward by a series of inclined hydraulic rams (one set for each half of the pit) and into the two primary input conveyors. Each of these conveyors feeds a horizontal shaft hammer-mill with a capacity of 90 tons/hr (226 Mg/ks). From the shredders, the refuse is conveyed to an air classification system, called a vibrolutriator, where the light and heavy weight fractions are separated. Heavy materials drop out of the bottom of the vibrolutriator and are then conveyed to a magnetic separator. The resulting ferrous and nonferrous components are individually loaded into trucks for removal.

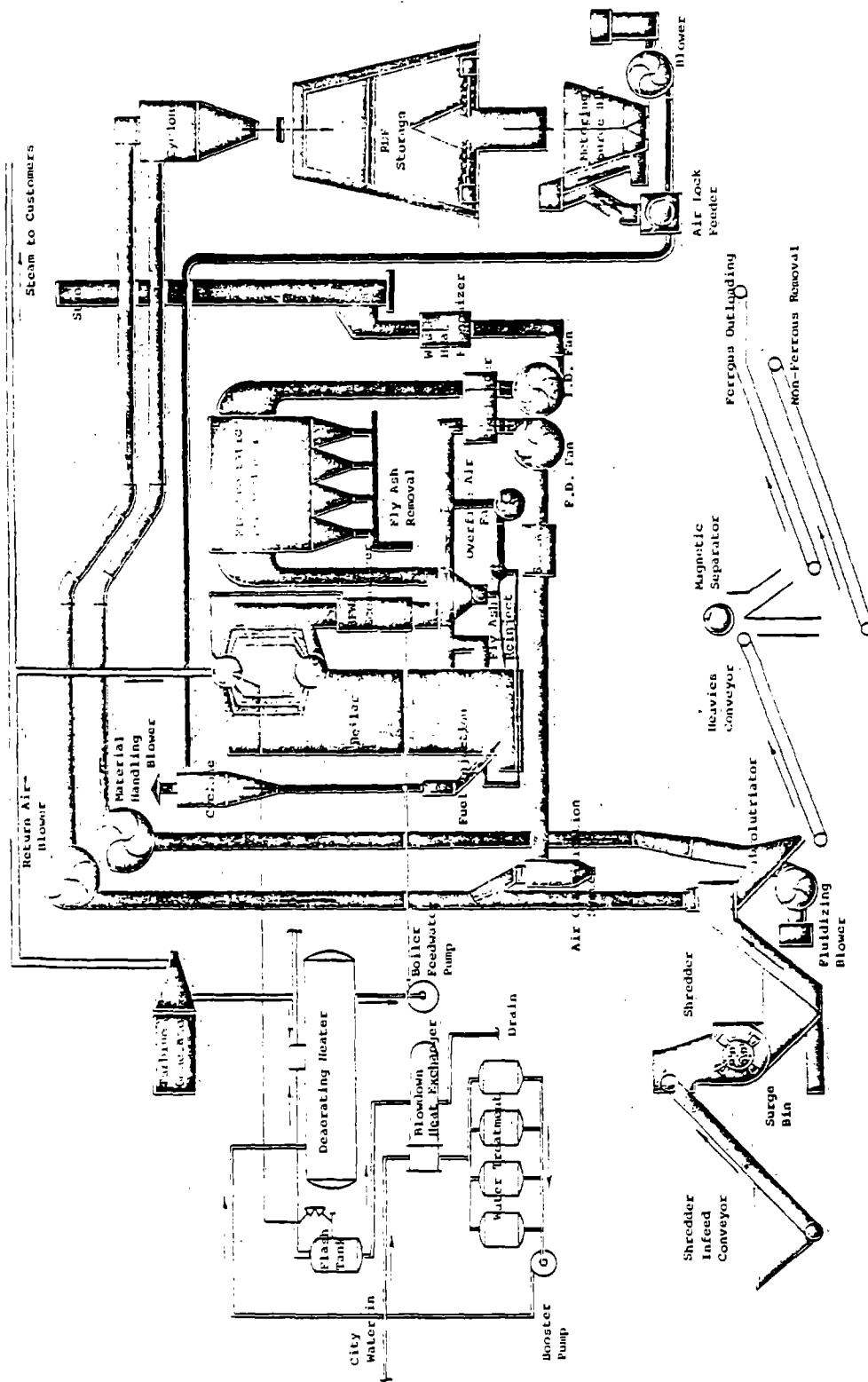


Figure C-1. Plant F process flow diagram.

The light material fraction from the air classification system is pneumatically conveyed to an RDF storage bin where a cyclone is used to de-entrain the solids from the air stream. Air leaving the cyclone is recirculated back to the air classifier. A shuttle conveyor takes the solid material from the cyclone and deposits it along the centerline of the bin. RDF is continuously retrieved from the storage bin via screw augers which traverse its length. These augers move material from beneath the refuse piles inward toward a chute located along the storage bin centerline. The RDF then drops into a metering surge bin which regulates the flow into an airlock feeder for the pneumatic transport system leading to the boilers.

The three RDF combustion units are conventional boiler systems originally designed for suspension firing of coal and adapted for RDF injection. Each unit has a single-pass boiler tube section followed by an economizer. The RDF is pneumatically injected into each combustion chamber with over-fire air. Oil/gas burners are also supplied with the boilers for use when the RDF flow is interrupted. After leaving the economizer section, the boiler exhaust gases pass through an electrostatic precipitator for particulate removal and then a regenerative air heater before exiting through an exhaust stack. Bottom ash from the combustion chamber collects in a hopper and must be manually removed on a regular basis. The ash is raked out through access doors and transported pneumatically to a storage silo to await removal by truck.

The design of the Plant F facility is such that it can be divided into four distinct functional segments: the tipping floor/storage pit; shredder area; control room offices; powerhouse; and fuel storage.

In Figure C-2, these four functional areas are designated as Buildings A, B, C, and D, respectively. A cutaway view of the facility is shown in Figure C-3 and illustrates the different floor elevations in each building. Although they form one contiguous structure, the four buildings are segregated by concrete block walls.

The tipping floor is an enclosed area which has eight square openings in the center of the floor to allow the refuse trucks to dump into the storage pit below. Wide mesh grating is located on either side of the openings to allow spillage to fall through into the pit. Since the storage pit has a "live bottom" conveyor, no other manipulation of the MSW (e.g., by front-end loader or overhead crane) is necessary, unlike most resource recovery plants.

The plant control room is located in Building B on the same level as the tipping floor. Through windows at either end of the room, the operators can observe activities on the tipping floor and in the boiler area. Another glass section allows the operators to view the two MSW infeed conveyors which run directly beneath the control room and into the shredders.

Closed-circuit television is used to monitor the shredders and other critical points throughout the plant. The two shredders and two air classifiers are located on the base level of Building B below the control room.

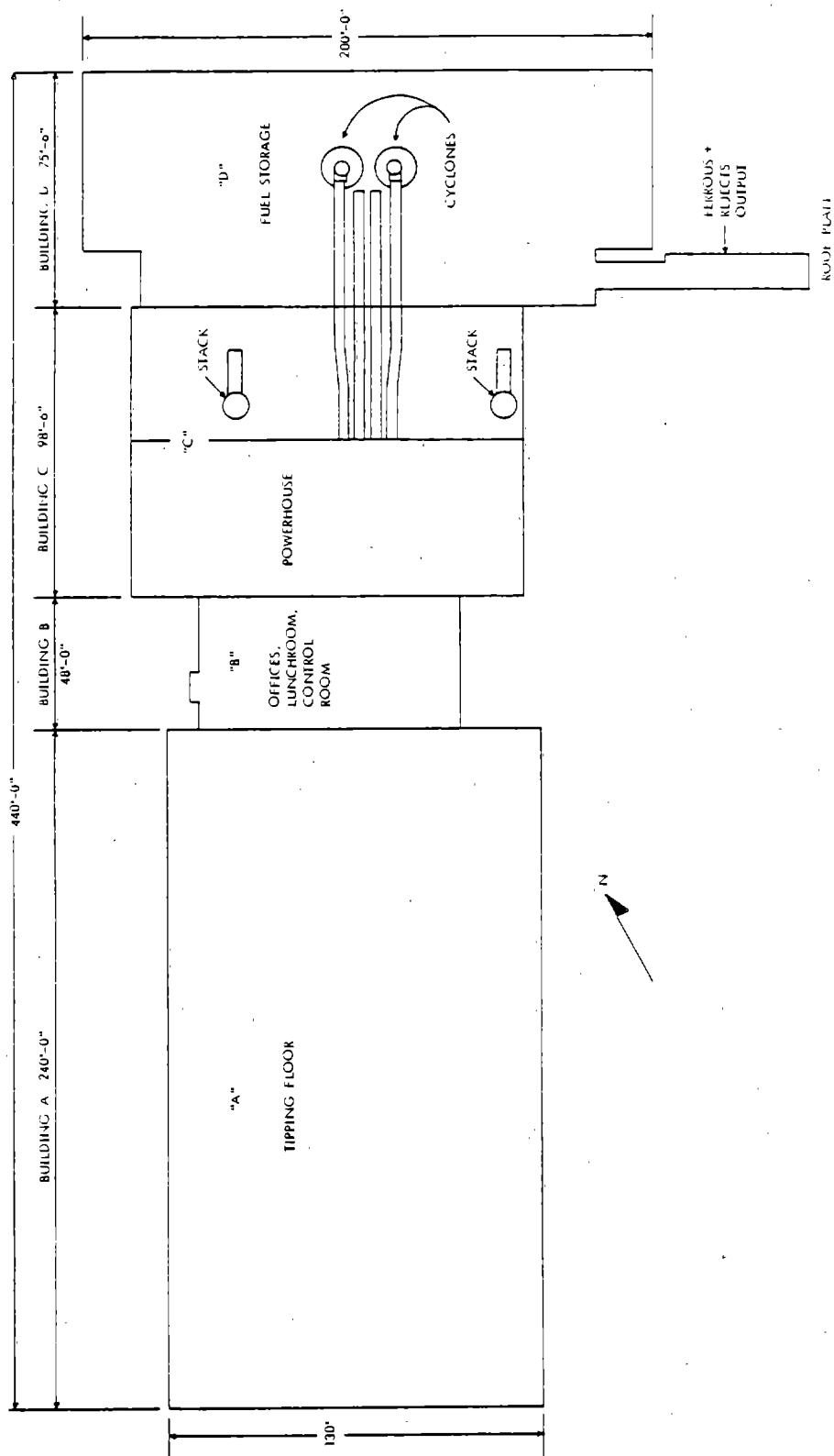


Figure C-2. Basic layout of Plant F facility.

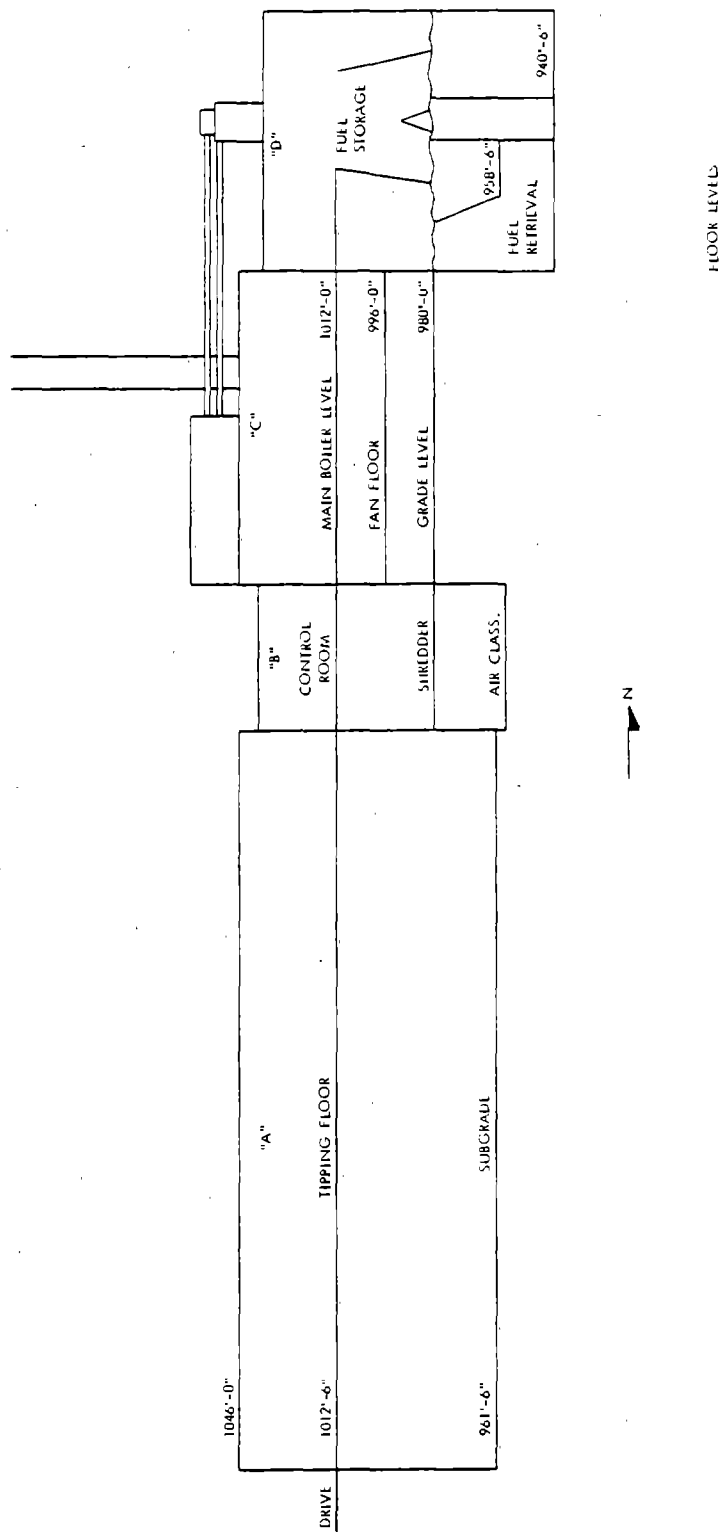


Figure C-3. Side view cutaway drawing of Plant G facility; rear view.

The plant's administrative offices are located on the grade level of Building B, but only on the front side. Thus, the offices are adjacent to the shredder area. Located one level above the offices are the employee locker room, a lunchroom, and a meeting room.

Building C, the powerhouse, has a number of different levels which provide access to all portions of the boilers and their associated equipment. The base level of this building is primarily an area for trucks to pull in beneath the ash storage hoppers when the bins are being unloaded. The levels above contain the forced and induced draft fans, feedwater pumps, turbine generator, and other equipment directly associated with operation of the boilers.

Building D actually contains four distinct functional areas: the fuel storage area, a water treatment section containing tanks and pumps for the boiler feedwater chemical treatment, a motor control section with electrical control panels, and a vacant area for future expansion. The RDF storage bin and retrieval system are located at the far end of the building. A small subgrade area below the storage bin houses the metering surge bin and pneumatic equipment. Access to the top of the storage bin is gained via a catwalk from Building C.

Plant Personnel

Plant F currently has 85 full-time employees classified into three major job categories: management, skilled, and utility. These workers, as shown in Table C-1, are distributed through four shifts which keep the plant operating 24 hr/day, 7 days/week. Routine maintenance activities are scheduled for the afternoon and night shifts.

Mechanics are responsible for the maintenance and repair of facility equipment and steam distribution lines, as well as cleanup after repairs and emergencies. They are to identify unsafe operating conditions and to work with the electricians. Engineers work on the steam generation and distribution systems. They provide steam, water, and condensate analysis of the steam generation; analyze chemical feeds; adjust burners and fuel handling equipment; and inspect steam generation, chemical, feedwater, and combustion air equipment. Equipment operators inspect and check all mobile equipment before providing appropriate services with that equipment. Additionally, they monitor solid waste for hazardous or unwanted materials which might cause a fire or shut down the processing system.

Ash removers are responsible for removing bottom ash, shifting ash, and fly ash. Utility crew members perform minor tasks in maintenance, repair, and cleanup. Scale operators weigh all vehicles coming into the facility, collect tonnage sheets, and keep records. The receiving floor attendants direct traffic and monitor wastes for hazardous material. Shredder operators are responsible for the control panel of the processing system and monitor the waste flow with a closed circuit television.

Employees of Plant F are represented by the United Rubber Workers Union.

TABLE C-1. PLANT F JOB CATEGORIES

Group	Classification	No. of employees
Management	Plant manager	1
	Plant engineer	1
	Operations and maintenance manager	1
	Manager of administration	1
	Shift supervisor	4
	Maintenance foreman	2
	Purchasing personnel	2
	Accounting personnel	2
	Receptionist	1
Skilled		
Mechanical maintenance	Lead mechanic	4
	Mechanic Class I	4
	Mechanic Class II	8
	Mechanic Class III (highest rating)	5
Electrical	Electrician	4
Engineering	Turbine/boiler engineer Class III	4
	Water treatment engineer Class III	1
	Shift engineer helper	4
Operational	Mobile equipment operator	3
Utility	Ash remover	8
	Utility crew	8
	Scale loader	5
	Scale operator	2
	Receiving floor attendant	4
	Shredder operator	4
	Supply room clerk	2
Total		85

RESULTS OF PLANT SURVEYS

Air Contaminants

The extensive chemical and physical hazards sampling and analysis program conducted during the survey of Plant F is summarized by types and numbers of samples in Table C-2, and by plant areas in Table C-3. The sampling areas designated by MRI are those locations involving principal operations and worker sites to provide data on sites with the greatest possible potential exposures to employees.

NIOSH approved sampling and analytical methods were used to evaluate contaminant levels throughout this survey. Full-shift monitoring was conducted when possible to determine 8-hr time weighted average (TWA) exposures. Shorter term sampling was used when limited collection times were required or when longer collection periods were not possible. When less than full-shift samples were obtained, data were used to calculate ambient contaminant levels rather than to provide TWA comparison values. Except personnel samples used to determine worker exposures to respirable dust and noise, all contaminants were monitored by area sampling.

The general results of this survey are listed in Table C-4. The data have been presented by sampling location in four plant areas. Figures C-4 through C-9 show the approximate sampling sites in relation to the building confines and major equipment. Survey results are discussed in the following paragraphs except for noise monitoring data, which are presented in a separate section.

Total and Respirable Dust--

Total dust concentrations were evaluated at eight locations in four general areas of Plant F. In each case, the measured level of nuisance dust was lower than the ACGIH/NIOSH recommended threshold limit value (TLV) of 10 mg/m^3 and the OSHA permissible exposure limit (PEL) of 15 mg/m^3 . The eight sample concentrations ranged from 0.24 to 5.32 mg/m^3 during sampling time, with TWA extrapolations from 0.24 to 4.73 mg/m^3 . The highest levels were found in the ash pulling and loading locations in the boiler house. Other locations in the boiler house and those isolated from the boiler house by walls had minimal total dust concentrations.

Respirable dust samples were collected by personnel monitoring in the areas listed in Table C-4. Calculated TWA exposures were less than the TLV and PEL of 5 mg/m^3 in six cases; however, one ash puller and his helper had TWA exposures of 24.2 and 9.09 mg/m^3 , respectively. These data demonstrate that Plant F employees working in areas where ash is handled may be over exposed to airborne dusts.

Trace Metals--

The decision to collect only one trace metal sample was made because of the negligible concentrations found during previous MRI surveys for trace metals. The ash pulling location was selected since it appeared to be the dustiest site in Plant F. One particulate sample was collected on the second level of the boiler house at an ash pulling location.

TABLE C-2. SURVEY SAMPLING AND ANALYSIS MATRIX--PLANT F

Substance sampled	No. of samples	Method of sampling	Analysis method
Total dust	8	NIOSH Method 29.02/inert or nuisance dust	Gravimetric
Respirable dust	8	NIOSH Method 29.02	Gravimetric
Trace metals	1	NIOSH Methods: 9.01/Beryllium 22.01/Zinc chloride S312/Cadmium dust S323/Chromium (soluble) S341/Lead	P&CAM 173
Pesticides (organophosphate/ carbamate)	2	NIOSH Method 21.01/impinger (distilled water)	Enzyme assay screen
Asbestos	1	NIOSH Method 2.02/Asbestos	P&CAM 239
Hydrogen chloride	4	Midjet impinger: 10 ml 0.5 NaC ₂ H ₃ O ₂	S246
Cyanide	4	Midjet impinger: 10 ml 0.1 m NaOH	P&CAM 116
PCBs	1	Florisil sorbent collection	P&CAM 244
PNAs	1	NIOSH glass fiber/silver membrane filter, backed by porous polymer tube	HPLC GC/MS
Organics	4	Portable IR; charcoal tube	Direct reading, P&CAM 127
Carbon monoxide	-	Interscan CO monitor	Direct reading
Particle sizing	4	Accu-vol samplers with Sierra impactors	Gravimetric
Noise	-	Sound level meter, octave band analysis	Direct reading
Ventilation	-	Thermoanemometer	Direct reading

TABLE C-3. SAMPLING MATRIX BY AREA--PLANT F

Sample	Tipping floor	Shredder area	Boiler house	Fuel storage
Total dust	1	1	4	2
Respirable dust	1	-	6	1
Trace metals	-	-	1	-
Pesticides	1	1	-	-
Asbestos	-	-	-	1
HCl	-	-	4	-
HCN	-	-	4	-
PCB	-	1	-	-
PNA	-	-	1	-
Organics	1	2	1	-
Particle size	-	-	3	1
Noise (dosimeter)	1	-	5	1

TABLE C-4. RESULTS OF PLANT F SURVEY BY SAMPLING LOCATION

Substance monitored	Concentration during sampling (mg/m ³)	TWA (mg/m ³)	TLV (mg/m ³)
<u>Tipping floor</u>			
Total dust	0.95	0.90	10
Respirable dust	0.21	0.21	5
<u>Shredder area</u>			
Total dust	1.76	1.76	10
Polychlorinated biphenyls (PCBs)			
Aroclor 1242	ND-LD 0.01 µg ^a	-	0.001
Aroclor 1254	ND-LD 0.01 µg ^a	-	0.001
Aroclor 1260	ND-LD 0.03 µg ^a	-	-
<u>Boiler house</u>			
Total dust	2.04	2.04	10
	5.32	4.73	10
	0.32	b	10
	4.23	b	10
Respirable dust	10.1	9.09	5
	0.41	0.38	5
	24.9	24.2	5
	0.29	0.25	5
	0.67	0.59	5
	1.2	b	5
Trace metals			
Beryllium	ND-LD 0.05 µg ^a	-	0.002
Cadmium	ND-LD 0.2 µg ^a	-	0.05
Chromium	ND-LD 0.5 µg ^a	-	0.05
Lead	0.0028	0.0025	0.05
Zinc	0.010	0.0088	-
Hydrogen chloride	0.33	b	7 ^c
	1.69	b	7 ^c
	0.62	b	7 ^c
	1.05	b	7 ^c

TABLE C-4. (continued)

Substance monitored	Concentration during sampling (mg/m ³)	TWA (mg/m ³)	TLV (mg/m ³)
Hydrogen cyanide	ND-LD 0.22 µg ^a	-	5 ^d
	0.0018	b	5 ^d
	ND-LD 0.15 µg ^a	-	5 ^d
	ND-LD 0.16 µg ^a	-	5 ^d
Polynuclear aromatic hydrocarbons (PNAHs)			
Benzo(a)anthracene	ND-LD 0.010 µg ^a	-	-
Benzo(a)pyrene	ND-LD 0.010 µg ^a	-	-
Chrysene	ND-LD 0.300 µg ^a	-	-
Fluoranthene	ND-LD 0.010 µg ^a	-	-
Pyrene	ND-LD 0.400 µg ^a	-	-
<u>Fuel storage</u>			
Total dust	0.70	0.70	10
	0.27	0.24	10
Respirable dust	2.12	b	5
Asbestos	ND-LD 2,457 fibers ^a	-	0.5 fibers/cc

a None detected at the limit of detection specified.

b Sample time less than 7 hr; extrapolation to TWA not appropriate.

c Ceiling value for 15 min.

d Ceiling value for 10 min.

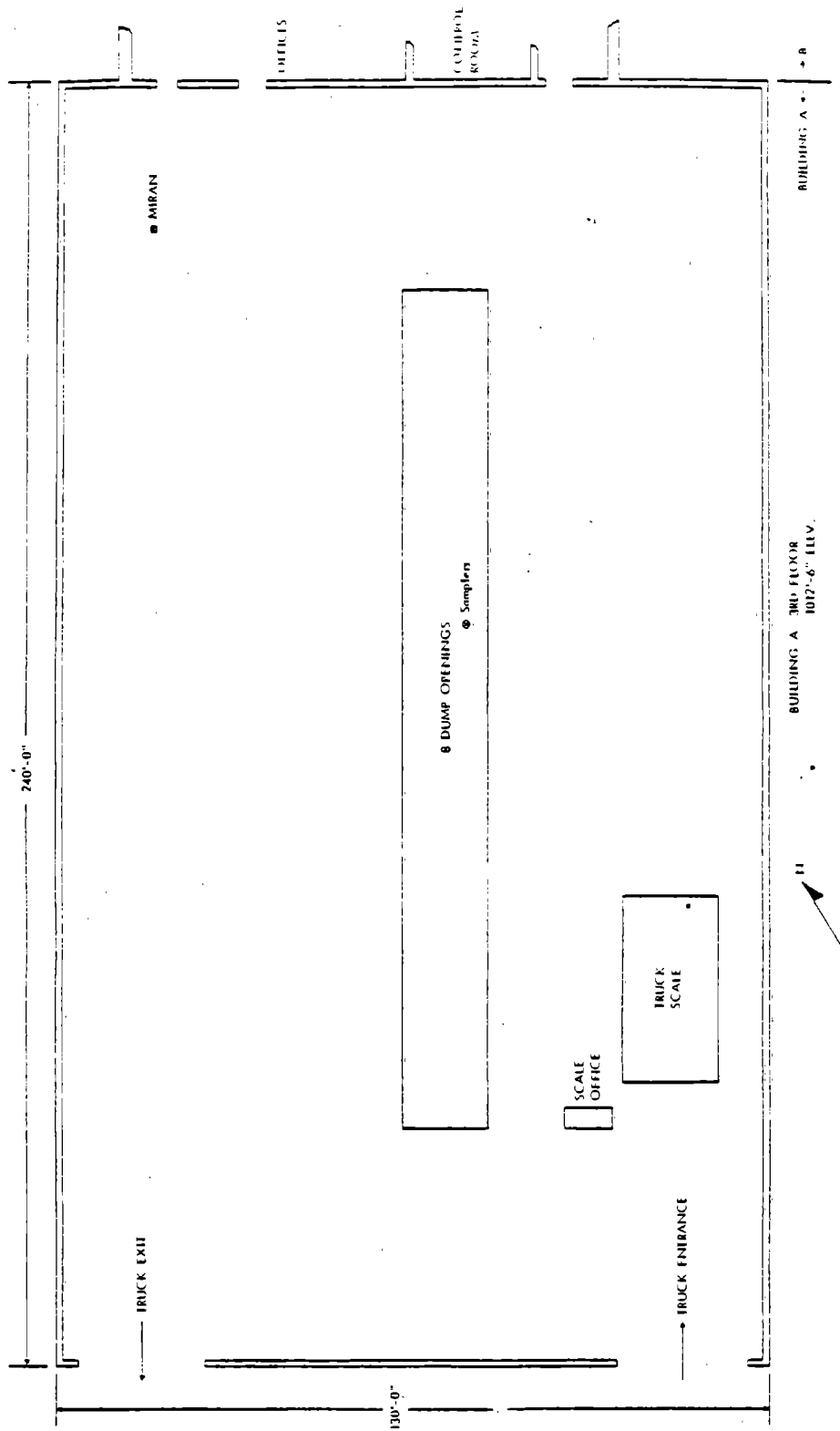


Figure C-4. Location of samplers in tipping floor area of Plant F.

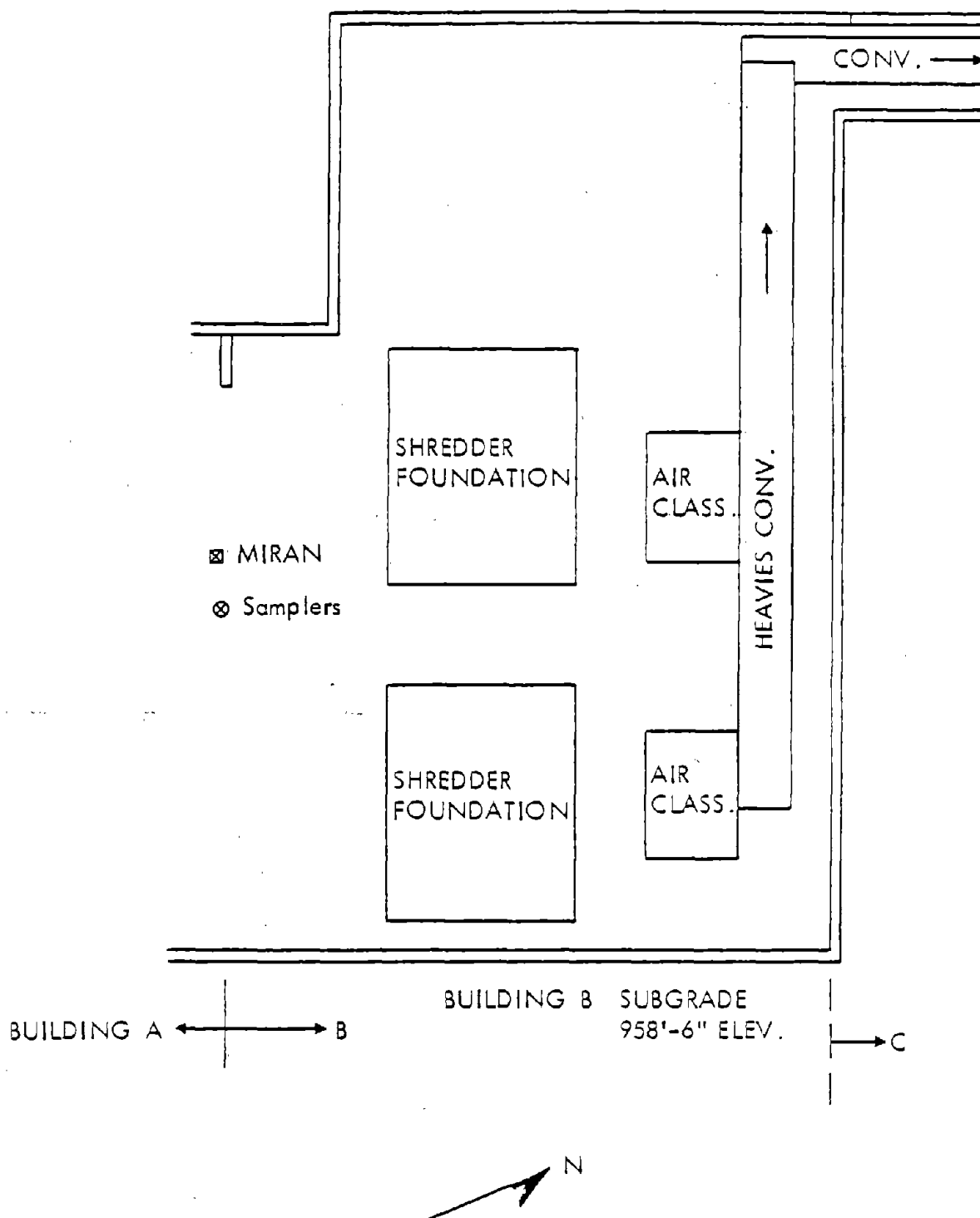


Figure C-5. Location of samplers in shredder area of Plant F.

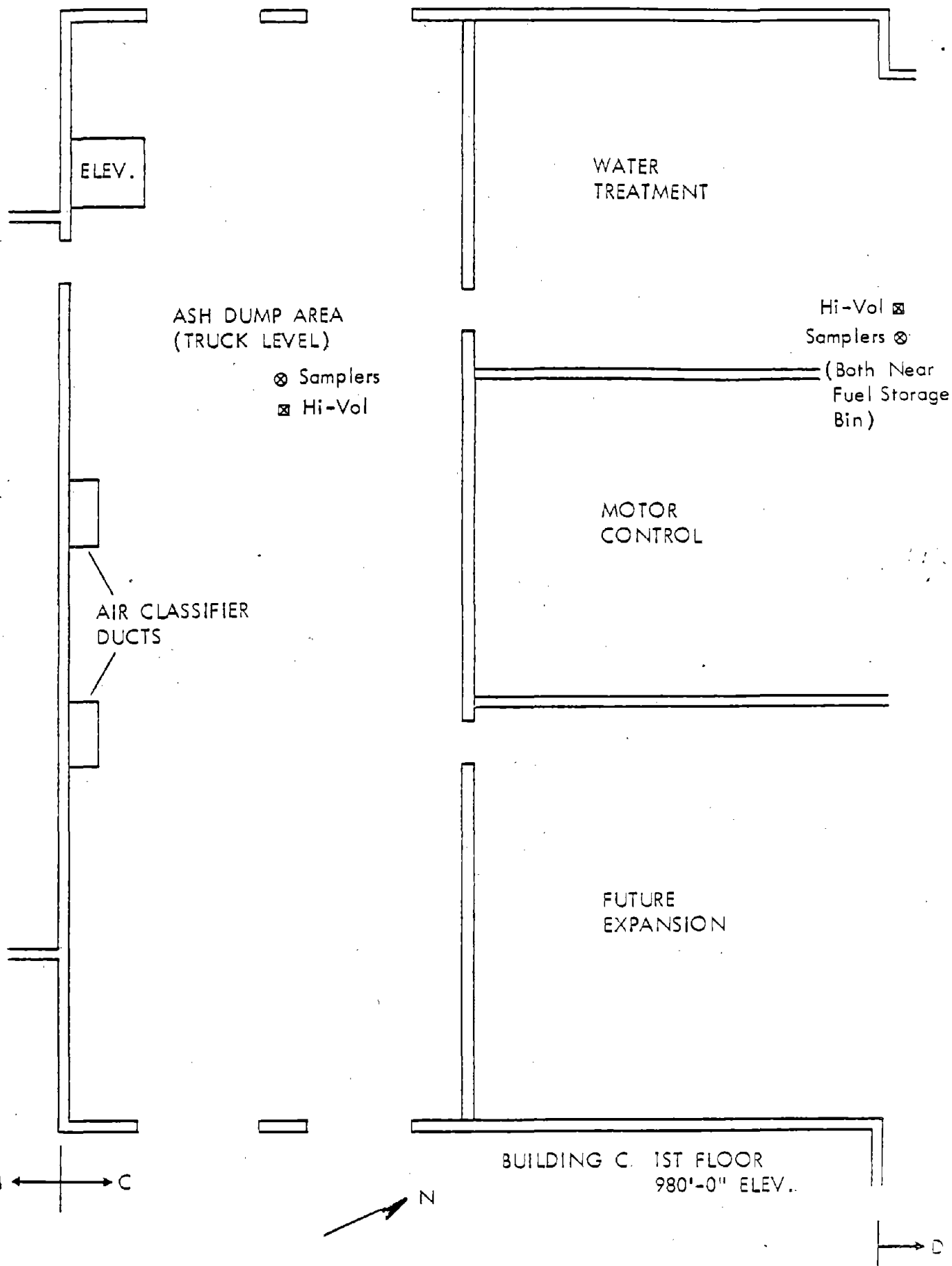


Figure C-6. Location of samplers in ash loading area of Plant F near base of fuel storage bin.

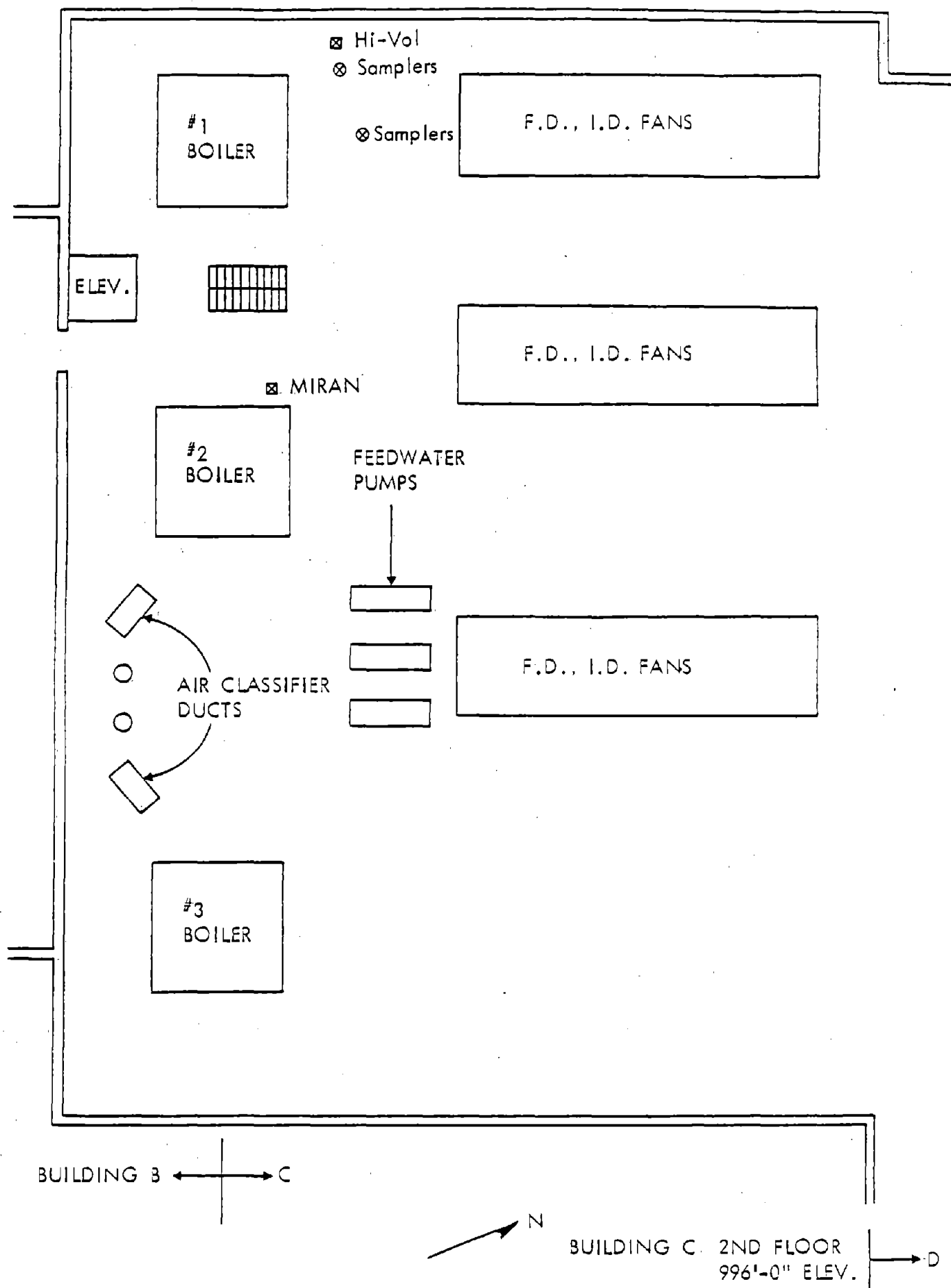


Figure C-7. Location of samplers on second level of boilerhouse of Plant F.

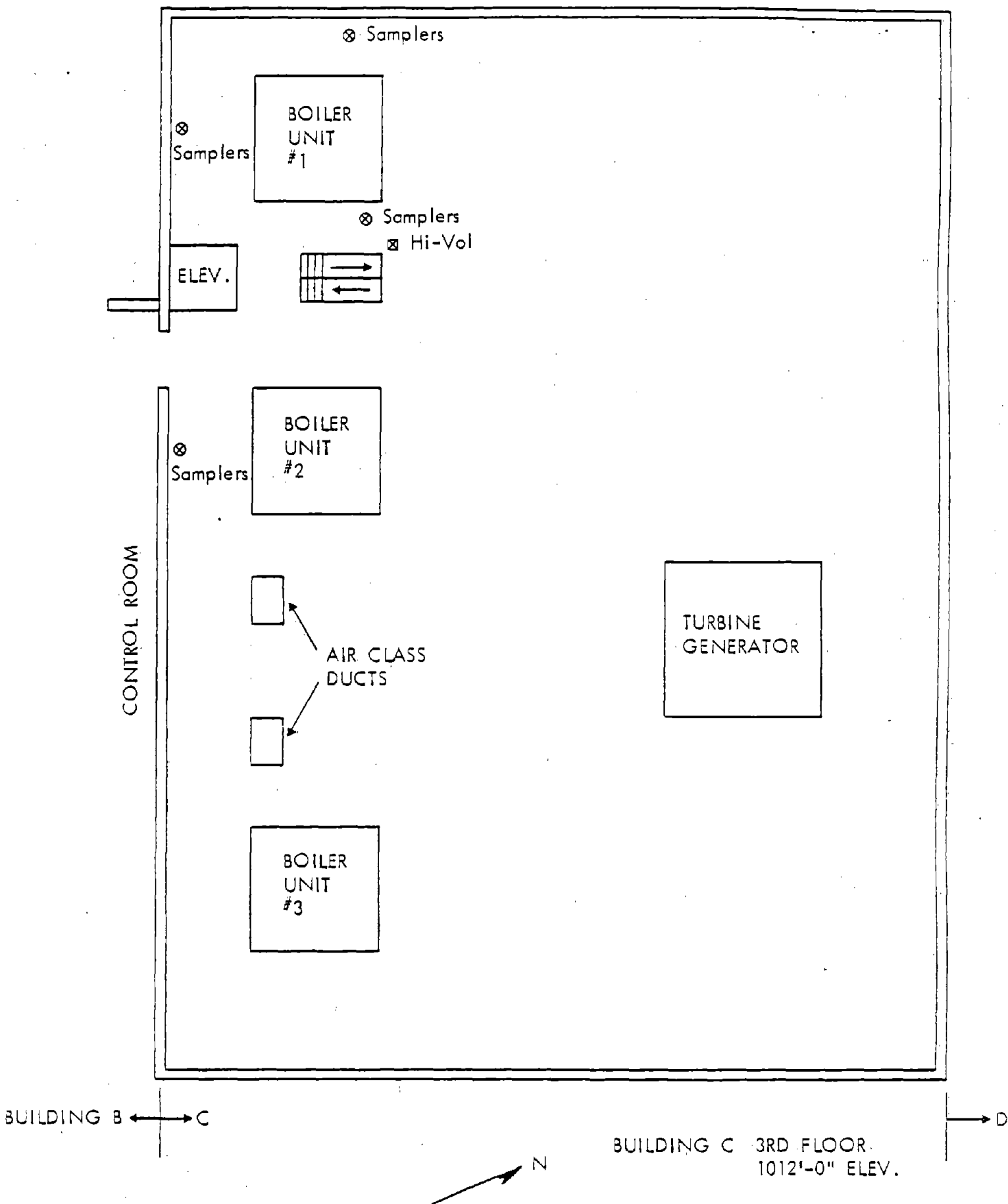


Figure C-8. Location of samplers on third level of boilerhouse of Plant F.

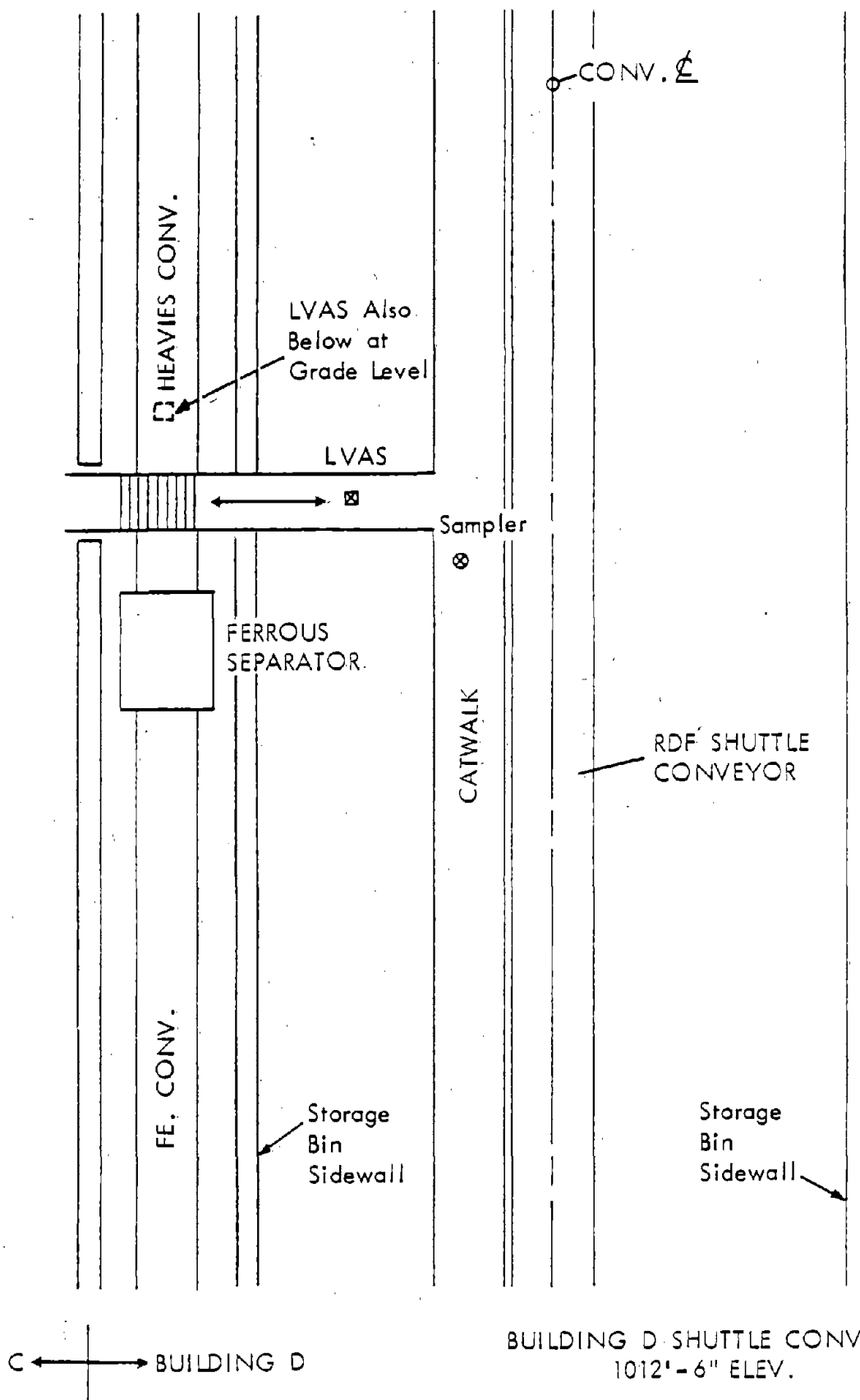


Figure C-9. Location of samplers in fuel storage bin area of Plant F.

This sample was analyzed for beryllium, cadmium, chromium, lead, and zinc by atomic absorption spectroscopy. Beryllium, cadmium, and chromium were not detected in the sample. The concentration of lead was orders of magnitude lower than the recommended TLV; the concentration of zinc was minimal.

Pesticides--

Two samples were collected by drawing air through water-filled midge impingers in the tipping floor and shredder areas. Analysis consisted of an "enzyme ticket" detection method developed by MRI. The presence of cholinesterase-inhibiting pesticides can be determined since the absence of a color change on the ticket substrate would indicate the presence of an anti-cholinesterase compound at a concentration greater than 1 ppm. Sample results indicated the absence of cholinesterase-inhibiting pesticides.

Asbestos--

The fuel storage area appeared to have the greatest potential for airborne asbestos fibers. Thus, a sample was collected there. Microscopic analysis did not provide a fiber count higher than the level of detectability. Since the fiber count was so minimal despite a short monitoring time and based on previous studies at other facilities, it does not seem likely that asbestos would be present as an airborne particulate hazard at Plant F.

Hydrogen Chloride (HCl)--

The process at Plant F involves the combustion of municipal solid waste containing plastics which could HCl. Work locations near the furnaces in the boiler house were selected for monitoring. Four samples were collected using a dilute, basic absorbing solution. Laboratory analysis demonstrated concentrations during sampling times of not more than 1.69 mg/m^3 , as compared to the NIOSH recommended 15-min ceiling TLV of 7.0 mg/m^3 . No exposure hazard to HCl was expected since the boilers normally operate under negative pressure.

Hydrogen Cyanide (HCN)--

Hydrogen cyanide is another potential combustion product. Four samples were collected for the same periods and from the same locations as hydrogen chloride, using dilute sodium hydroxide solutions as the capture medium. Only one sample had a concentration above the level of detection (0.002 mg/m^3), which is negligible when compared to the NIOSH recommended 10-min ceiling TLV of 5.0 mg/m^3 . There appears to be a minimal potential exposure hazard to HCN.

Polychlorinated Biphenyls (PCBs)--

A solid sorbent tube containing Florisil was used to collect one air sample for PCBs in the shredder area under the conveyor feed system. Analysis consisted of gas-liquid chromatography assays for Aroclor 1242, Aroclor 1254, and Aroclor 1260. These compounds were not detected.

Polynuclear Aromatic Hydrocarbons--

One sample was collected in the boiler house near the fuel feed system for Boiler No. 2 on a combination glass fiber/silver membrane filter mounted in

a cassette, followed by a porous polymer backup tube. This sample was analyzed for: benzo(a)anthracene, benzo(a)pyrene, chrysene, fluoranthene, and pyrene. No detectable levels of any were found.

General Organics--

Survey evaluations for organic compounds were conducted using a direct-reading, MIRAN 1A analyzer and concurrent charcoal tube sampling. The MIRAN was operated primarily in the scan mode to search for absorbance peaks suggesting the presence of organic compound groups. The instrument was also run at specific absorbance wavelengths to attempt to detect certain organics suspected of being associated with this process. Scans were run at locations on the tipping floor and in the shredder area. Since no absorbance peaks were observed, the charcoal tube samples that were collected were not submitted for analysis.

Particle Size--

High volume, ambient air samplers equipped with Sierra five-stage cascade impactors were used to determine the approximate particle size distribution of airborne dust within Plant F. The Sierra impactor aerodynamically segregates particles at five size stages: 10.2, 4.2, 2.1, 1.4, and 0.73 μm .

Three samples were collected in the boiler house: one in the ash loading area, one near the No. 1 boiler ash cleanout doors, and the third on the third level near the No. 1 boiler. A fourth sample was collected in the fuel storage area near the metals conveyor. Data are presented graphically in Figures C-10 through C-13. The curves designated "actual" were generated by adjusting the "raw" data for a known mass bias on the final filter of the Sierra impactor. It is typical to find an excess of particulate material on the final filter which indicates that a particle "bounce" phenomenon had occurred as the sample was collected. The applied correction is used to yield the more true size distribution.

The samples collected at the ash cleanout and ash-loading locations had median particle diameters of 7.3 and 8.0 μm , respectively. The other boiler house sample (on the furnace level) indicated a much smaller median diameter of 4.2 μm . The fuel storage sample yielded a median particle diameter of 10.2 μm .

Carbon Monoxide (CO)--

Carbon monoxide readings were taken at various locations in each of the four identified plant areas. Tipping floor values ranged from 5 to 20 ppm, with the highest values occurring while refuse trucks were running. The shredder area values ranged up to a maximum of 5 ppm. The boiler house had maximum readings of 15 ppm at the ash truck loading location, although most readings were in the 2- to 3-ppm range elsewhere in the boiler house. Fuel storage area values were less than 5 ppm, and most locations showed less than 1 ppm. With a TLV for CO of 35 ppm, these exposures were not hazardous to workers.

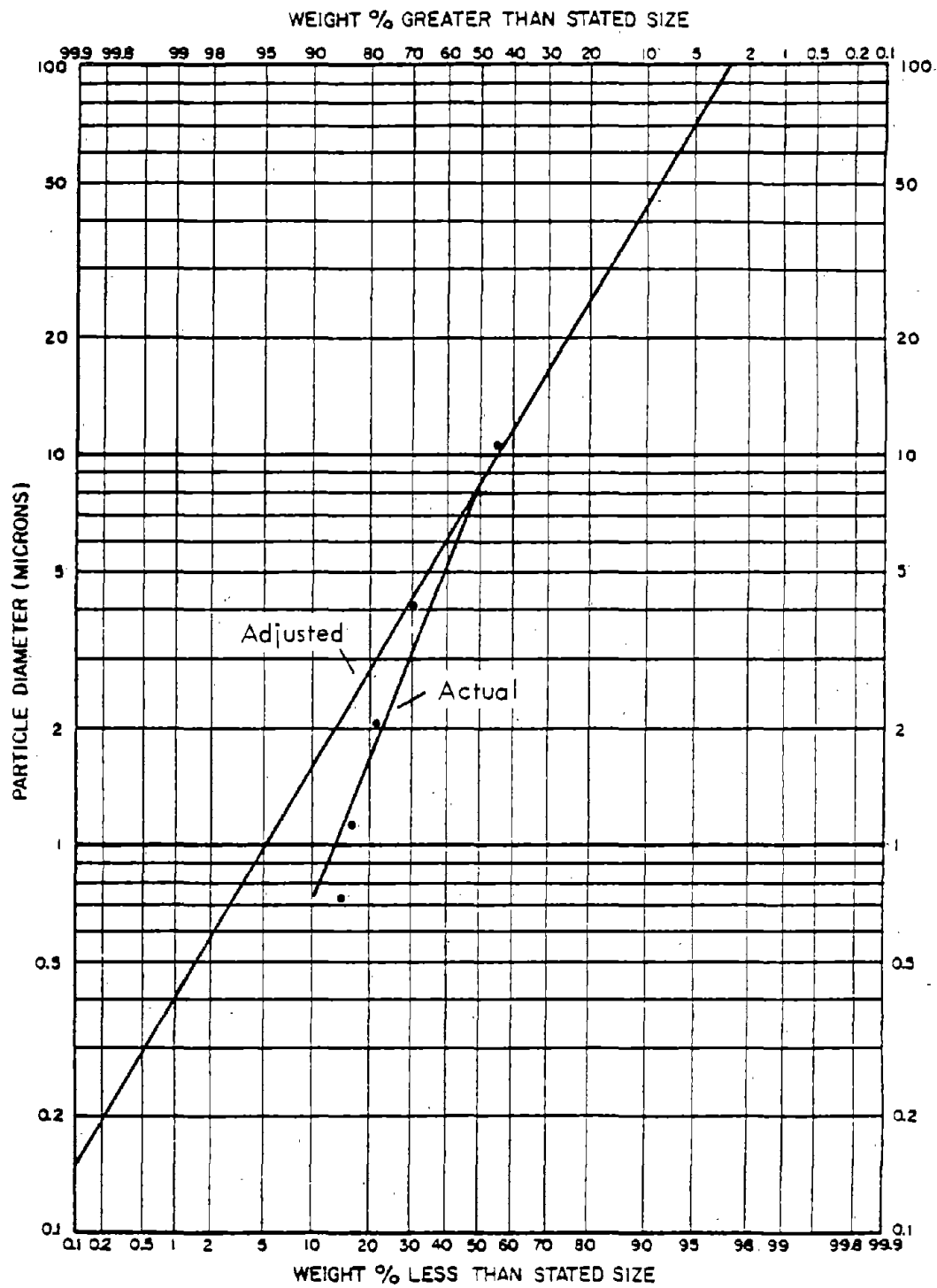


Figure C-10. Particle size distribution in ash loading area of Plant F.

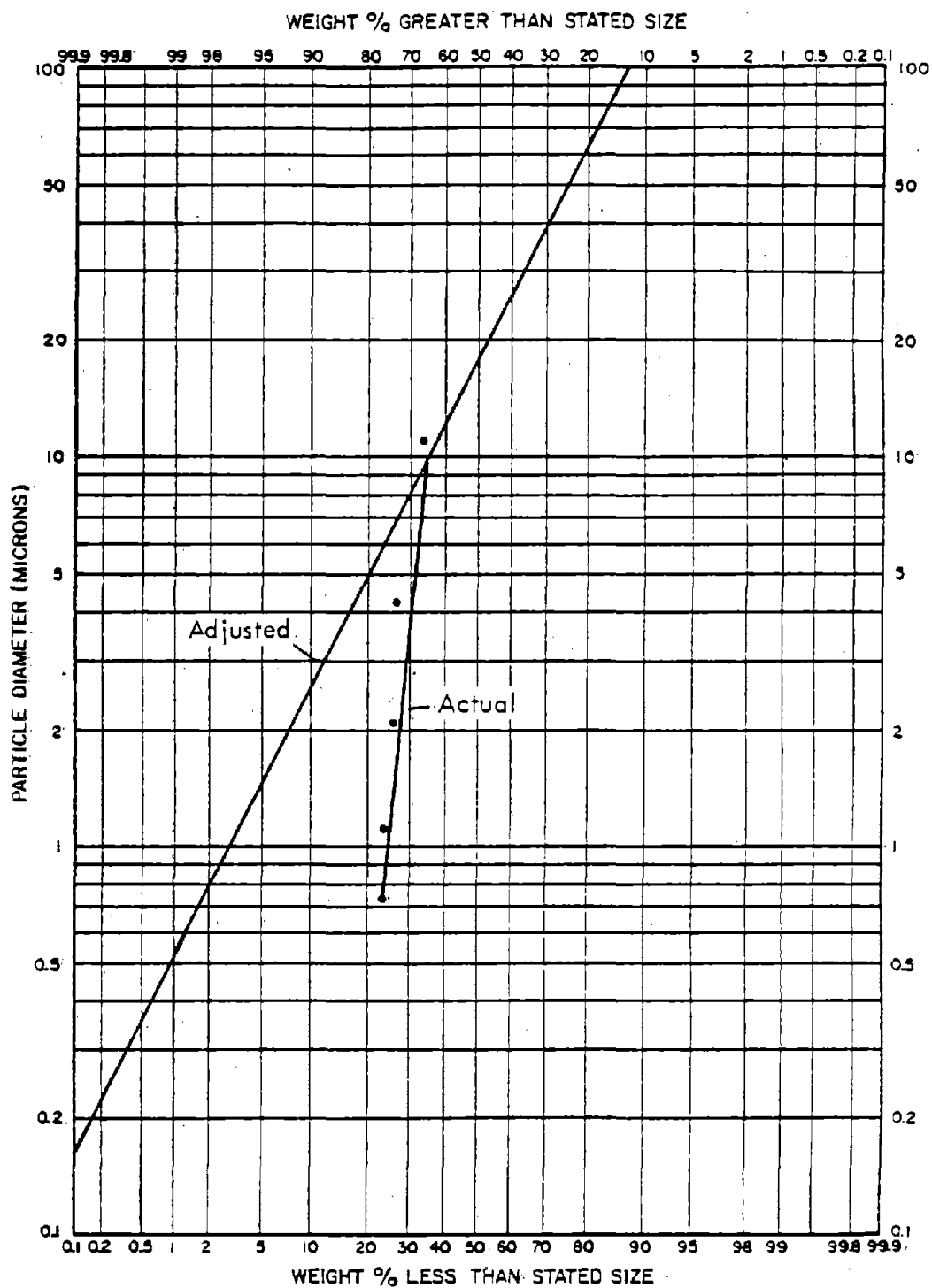


Figure C-11. Particle size distribution near fuel storage bin of Plant F.

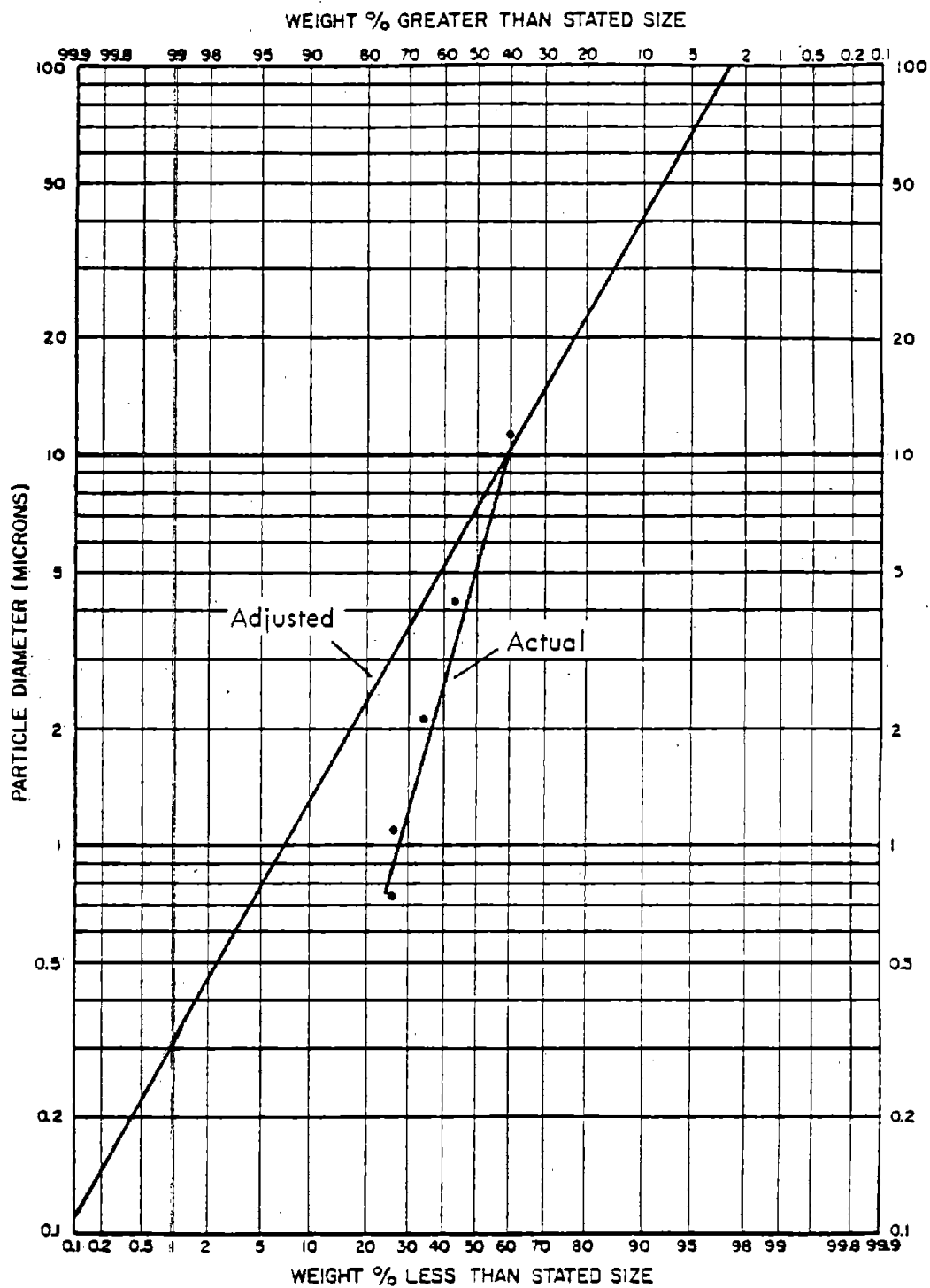


Figure C-12. Particle size distribution near ash puller station, Boiler No. 1, at Plant F.

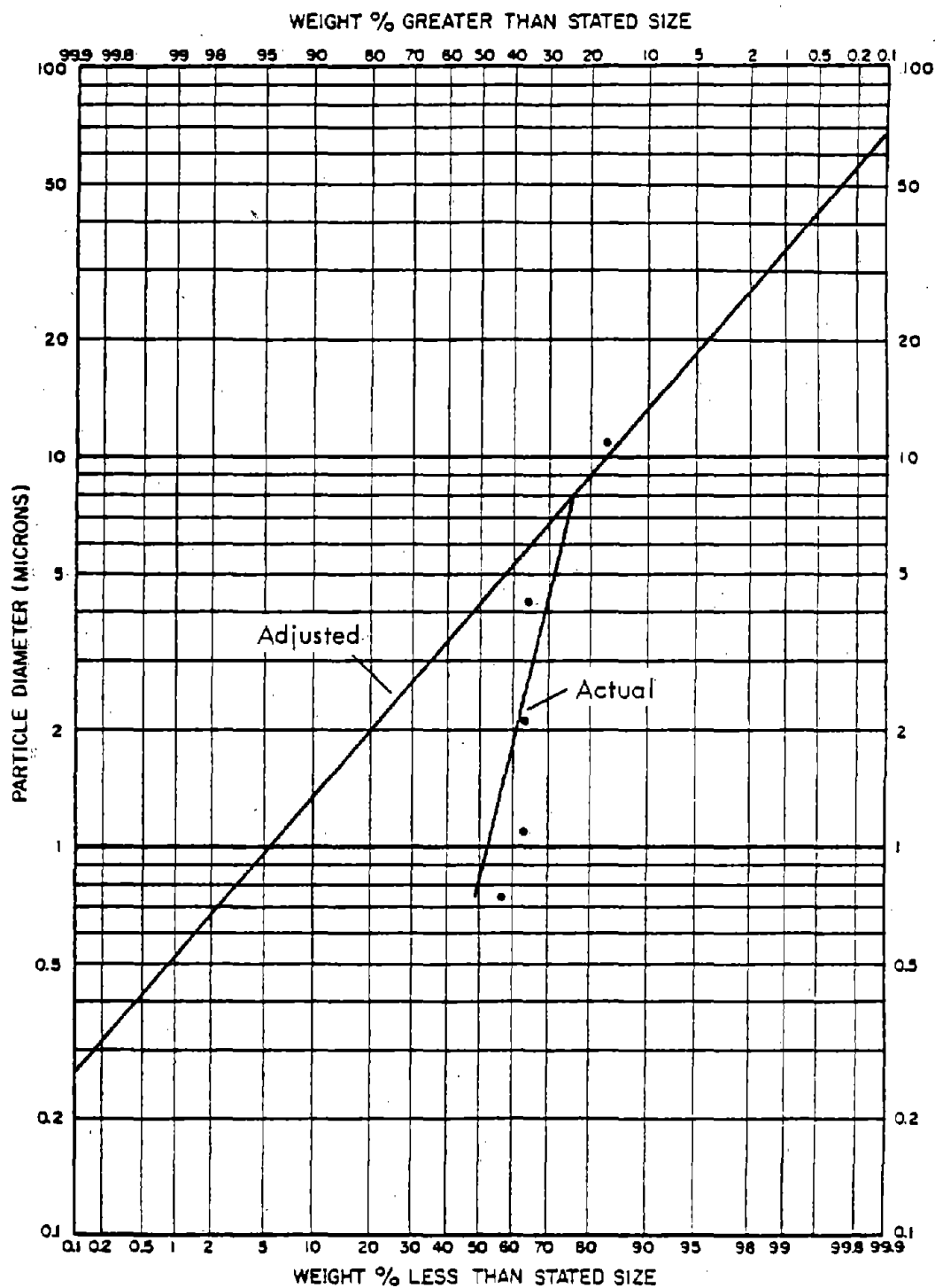


Figure C-13. Particle size distribution on third level near Boiler No. 1, at Plant F.

Microbiological Aerosols: Plant F

Analytical results of the microbiological sampling program conducted at the Plant F resource recovery facility are presented in this section. The microbiological survey included analyses for selected bacterial indicator complexes, and infectious agents (see Table 2). These analyses were performed on aerosol, solid waste, and settled dust samples. It must be kept in mind that ambient environmental microbiology standards have not been established and that any microbiological results must be interpreted with extreme care. Complete descriptions of the sampling methods and analytical methodologies are included in Appendix A.

Sampling Sites--

Microbial aerosol samples were collected at two locations within Plant F. Aerosol samples collected on 10/8/80 were taken on the catwalk above the fuel storage bin in Building D. Aerosol samples collected on 10/9/80 were taken at grade level in Building D beside the storage bin and almost directly beneath the other sampling site (refer to Figure C-9).

Two sets of indoor aerosol control samples were collected when the plant was not operating. These samples are designated AGI 1-1 and 2-1; the LVAS 1-1 and 2-1.

Four sets of aerosol samples were collected when the plant was operating under normal conditions. These samples included numbers AGI 1-4, 2-3, 2-5, and 2-7; and LVAS samples 1-2, 2-2, and 2-3. The fourth LVAS sample was broken in transit and could not be processed.

Two types of solid samples were collected for microbiological analysis. Partially processed solid waste samples were collected from the storage bin and the conveyor which feeds the bin. Settled dust samples were collected from catwalk railings at locations near the aerosol sampling sites.

Sampling methods--Complete sampling methods are presented in Appendix G.

Analytical Results--

The results from bacteriological analysis of stationary dust samples are presented in Table C-5. Aerosol sample results may be found in Tables C-6 and C-7.

Bacteriological--The average total bacteria concentration of solid waste at Plant F was 1.8×10^8 bacteria/g. Stationary dust samples contained an average of 7.6×10^7 bacteria/g. The total bacteria concentrations of the two indoor aerosol control samples were 2.1×10^5 cfu/m³ (AGI) and 2.7×10^4 cfu/m³ (LVAS). Production aerosol samples contained an average of 1.7×10^5 bacteria/m³ by the AGI method versus 2.4×10^6 bacteria/m³ by the LVAS.

Fecal coliform results--Fecal coliforms (FC) were found in 75% of the solid waste samples tested. When present, the fecal coliform concentration of the solid waste samples averaged 2.5×10^4 FC/g. The settled dust samples contained 2.2×10^4 FC/g.

TABLE C-5. MICROBIOLOGICAL SOLID SAMPLE RESULTS OBTAINED AT PLANT F

Microbial assay	Solid waste samples				Dust samples			
	1-1	1-2	2-1	2-2	1-1	1-2	2-1	2-2
Total bacteria	3.0×10^6	5.8×10^8	1.3×10^8	1.4×10^5	1.6×10^8	1.2×10^8	7.8×10^7	1.7×10^7
Fecal coliforms	6.8×10^4	1.6×10^3	4.6×10^3	$< 8.0 \times 10^2$	5.2×10^3	9.8×10^4	2.0×10^3	3.0×10^3
Salmonella sp.	$< 2.0 \times 10^2$	$< 2.0 \times 10^2$ ^b	$< 2.0 \times 10^2$	$< 2.0 \times 10^2$	$< 2.0 \times 10^2$	$< 2.0 \times 10^2$	$< 2.0 \times 10^2$	$< 2.0 \times 10^2$
Shigella sp.	$< 2.0 \times 10^2$	$< 2.0 \times 10^2$	$< 2.0 \times 10^2$	$< 2.0 \times 10^2$	$< 2.0 \times 10^2$	$< 2.0 \times 10^2$	$< 2.0 \times 10^2$	$< 2.0 \times 10^2$
Klebsiella sp.:								
K. pneumoniae	8.0×10^{13} ^d	$< 2.0 \times 10^3$	4.9×10^5	7.7×10^2	$< 2.0 \times 10^3$	3.4×10^4	5.1×10^3	1.4×10^4
K. oxytoca	$< 2.0 \times 10^3$	$< 2.0 \times 10^3$	2.9×10^5	7.7×10^2	$< 2.0 \times 10^3$	1.4×10^4 ^d	$< 2.0 \times 10^3$	$< 2.0 \times 10^3$
Staphylococcus aureus	1.0×10^3	$< 2.0 \times 10^2$	$< 2.0 \times 10^2$	8.0×10^3	1.0×10^4	7.0×10^4	$< 2.0 \times 10^2$	2.0×10^3
Nocardia sp.	$< 2.0 \times 10^3$	$< 2.0 \times 10^3$	$< 2.0 \times 10^3$	$< 2.0 \times 10^3$	$< 2.0 \times 10^3$	$< 2.0 \times 10^3$	$< 2.0 \times 10^3$	$< 2.0 \times 10^3$
Streptomyces sp.	2.0×10^4	1.3×10^6	2.5×10^5	1.1×10^6	9.4×10^5	3.1×10^6	6.3×10^5	6.4×10^6
Aspergillus fumigatus	3.4×10^3	$< 2.0 \times 10^2$	$< 1.0 \times 10^1$	$< 2.0 \times 10^2$	2.8×10^4	5.0×10^5	6.0×10^4	3.8×10^4
Aspergillus flavus	$< 2.0 \times 10^2$	$< 2.0 \times 10^2$	$< 2.0 \times 10^2$	$< 2.0 \times 10^2$	$< 2.0 \times 10^2$	$< 2.0 \times 10^2$	$< 2.0 \times 10^2$	6.0×10^3
Mycobacterium sp.	OG ^e	OG	OG	OG	$< 2.0 \times 10^1$	$< 2.0 \times 10^1$	OG	OG

^a Less than values, e.g., $< 2.0 \times 10^2$, indicate the overall minimum detection limits and that no microorganisms were detected.

^b *Salmonella enteritidis* group C₁ by enrichment only.

^c *Salmonella enteritidis* group E by enrichment only.

^d Concentration based upon statistically unreliable microbial count, i.e., < 30 colonies per plate.

^e OG = Overgrown by molds.

TABLE C-6. MICROBIOLOGICAL COMPOSITION OF AEROSOL SAMPLES COLLECTED BY THE AGI-30 SAMPLER AT PLANT F

Parameter	AGI-30 samples						Indoor controls	
	1-4	2-3	2-5	2-7	1-1	2-1		
<u>Sampling data:</u>								
Sampling date	10/7/80	10/8/80	10/8/80	10/8/80	10/7/80	10/8/80	10/8/80	
Air volume sampled (m ³)	0.7	0.6	0.5	0.4	0.5	0.5	0.5	
<u>Microbiological assay (cfu/m³)^a</u>								
Total bacteria	3.4x10 ⁵	<1.6x10 ²	2.0x10 ^{5b}	1.5x10 ^{5b}	4.0x10 ⁴	3.8x10 ⁵		
Fecal coliforms	3.3x10 ²	3.3x10 ¹	4.0x10 ¹	6.6x10 ²	1.6x10 ²	4.0x10 ¹		
Salmonella sp.	<1.4x10 ³	<1.6x10 ³	<2.0x10 ³	<2.1x10 ³	<2.0x10 ³	<2.0x10 ³		
Shigella sp.	<1.4x10 ³	<1.6x10 ³	<2.0x10 ³	<2.1x10 ³	<2.0x10 ³	<2.0x10 ³		
Klebsiella sp:								
K. pneumoniae	<1.4x10 ³	<1.6x10 ³	<2.0x10 ³	<2.1x10 ³	<2.0x10 ³	<2.0x10 ³		
K. oxytoca	<1.4x10 ³	<1.6x10 ³	<2.0x10 ³	<2.1x10 ³	<2.0x10 ³	<2.0x10 ³		
Staphylococcus aureus	<1.4x10 ³	<1.6x10 ³	<2.0x10 ³	<2.1x10 ³	<2.0x10 ³	<2.0x10 ³		
Nocardia sp.	<1.4x10 ³	<1.6x10 ³	<2.0x10 ³	<2.1x10 ³	<2.0x10 ³	<2.0x10 ³		
Streptomyces sp.	2.7x10 ⁵	<1.6x10 ³	1.6x10 ^{4b}	<2.1x10 ³	<2.0x10 ³	1.1x10 ^{5b}		
Aspergillus fumigatus	1.7x10 ⁴	1.6x10 ^{3b}	4.0x10 ^{3b}	2.1x10 ^{3b}	2.0x10 ^{3b}	8.0x10 ^{4b}		
Aspergillus flavus	2.9x10 ^{3b}	<1.6x10 ³	2.0x10 ^{4b}	<2.1x10 ³	2.0x10 ^{3b}	2.2x10 ⁵		
Mycobacterium sp.	<1.4x10 ²	<1.6x10 ²	<2.0x10 ²	<2.0x10 ²	OG ^c	OG		

^a Less than values, e.g., <1.6x10², indicate the overall minimum detection limits and that no microorganisms were detected.

^b Concentration based upon statistically unreliable microbial count, i.e., <30 colonies per plate.

^c OG = Overgrown by molds.

TABLE C-7. MICROBIOLOGICAL COMPOSITION OF AEROSOL SAMPLES COLLECTED BY THE
LARGE VOLUME AIR SAMPLER (LVAS) AT PLANT F

Parameter	LVAS samples					
	1-2	2-2	2-3	Indoor control		10/8/80
				1-1	2-1	
<u>Sampling data:</u>						
Sampling date	10/7/80	10/8/80	10/8/80	10/7/80	10/8/80	10/8/80
Air volume sampled (m ³)	11.5	56.3	31.5	57.0	56.5	56.5
<u>Microbiological assay (cfu/m³)^a</u>						
Total bacteria	7.1x10 ⁶	7.4x10 ⁴	4.3x10 ⁴	2.7x10 ⁴	OG ^b	OG ^b
Fecal coliforms	≥4.3x10 ³	1.7x10 ¹	<1.7	1.9x10 ¹	1.2x10 ¹	1.2x10 ¹
Salmonella sp.	<1.8x10 ²	<3.5x10 ¹	<8.5x10 ¹	<5.6x10 ¹	<5.6x10 ¹	<5.6x10 ¹
Shigella sp.	<1.8x10 ²	<3.5x10 ¹	<8.5x10 ¹	<5.6x10 ¹	<5.6x10 ¹	<5.6x10 ¹
Klebsiella sp:						
K. pneumoniae	1.5x10 ⁵	<3.5x10 ¹	<8.5x10 ¹	<5.6x10 ¹	<5.6x10 ¹	<5.6x10 ¹
K. oxytoca	3.8x10 ⁴	<3.5x10 ¹	<8.5x10 ¹	<5.6x10 ¹	<5.6x10 ¹	<5.6x10 ¹
Staphylococcus aureus	5.4x10 ³	<3.5x10 ¹	<8.5x10 ¹	<5.6x10 ¹	<5.6x10 ¹	<5.6x10 ¹
Nocardia sp.	<1.8x10 ³	<3.5x10 ¹	<8.5x10 ¹	<5.6x10 ¹	<5.6x10 ¹	<5.6x10 ¹
Streptomyces sp.	1.4x10 ⁵	2.8x10 ³	1.4x10 ⁴	2.6x10 ^{3c}	1.4x10 ⁵	1.4x10 ⁵
Aspergillus fumigatus	3.4x10 ^{4c}	4.9x10 ³	<8.5x10 ¹	7.3x10 ³	<5.6x10 ¹	<5.6x10 ¹
Aspergillus flavus	<1.8x10 ²	7.0x10 ²	1.6x10 ⁴	2.2x10 ^{3c}	5.6x10 ⁴	5.6x10 ⁴
Mycobacterium sp.	OG ^d	OG	OG	<5.6	OG	OG

^a Less than values, e.g., <1.8x10², indicate the overall minimum detection limits and that no microorganisms were detected.

^b Data lost due to overgrowth by molds.

^c Concentration based upon statistically unreliable microbial count, i.e., <30 colonies per plate.

^d OG = Overgrown by molds.

Fecal coliforms were found in all of the AGI aerosol samples but in only a few of the LVS samples. The AGI production aerosol samples contained an average of 2.7×10^2 FC/m³ versus 1.0×10^2 FC/m³ for the controls. Only one of three LVS production samples contained fecal coliforms at 17 FC/m³. The LVS control samples contained an average of 16 FC/m³.

Salmonella--Salmonella sp. were recovered from two solid samples but not from the aerosol samples. Salmonella enteritidis Group C₁ was recovered from a solid waste sample at < 200 cells/g. A stationary dust sample yielded Salmonella enteritidis Group E at < 200 cells/g.

Shigella--Shigella sp. was not detected in any of the samples collected at Plant F.

Klebsiella--Solid waste samples contained both Klebsiella pneumoniae and Klebsiella oxytoca. Klebsiella pneumoniae was found in 75% of the solid waste specimens and averaged 1.7×10^5 cfu/g when present. Klebsiella oxytoca was present in 50% of the specimens at a mean concentration of 1.5×10^5 cfu/g when present.

Settled dust samples also harbored Klebsiella pneumoniae and Klebsiella oxytoca. The concentration of Klebsiella pneumoniae in stationary dust was 2.1×10^4 cfu/g when present. The isolation frequency of Klebsiella pneumoniae was 80%. Klebsiella oxytoca was only found in one dust sample (a 20% isolation frequency) at 1.4×10^4 cfu/g.

Klebsiella aerosols were detected in only one air sample collected during normal plant operations. The sample contained 1.5×10^5 cfu/m³ Klebsiella pneumoniae and 3.8×10^4 cfu/m³ Klebsiella oxytoca.

Staphylococcus aureus--Staphylococcus aureus was found in 50% of the solid waste and 80% of the settled dust samples. When present, the mean concentration of Staphylococcus aureus in solid waste was 4.5×10^3 cfu/g. In the dust samples, the mean Staphylococcus aureus concentration was 2.1×10^4 cfu/g.

Staphylococcus aureus aerosols were detected only once during the survey. The sample contained 5.4×10^3 cfu/m³ and was collected by the LVS. The sample site was the catwalk above the fuel storage bin. The bin was being filled at the time and the air at the sampling location was heavily laden with dust. The conditions were so dusty, in fact, that the LVS was only able to run 11.5 min (640 s) before the return manure line became clogged and sampling was terminated.

Nocardia sp.--Nocardia sp. were not found in the solid or aerosol samples collected at Plant F.

Streptomyces sp.--Streptomyces sp. were found in all of the solid samples collected at Plant F. Solid waste samples contained Streptomyces at 6.7×10^5 cfu/g. Settled dust samples contained a slightly higher concentration of Streptomyces than did solid waste at 2.8×10^6 cfu/g.

Streptomyces sp. aerosols were detected in all LVAS samples, including the controls, but were detected only sporadically by the AGI. The concentration of Streptomyces sp. aerosols collected with the LVAS was 5.2×10^4 cfu/m³ during production periods and 7.1×10^4 cfu/m³ during the indoor control runs. Streptomyces sp. aerosols were detected with the AGI at a 50% frequency for both production and indoor control samples. When detected, the AGI concentration of Streptomyces sp. aerosols during production was 1.4×10^5 cfu/m³ and 1.1×10^5 cfu/m³ during indoor control sampling.

Aspergillus fumigatus--Aspergillus fumigatus was isolated from 25% of the solid waste samples (one sample) and 100% of the dust samples. The average concentration of A. fumigatus, when isolated, was 3.4×10^3 cfu/g. The A. fumigatus concentration of the dust samples was 1.4×10^5 cfu/g.

A. fumigatus aerosols were consistently detected at Plant F. The aerosol samples collected with the AGI always contained A. fumigatus. The concentration of A. fumigatus aerosols collected by the AGI during production sampling averaged 6.2×10^3 cfu/m³. The concentration was slightly higher during the indoor control sampling and equalled 4.1×10^4 cfu/m³.

The LVAS detected A. fumigatus aerosols with a 67% frequency during production sampling and with a 50% frequency during indoor control sampling. When present, the concentration of A. fumigatus aerosols equalled 1.9×10^4 cfu/m³ during production and 7.3×10^3 cfu/m³ during control sampling.

Aspergillus flavus--Aspergillus flavus was found in the settled dust samples but not in the solid waste samples. A. flavus was detected in two dust samples (40% frequency) at an average concentration of 4.0×10^3 cfu/g.

A. flavus aerosols were sporadically recovered by both the LVAS and AGI. A. flavus aerosols were detected in 50% of the AGI production samples at an average concentration of 1.1×10^4 cfu/m³. Similarly, the LVAS recovered A. flavus aerosols at 8.4×10^3 cfu/m³ during production sampling. All indoor control samples contained A. flavus aerosols whether collected by the AGI (1.1×10^5 cfu/m³) or LVAS (2.9×10^4 cfu/m³).

Mycobacterium sp.--Mycobacterium sp. were not found at Plant F within the limitations of the techniques used.

Viral--Virus study results are summarized in Table C-8. A single virus isolate was obtained from a solid waste sample (SW 2-1) collected on the 2nd day of the survey (October 8). The virus isolate was identified as poliovirus type 3 and was presumed to be a vaccine strain. The virus was originally isolated in both primary monkey kidney and human embryonic lung cell cultures; however, it was not detected by newborn mice or by electron microscopy. The concentration of the poliovirus was determined to be between 3 and 30 infectious units per gram of solid waste. The isolate was neutralized by both monotypic poliovirus type 3 antiserum and by an antisera pool of all three poliovirus types. The isolate was obtained from 30 g of solid waste which had been homogenized in 250 ml of HBSS and concentrated to 8.0 ml. Titration of the concentrate in primary monkey kidney cells

TABLE C-8. VIRUS COMPOSITION OF SAMPLES COLLECTED AT PLANT F

Sample no.	Date collected	Air volume sampled (m ³) or assay wt. (g)	Virus isolation results (viral particles/m ³ or g) ^a										Electron microscopy rotavirus, etc.
			Assay in PMK, HEp-2, and MDCK cells ^b					Newborn mice inoculation					
			Adeno	Rhino	Herpes	Polio	Cox. B.	Echo	Influenza ^c	Parainfluenza ^c	Cox. A		
AG1 1-2 ^h	10/7/80	0.5	<30 ^d	<30	<30	<20	<20	<20	<30	<20	<13,000		
AG1 1-3	10/7/80	0.7	<20	<20	<20	<10	<10	<20	<20	<10	<9,000		
AG1 2-4	10/8/80	0.5	<30	<30	<30	<20	<20	<20	<30	<20	<13,000		
AG1 2-6	10/8/80	0.5	<30	<30	<30	<20	<20	<20	<30	<20	<13,000		
AG1 2-8	10/8/80	0.38	<40	<40	<40	<20	<20	<20	<40	<20	<17,000		
AG1 2-9 ⁱ	10/8/80	-	-	-	-	+ ^e	-	-	-	ND ^j	-		
LVAS 2-2	10/8/80	56.3	<0.2	<0.2	<0.2	<0.1	<0.1	<0.2	<0.2	<0.1	<100		
LVAS 2-3	10/8/80	31.5	<0.4	<0.4	<0.4	<0.3	<0.3	<0.4	<0.4	<0.3	<200		
LVAS 2-4	10/8/80	39.0	<0.3	<0.3	<0.3	<0.2	<0.2	<0.3	<0.3	<0.2	<200		
LVAS 2-5 ⁱ	10/8/80	-	-	-	-	+ ^f	-	-	-	ND ^j	-		
SW 2-1	10/8/80	30.0	<0.4	<0.4	<0.4	3-30 ^g	<0.3	<0.4	<0.4	<0.3	<200		

- ^a AGI and LVAS aerosol sample results are expressed as viral particles/m³. Solid waste results are expressed as viral particles/g.
- ^b PMK = Primary monkey (Cynomolgus) kidney; HEPL = human embryonic lung; MDCK = Madin darby canine kidney.
- ^c Inoculated PMK and MDCK tubes were tested for hemagglutination and hemadsorption for detection of influenza and parainfluenza viruses.
- ^d All less than values, e.g., <30, indicate the theoretical detection limits and that no viruses were detected.
- ^e Mixture of poliovirus types 1, 2, and 3 at 10^{6.25} TCID₅₀/ml.
- ^f Mixture of poliovirus types 1, 2, and 3 at 10^{5.75} TCID₅₀/ml.
- ^g Poliovirus type 3.
- ^h Indoor control.
- ⁱ Positive control.
- ^j ND = not done.

indicated that the virus was present only in the concentrate and not at subsequent dilutions.

Positive virus controls were sent to the analytical lab during the Plant F survey. The samples were shipped as blind samples camouflaged as routine aerosol samples. The samples were submitted to the lab as an internal check on method sensitivity since previous samples were all negative.

The results of the positive control samples submitted as blind unknowns were completely satisfactory and were generally within expected limitations. The spiked LVS and AGI samples submitted to the analytical lab contained at least 103.8 to 104.8 TCID₅₀/ml* poliovirus type 1 based upon the vaccine's stated potency. Using cell culture techniques, the analytical lab determined the titer of the spiked samples to be 10^{6.25} TCID₅₀/ml for the AGI sample and 10^{5.75} TCID₅₀/ml for the LVS sample.

The analytical lab's results were between 0.95 and 2.45 TCID₅₀ logs greater than the theoretical results. This discrepancy may be explained by several factors including: (a) virus aggregation during assay, (b) concentration errors, (c) statistical limitations of titration method, and (d) possible error in the reported titer of the vaccine.

A rough titer of the AGI sample was calculated to be 10^{9.75} virus particles/ml original sample based upon TEM results. This estimate is 3.5 logs higher than the titer obtained by roller tube methodology. The difference in titers between the two methods may represent viral particles that are no longer infectious in cell culture, differences in methodology, or both.

Suckling mice were not used to titrate the positive virus control samples.

Noise Exposures

This section details the noise exposure survey results from Plant F. The noise survey was conducted as part of an overall industrial hygiene assessment of the facility. Three measurement techniques were used for evaluating noise exposures: a general plant survey utilizing a sound level meter, octave band analysis at the most significant noise level locations, and personnel dosimetry of selected at-risk employees.

The current OSHA standard, as well as the proposed NIOSH and ACGIH standards, are presented in Table C-9. However, OSHA and other standards are based on personal exposure rather than source generation. Therefore, compliance efforts should not be based solely on noise level production by the equipment, but rather on time/motion studies or personnel dosimetry.

* TCID₅₀ = 50% tissue culture infective dose.

TABLE C-9. OSHA NOISE STANDARDS AND SUGGESTED
OR PROPOSED STANDARDS

Exposure (hr/day)	Continuous noise		
	OSHA (dBA)	ACGIH (dBA)	NIOSH proposed (dBA)
16		80	
8	90	85	85
4	95	90	90
2	100	95	95
1	105	100	100
1/4	115 (max)	110	110
1/8		115 (max)	115 (max)

Impact or impulse noise ^a		
Sound pressure level (dB)	ACGIH	OSHA
140	100 ^b	Not to exceed
130	1,000	140 dB
120	10,000	

^a Impacts at intervals > 1 sec.

^b Maximum number of impacts permitted per 8-hr day.

Average A-weighted noise levels within the plant were measured with a hand-held General Radio sound level meter on all 3 days of the MRI survey. Readings were taken in all major areas of concern, as shown in the diagrams in Figures C-14 through C-22. Table C-10 summarizes the range of noise level readings obtained in each of the major plant areas.

Only two noise readings were obtained in the tipping floor area (Building A) due to the general lack of vehicle activity during the MRI survey. The noise levels measured were 66.0 and 69.5 dBA (as shown in Figure C-16) when no trucks were in the area. When vehicle activity is high, noise levels would fluctuate widely, depending on the number of trucks present. However, maximum levels should not pose exposure problems for workers stationed on the tipping floor since periods of high activity are brief and occur only twice per day.

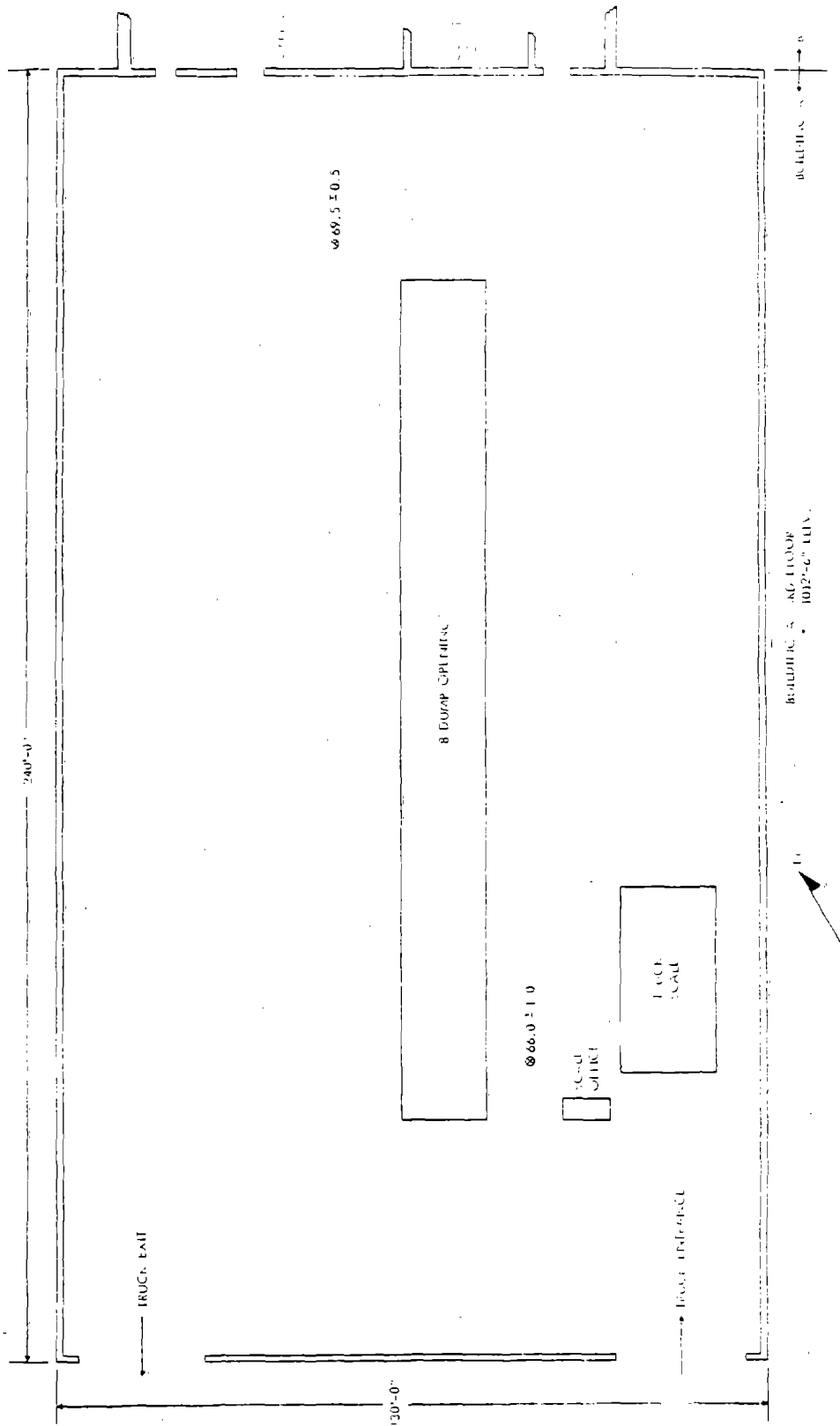


Figure C-14. Sound level readings obtained on tipping floor of Plant F.

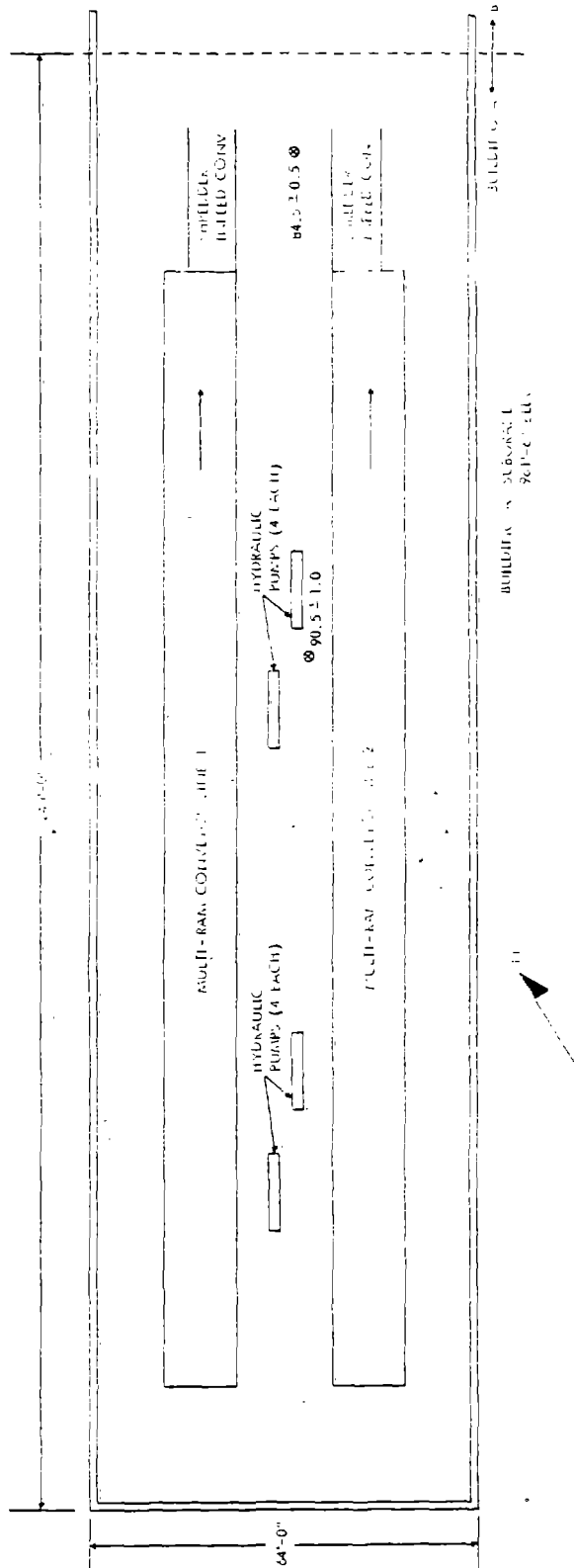


Figure C-15. Sound level readings obtained in the refuse pit/ram conveyor area of Plant F.

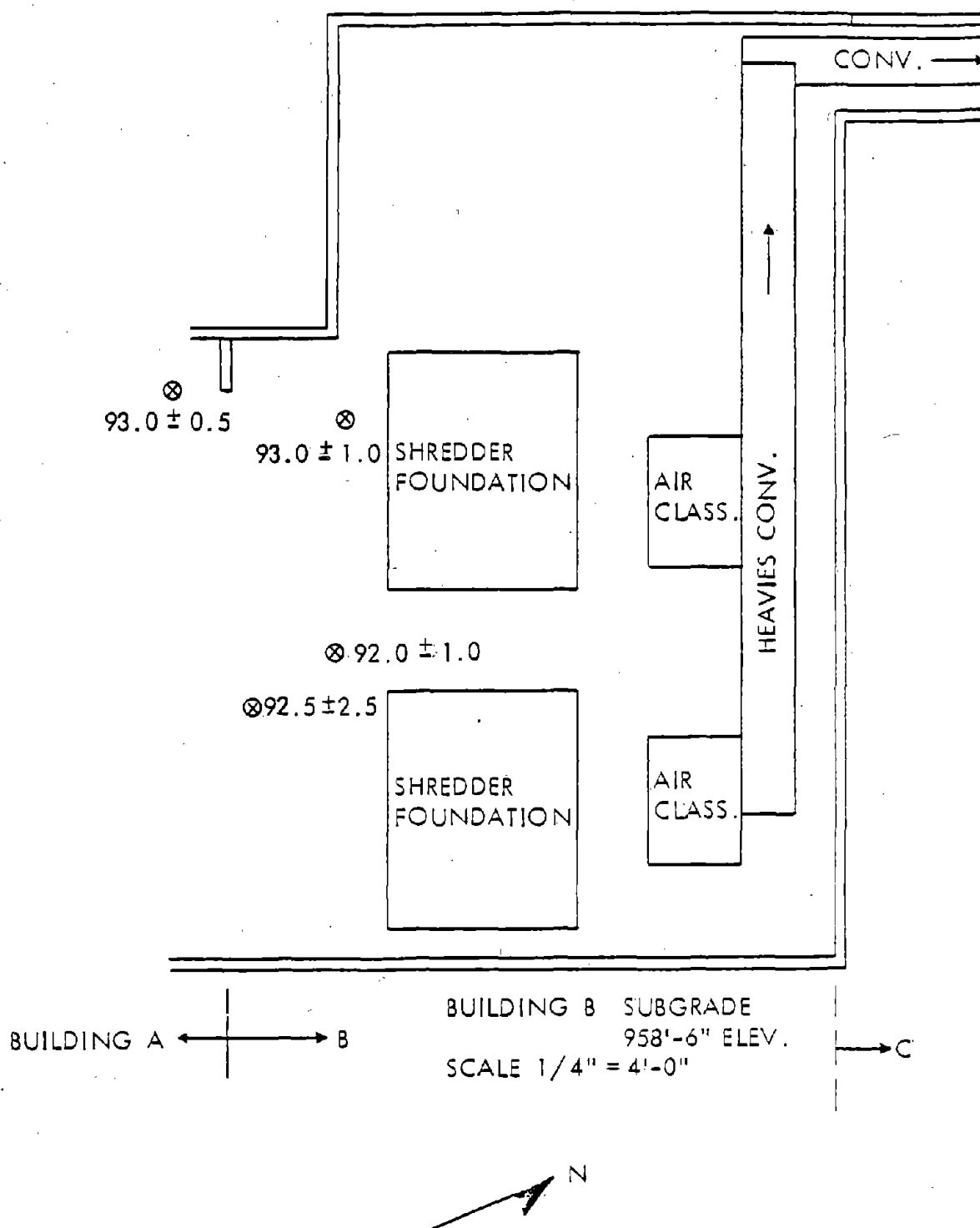


Figure C-16. Sound level readings obtained in the shredder area of Plant F.

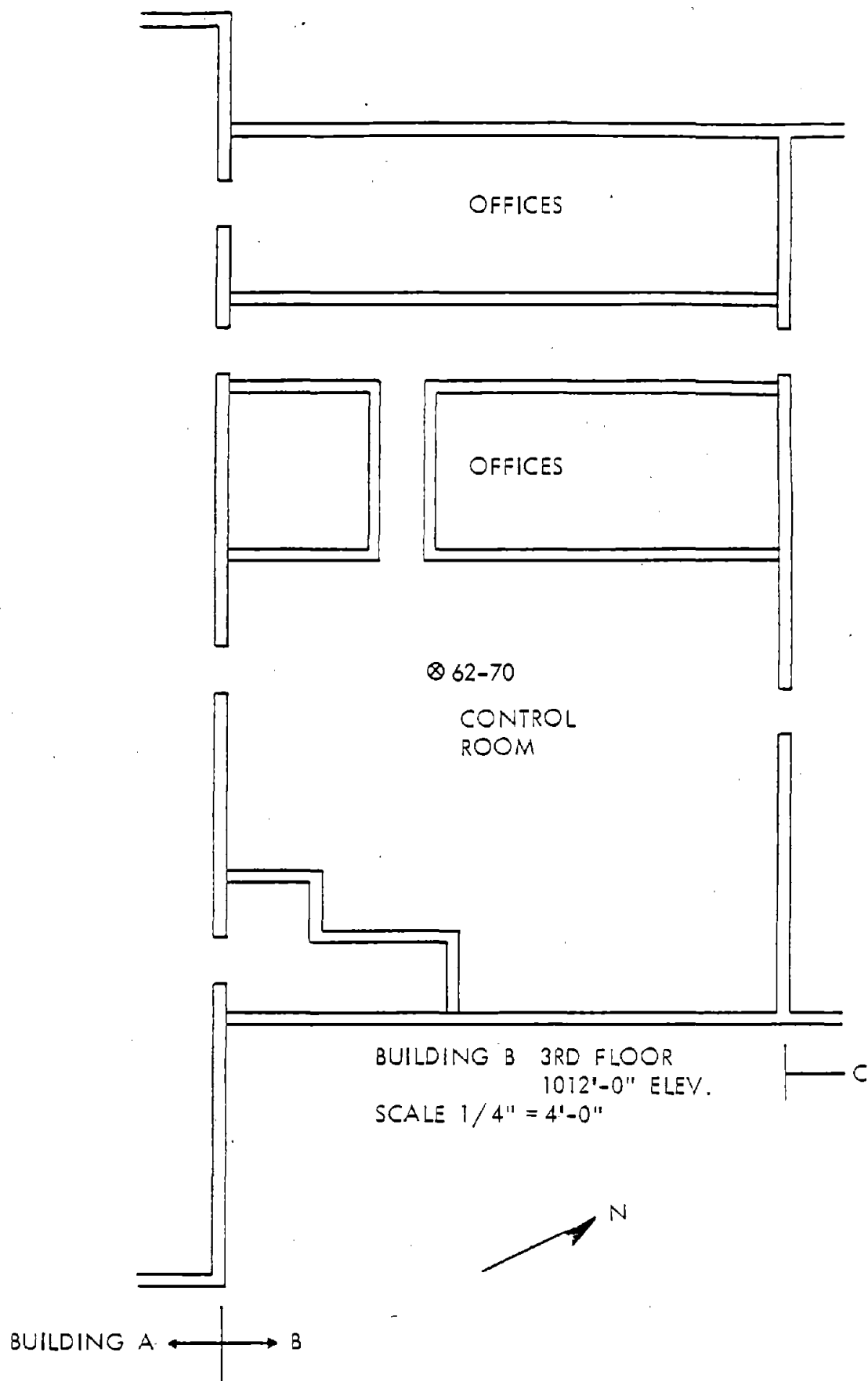


Figure C-17. Sound level readings obtained in the control room of Plant F.

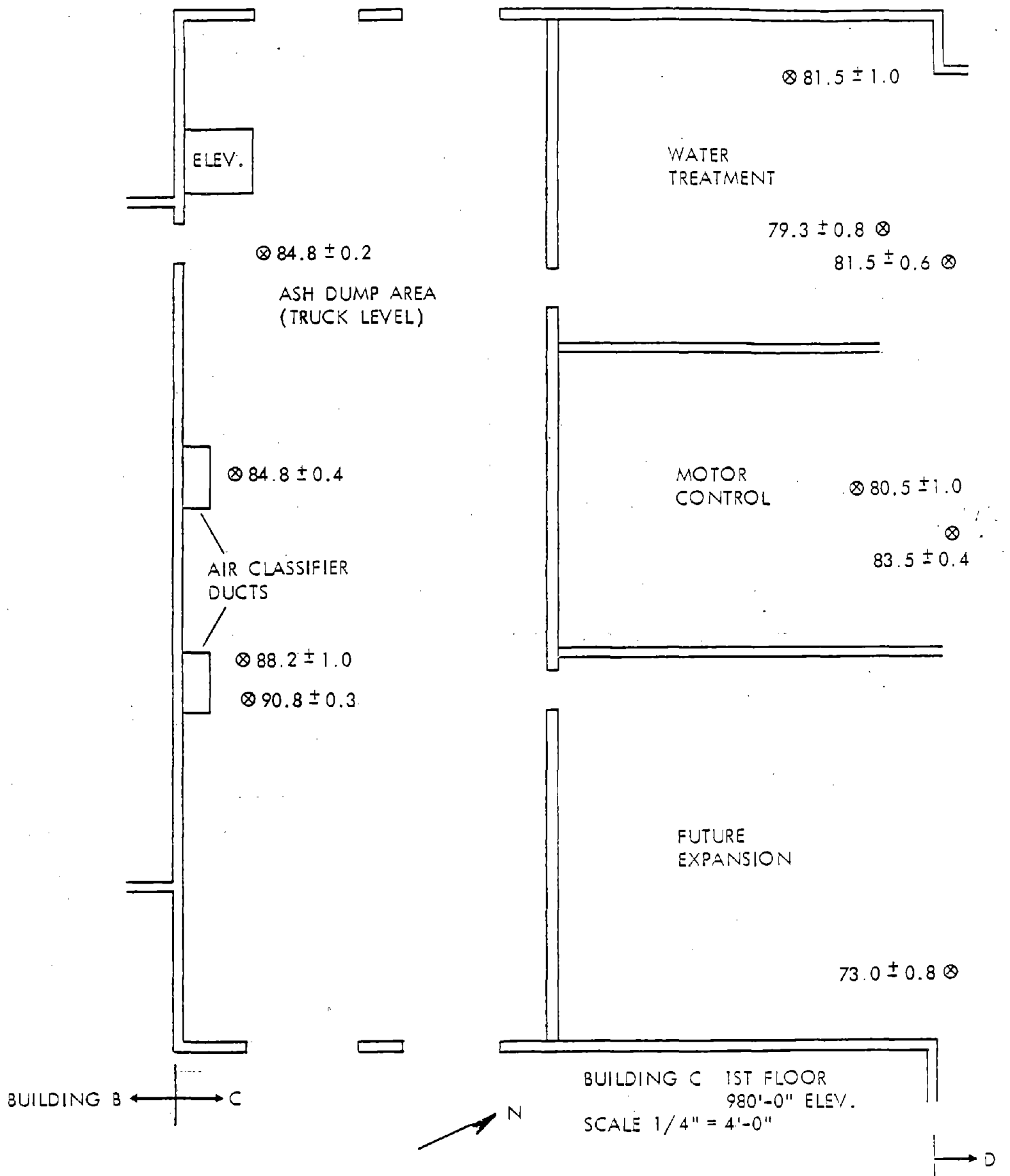


Figure C-18. Sound level readings obtained in the ash loading (truck bay) area of Plant F.

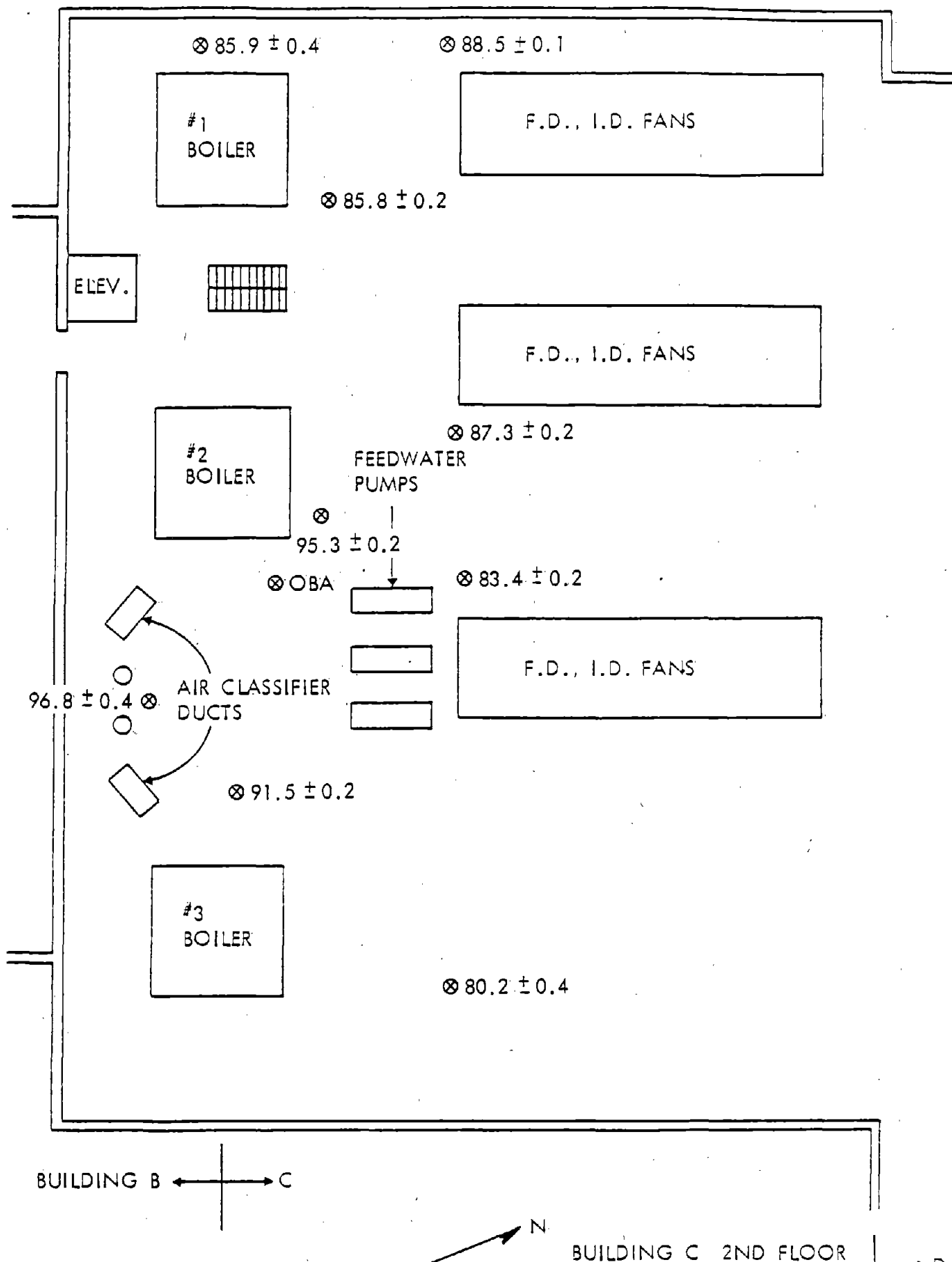


Figure C-19. Sound level readings obtained in the boilerhouse (second level) of Plant F.

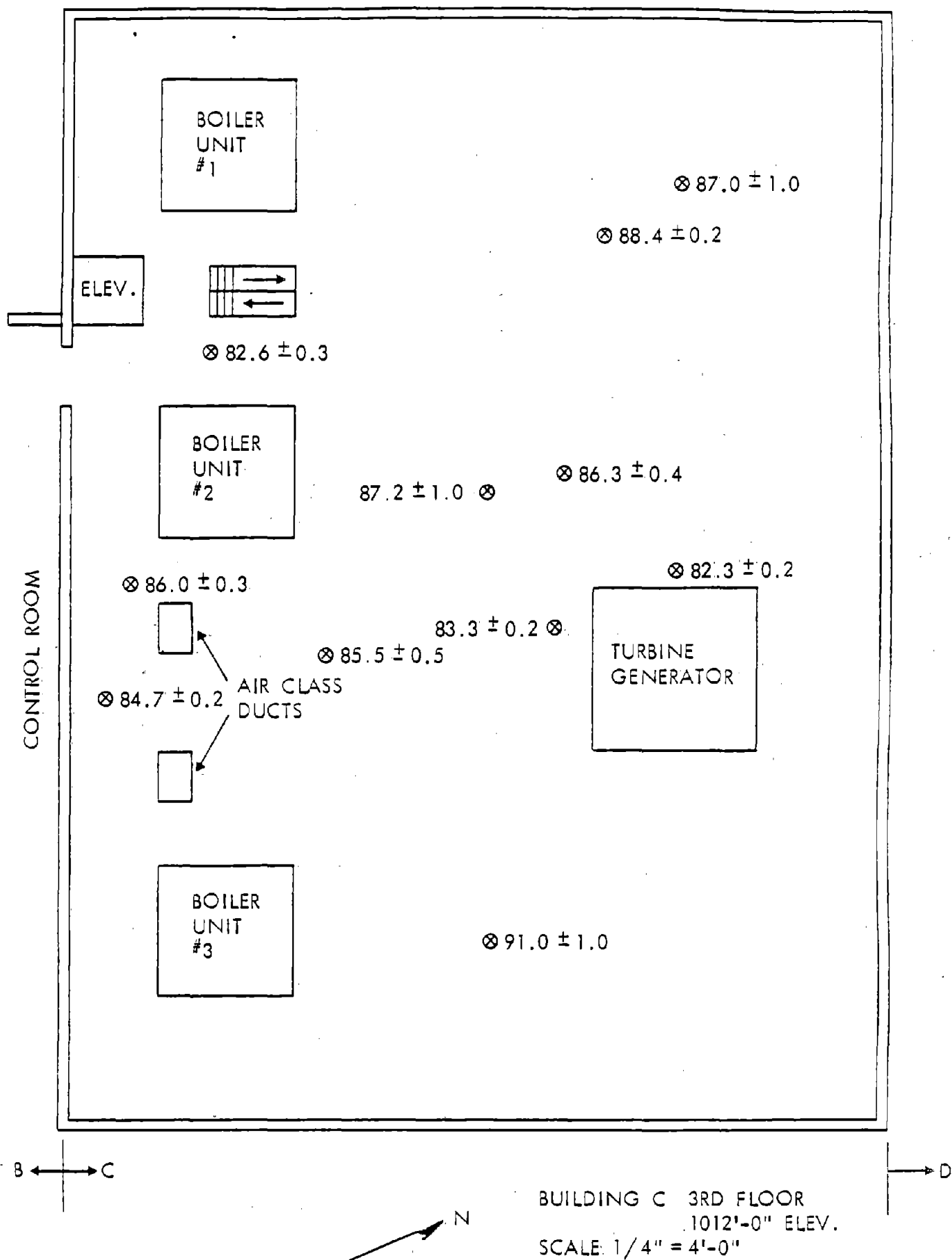


Figure C-20. Sound level readings obtained in the boilerhouse (third level) of Plant F.

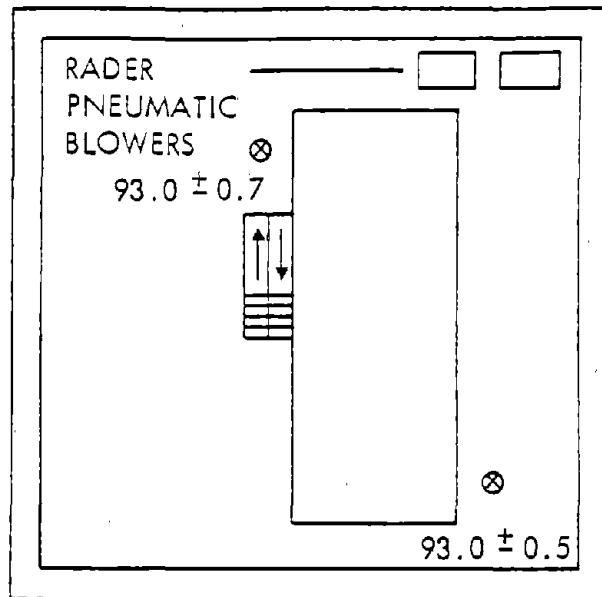


Figure C-21a. BUILDING D BASEMENT
940'-6" ELEV.
SCALE 1/4" - 4'-0"

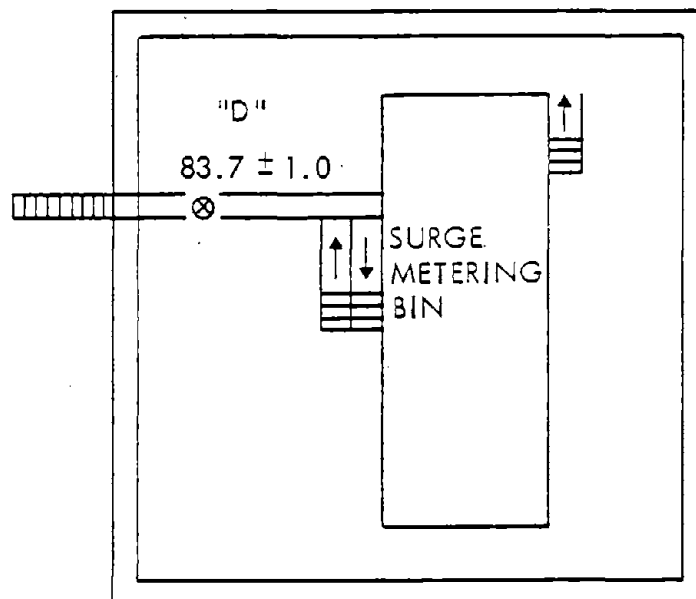
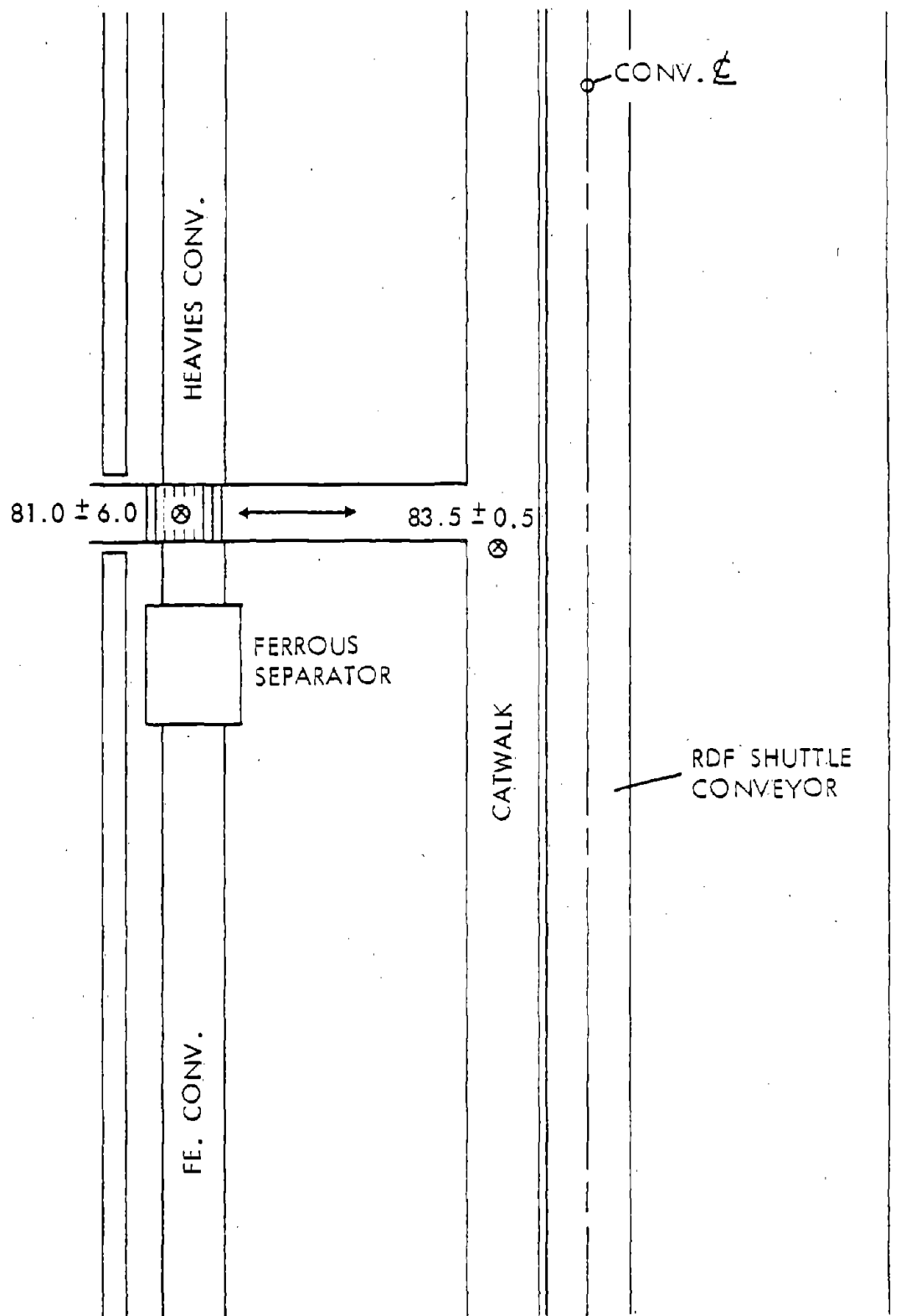


Figure C-21b. BUILDING D PLATFORM
958'-6" ELEV.
SCALE 1/4" - 4'-0"

Sound level readings obtained in the basement area of Plant F beneath the fuel storage bin.



C ← → BUILDING D

BUILDING D SHUTTLE CONV.
1012'-6" ELEV.
SCALE 1/4" = 4'-0"

Figure C-22. Sound level readings obtained in the catwalk area of Plant F above the fuel storage bin.

TABLE C-10. SUMMARY OF NOISE SURVEY RESULTS

Area monitored	Noise measurements (dBA)
Tipping floor	66.0 - 69.5
Refuse pit level	84.5 - 90.5
Shredder room	92.0 - 93.0
Control room	62.0 - 70.0
Boiler house	73.0 - 96.8
Ash removal and auxiliaries	79.3 - 90.8
Fuel storage and retrieval	81.0 - 93.0

The pit area beneath the tipping floor contains hydraulic equipment which powers the multi-ram conveyors at the base of each half of the refuse pit. Noise level readings taken there were 84.5 and 90.5 dBA; the higher readings were obtained adjacent to one of the banks of hydraulic pumps (see Figure C-15). No plant personnel work in this area, except for occasionally maintenance workers.

Noise levels near the base of the shredders (Building B) were relatively constant at 92 to 93 dBA. These readings were taken while both shredders were operating. Employee exposures in this area are limited since it is a restricted area during operation and no one remains in the area unless the shredders are shut down for maintenance.

For comparison, noise measurements were made in the control room located directly above the shredders. Readings of 62 to 70 dBA, depending upon the level of conversation, were observed.

The boiler house (Building C) had the widest range of noise levels, primarily because of the diversity of equipment which it contains. The measurements varied from 80.2 to 96.8 dBA on the second and third floors of Building C, which contained the major noise sources (feed water pumps, air classifier ducts, forced draft and induced draft fans). The areas which generally exceeded 90 dBA were in the vicinity of the three feed water pumps and two air classifier ducts on the second floor, and near the east ash silo on the third floor.

The first (ground) level of Building C consists mainly of one area where trucks are loaded with ash from the boilers and the air pollution control equipment, and segregated, adjoining areas for boiler water treatment equipment, electrical control panels, and room for future expansion. Noise levels in these areas were below 85 dBA except close to the air classifier ducts (see Figure C-18). There is a general lack of noise-producing equipment on this level, which is reflected in the recorded noise measurement data.

Noise levels in the fuel storage and retrieval (Building D) portion were generally in the range of 80 to 85 dBA with the exception of the basement area beneath the storage bin. Because of the heavy duty pneumatic equipment next to the surge bin, readings of about 93 dBA were there.

The remainder of the fuel storage building is a relatively low noise area, and also one of very low work activity. Only maintenance or cleanup personnel work there intermittently.

The actual noise exposures of the workers at Plant F differ from the general noise levels discussed in the previous section, since their job activities require a great deal of movement within and outside the facility. To determine some of their actual noise dosages, personnel noise dosimeters were worn by several employees during their full work shift. Results of this monitoring are shown in Table C-11.

TABLE C-11. RESULTS OF PERSONNEL NOISE
DOSIMETRY--PLANT F

Job category	Cumulative exposure (dBA)	
	10/7/80	10/8/80
Lead maintenance	78.3	
Receiving floor attendant	79.3	
Utility	86.3	
Utility (ash remover)	82.7	90.7
Utility		82.5
Utility		85.3

Only one of the workers monitored showed a cumulative noise exposure in excess of the OSHA limitation of 90 dBA for 8 hr. The other workers were found to be only moderately exposed. However, several situations of personnel working in high noise areas (95 to 100 dBA) with no hearing protection were observed. Since these employees were not monitored, it is not known how much their overall 8-hr exposures were adversely affected by the time spent in the high noise areas.

Since an area near the feed water pumps by the No. 2 boiler produced one of the highest initial readings, an octave band analysis (OBA) was conducted to determine the noise frequency characteristics. Sound level readings were recorded as the mean value at each band setting and also as the peak value for each octave band. Results of this OBA are shown in Figures C-23 through C-26.

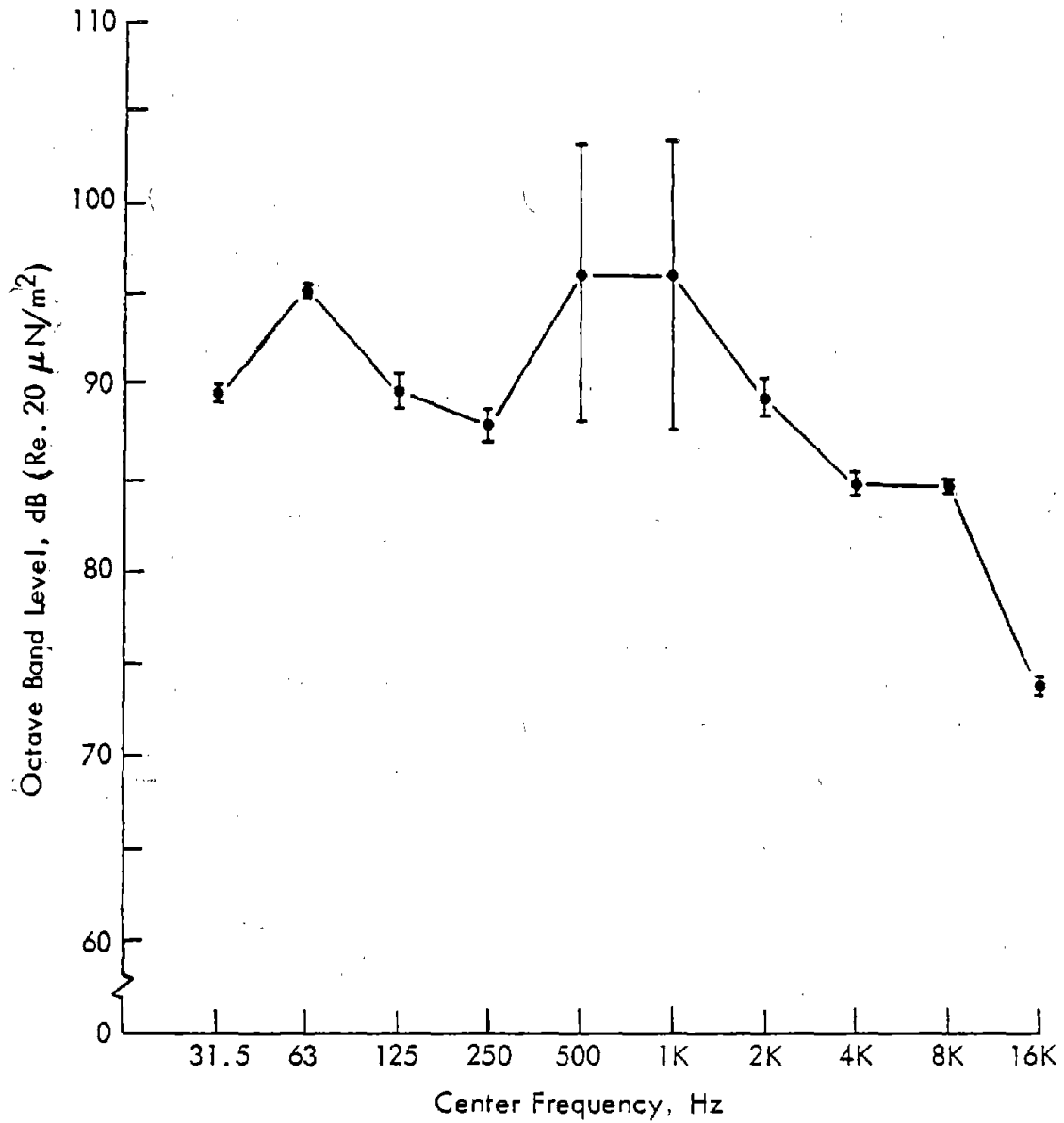


Figure C-23. Average noise readings at 10 octave band center frequencies; feed pump location at Plant F.

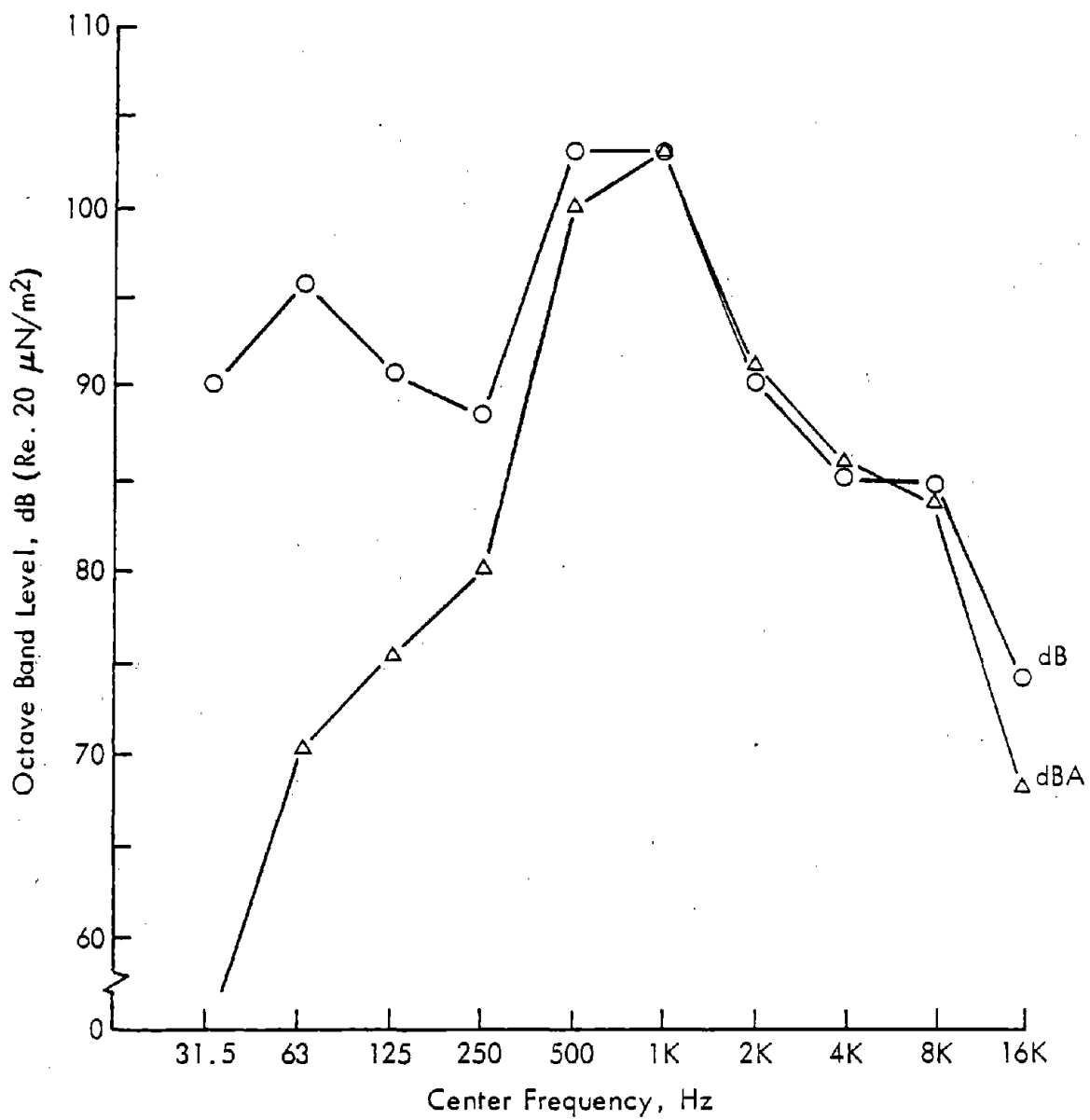


Figure C-24. Maximum noise readings at 10 octave band center frequencies; feed pump location at Plant F.

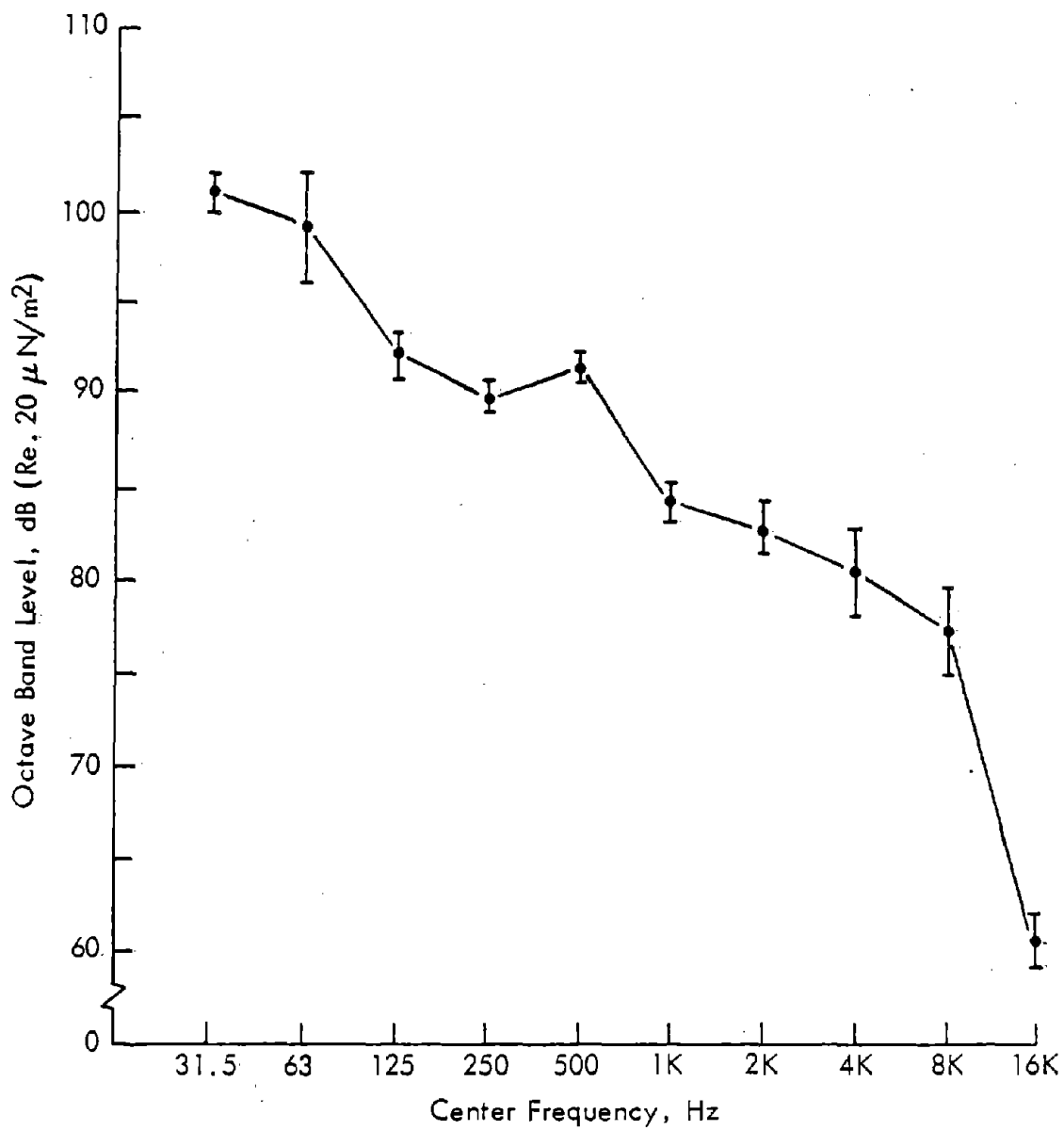


Figure C-25. Average sound level readings at 10 octave band center frequencies; shredder location at Plant F.

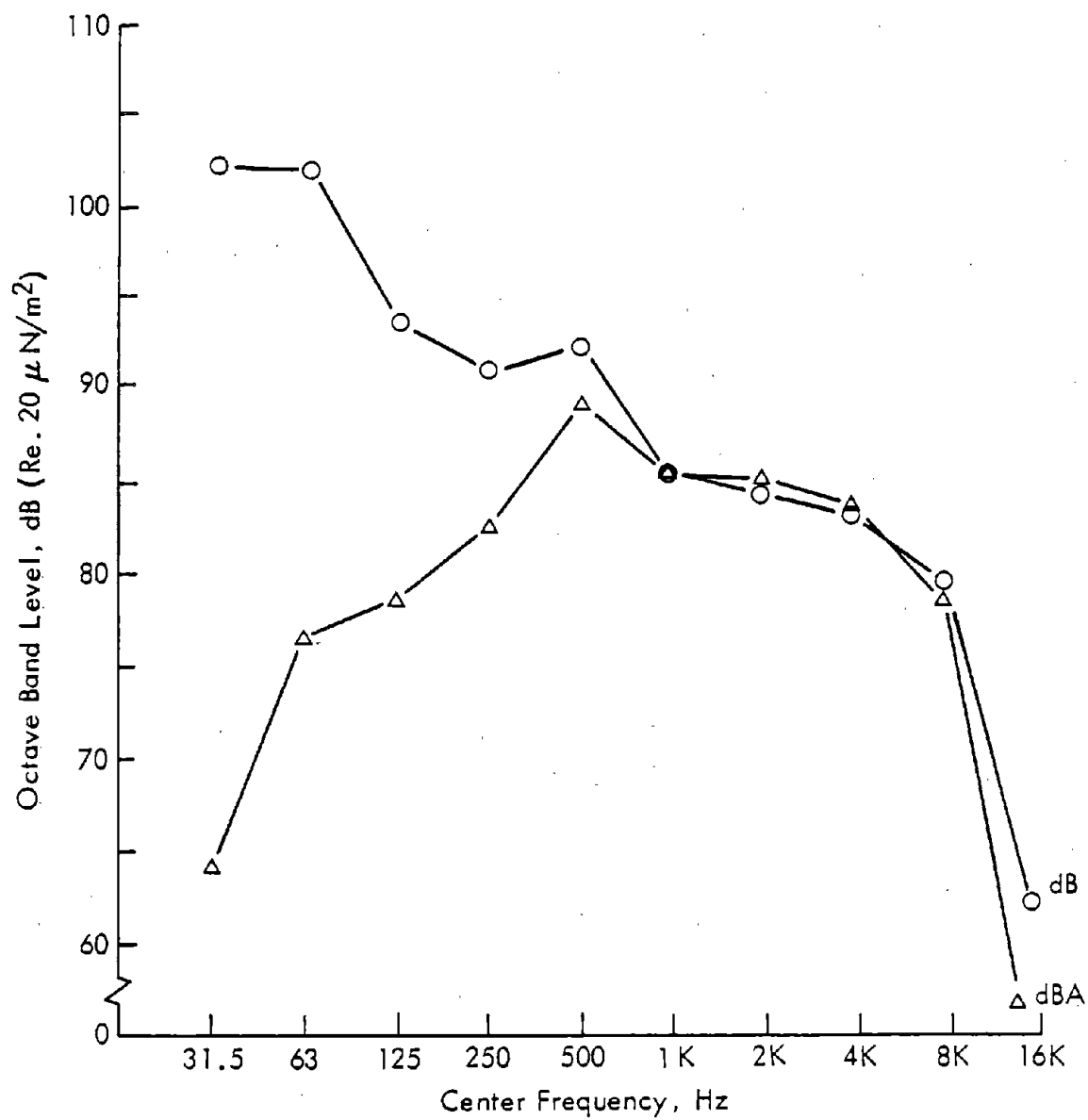


Figure C-26. Maximum sound level readings at 10 octave band center frequencies; shredder location at Plant F.

Figure C-23 shows the average readings obtained at the feed pump measurement location. The maximum dB and dBA levels recorded are shown in Figure C-24. A definite peak at 500 to 1,000 Hz is seen in the plot of these readings when they are adjusted to the A-weighted scale, which compensates for sensitivity characteristics of the human ear. Since the human ear is most sensitive to noise between 1,000 and 2,000 Hz, high sound levels (> 90 dBA) in that range are significant and should be the focus of a control strategy.

Results of the octave band analysis near the bases of the two shredders (Figures C-25 and C-26) indicate the highest noise levels at the low end of the frequency spectrum. These levels gradually decrease with the increase in frequency. When expressed as dBA values, the results show a peak at 500 Hz, but only at a level of 89.8 dBA.

Appendix D. Comprehensive Sampling Data at Plants A-G

TABLE D-1. COMPREHENSIVE SAMPLING DATA AT PLANT A

Substance monitored	IH Log No. (4856-)	Flow rate (Lpm)	Sampling time (min)	Total volume (m ³)	Amount of substance (mg)	Concentration during sampling (mg/m ³)	TWA ^a (mg/m ³)	NIOSH TLV (mg/m ³)
<u>Tipping floor</u>								
Total dust	0001 0064	2.00 2.00	425 240	0.850 0.480	0.43 0.07	0.51 0.2	0.45 -	10 10
Respirable dust	0005 0070	1.70 1.70	450 513	0.765 0.872	0.07 0.31	0.09 0.36	0.09 0.36	5 5
Trace metals	0009	1.50	430	0.645				
Beryllium					ND-LD 0.05 µg ^b	-	-	0.002
Cadmium					ND-LD 0.2 µg ^b	-	-	0.05
Chromium					ND-LD 0.5 µg ^b	-	-	0.05
Lead					0.0019	0.0029	0.0026	0.05
Zinc (oxide fume)					0.00072	0.0011	0.0010	5
Silica (total)	0071	1.70	450	0.765	ND-LD 0.01 mg	-	-	-
<u>Primary shredder</u>								
Total dust	0003 0067	2.00 2.00	450 240	0.900 0.480	3.02 1.28	3.36 2.67	3.15 -	10 10
Respirable dust	0007	1.70	450	0.765	0.27	0.35	0.33	5
Trace metals	0011	1.50	435	0.653				
Beryllium					ND-LD 0.05 µg ^b	-	-	0.002
Cadmium					ND-LD 0.2 µg ^b	-	-	0.05
Chromium					ND-LD 0.5 µg ^b	-	-	0.05
Lead					0.0060	0.0091	0.0083	0.05
Zinc (oxide fume)					0.0038	0.0058	0.0053	5

TABLE D-1. (continued)

Substance monitored	IH Log No. (4856-)	Flow rate (Lpm)	Sampling time (min)	Total volume (m ³)	Amount of substance (mg)	Concentration during sampling (mg/m ³)	TWA ^a (mg/m ³)	NIOSH TLV (mg/m ³)
Polychlorinated biphenyls (PCBs)	0020	0.200	286	0.057				
Aroclor 1242					0.000055 ^b	0.00096	-	0.001
Aroclor 1254					ND-LD 0.08 µg ^b	-	-	0.001
Aroclor 1260					ND-LD 0.05 µg ^b	-	-	-
Silica (total)	0073	1.70	450	0.765	0.03	0.04	0.04	-
Asbestos	0022	1.70	30	51,000 cc	10,850 fibers	0.21 total ^c	-	0.5 fibers/cc
Pesticides	0076	1.70	417	0.417	ND	ND	-	-
Organics ^d	0082	0.200	65	0.013				
Benzene					ND-LD 1 µg ^b	-	-	3
Ethyl alcohol					ND-LD 11 µg ^b	-	-	1,900
Heptane					ND-LD 7 µg ^b	-	-	340
Hexane					ND-LD 3 µg ^b	-	-	360
Secondary shredder								
Total dust	0004	2.00	450	0.900	14.76	16.4	15.4	10
	0066	2.00	240	0.480	13.03	27.1	-	10
Respirable dust	0008	1.70	450	0.765	0.31	0.41	0.38	5

TABLE D-1. (continued)

Substance monitored	IH Log No. (4856-)	Flow rate (Lpm)	Sampling time (min)	Total volume (m ³)	Amount of substance (mg)	Concentration during sampling (mg/m ³)	TWA ^a (mg/m ³)	NIOSH TLV (mg/m ³)
Trace metals	0012	1.50	430	0.645				
Beryllium					ND-LD 0.5 µg ^b	-	-	0.002
Cadmium					ND-LD 0.2 µg	-	-	0.05
Chromium					0.00085	0.0013	0.0012	0.05
Lead					0.013	0.020	0.018	0.05
Zinc (oxide fume)					0.028	0.043	0.039	5
Polychlorinated biphenyls (PCBs)	0019	0.200	335	0.067	0.000075 µg ^b	0.0011	-	0.001
Aroclor 1242					ND-LD 0.08 µg ^b	-	-	0.001
Aroclor 1254					ND-LD 0.05 µg	-	-	-
Aroclor 1260								
Silica (total)	0072	1.70	450	0.765	0.33	0.43	0.40	-
Asbestos	0021	1.70	37	62,900 cc	8,450 fibers	0.13 total ^c fibers/cc	-	0.5 fibers/cc
Pesticides	0077	1.00	408	0.408	ND	ND		
Ground floor								
Respirable dust	0068	1.70	494	0.840	0.32	0.38	0.38	5
Organics ^d	0017	0.200	287	0.057	ND-LD 1 µg ^b	-	-	3
Benzene					0.011 µg ^b	0.19	-	1,900
Ethyl alcohol					ND-LD 7 µg ^b	-	-	340
Heptane					ND-LD 3 µg	-	-	360
Hexane								

TABLE D-1. (continued)

Substance monitored	IH Log No. (4856-)	Flow rate (Lpm)	Sampling time (min)	Total volume (m ³)	Amount of substance (mg)	Concentration during sampling (mg/m ³)	TWA ^a (mg/m ³)	NIOSH TLV (mg/m ³)
Organics ^d (continued)	0018	0.200	305	0.061				
Benzene					0.072	1.2	-	30
Ethyl alcohol					1.710 ^b	28	-	1,900
Heptane					ND-LD 37 µg	-	-	1,600
Hexane					0.014	0.23	-	360
<u>Reject load outs</u>								
Total dust	0002	2.00	450	0.900	1.08	1.20	1.3	10
	0065	2.00	240	0.480	0.53	1.1	-	10
Respirable dust	0069	1.70	499	0.848	0.44	0.52	0.52	5
	0006	1.70	450	0.765	0.16	0.21	0.20	5
Trace metals	0010	1.50	431	0.647				
Beryllium					ND-LD 0.05 µg ^b	-	-	0.002
Cadmium					ND-LD 0.2 µg ^b	-	-	0.05
Chromium					ND-LD 0.5 µg ^b	-	-	0.05
Lead					0.0039	0.0060	0.0053	0.15
Zinc (oxide fume)					0.0019	0.0029	0.0026	-
Asbestos	0023	1.70	30	51,000 cc	3,550 fibers	0.070 total ^c fibers/cc	-	0.5 fibers/cc
Organics ^d	0074	0.200	205	0.041				
Benzene					ND-LD 10 µg ^b	-	-	3
Ethyl alcohol					0.150 ^b	3.7	-	1,900
Heptane					ND-LD 7 µg ^b	-	-	340
Hexane					0.051	1.2	-	360

TABLE D-1. (concluded)

Substance monitored	IH Log No. (4856-)	Flow rate (Lpm)	Sampling time (min)	Total volume (m ³)	Amount of substance (mg)	Concentration during sampling (mg/m ³)	TWA ^a (mg/m ³)	NIOSH TLV (mg/m ³)
Organics ^d (continued)	0075	0.200	205	0.041				
Benzene					0.064	1.6	-	3
Ethyl alcohol					1.390	34	-	1,900
Heptane					ND-LD 37 µg ^b	-	-	340
Hexane					0.036	0.88	-	360

(conc. during sampling)(sampling time)

a When sampling time < 480 min, TWA =

480

. Extrapolation not appropriate

when sampling time < 420 min. When sampling time ≥ 480 min, TWA = conc. during sampling.

b None detected at the limit of detection specified.

c Measured concentrations of total fibers. No asbestos confirmed in sample.

d Results of charcoal tube analyses were coordinated with peaks detected by the Miran 1-A analyzer. Ethyl alcohol represents group including: ethanol, methanol, methyl acetate, dimethoxy methane, methylcyclohexanol, diethyl malonate, 1-heptanol. Heptane and hexane represent groups including: cyclohexane, ethylamine, isophorone, LPG, methylamine, methylcyclohexane, octane, pentane, naptha, stoddard solvent, and turpentine.

TABLE D-2. COMPREHENSIVE SAMPLING DATA AT PLANT B

Substance monitored	IH Log No.	Flow rate (Lpm)	Sampling time (min)	Total volume (m ³)	Amount of substance (mg)	Concentration		NIOSH TLV (mg/m ³)
						during sampling (mg/m ³)	TWA ^a (mg/m ³)	
<u>Picking station</u>								
Total dust	0102	1.48	360	0.533	0.80	1.5	-	10
	0101	1.49	426	0.635	0.85	1.3	1.2	10
Respirable dust	0092	1.69	400	0.676	0.33	0.49	-	5
	0094	1.71	394	0.674	0.19	0.28	-	5
	0096	1.69	383	0.647	0.22	0.34	-	5
	0097	1.71	400	0.684	0.25	0.37	-	5
	0091	1.71	465	0.795	0.34	0.43	0.41	5
	0098	1.69	436	0.737	0.36	0.49	0.44	5
	0095	1.70	467	0.794	0.40	0.50	0.49	5
	0093	1.69	401	0.678	0.31	0.46	-	5
Trace metals	0113	1.50	420	0.630	ND-LD 0.05 µg	-	-	0.002
	Beryllium				ND-LD 0.2 µg	-	-	0.05
	Cadmium				ND-LD 0.5 µg	-	-	0.05
	Chromium				0.0023	0.0037	0.0032	0.05
	Lead				0.0021	0.0033	0.0029	5
Zinc (oxide fume)								
Trace metals	0112	1.50	360	0.540	ND-LD 0.05 µg ^b	-	-	0.0002
	Beryllium				ND-LD 0.2 µg ^b	-	-	0.05
	Cadmium				ND-LD 0.5 µg	-	-	0.05
	Chromium				0.0028	0.0052	-	0.05
	Lead				0.0022	0.0041	-	5
Zinc (oxide fume)								
Silica	0117	1.70	368	0.626	0.04	0.06	-	-
Asbestos	0120	1.49	5	7,500 cc	7,630 fibers	1 fiber/cc ^c	-	0.5 fibers/cc

TABLE D-2. (continued)

Substance monitored (4856-)	IH Log No.	Flow rate (lpm)	Sampling time (min)	Total volume (m ³)	Amount of substance (mg)	Concentration		NIOSH TLV (mg/m ³)
						during sampling (mg/m ³)	TWA ^a (mg/m ³)	
Primary shredder exit								
Organics	0129	0.201	369	0.074	ND-LD 1,100 µg ^b	-	-	1,900
Ethanol					0.440	5.9	-	1,400
Ethyl acetate					0.490	6.6	-	260
Methylene chloride								
Organics	0130	0.205	356	0.073	ND-LD 980 µg ^b	-	-	1,900
Ethanol					0.570	7.8	-	1,400
Ethyl acetate					0.580	7.9	-	260
Methylene chloride								
Organics	0131	0.201	462	0.093	ND-LD 88 µg ^b	-	-	1,900
Ethanol					ND-LD 67 µg ^b	-	-	1,400
Ethyl acetate					0.051	0.55	0.53	260
Methylene chloride								
Organics	0132	0.205	438	0.090	ND-LD 1,100 µg ^b	-	-	1,900
Ethanol					1.220	14	12	1,400
Ethyl acetate					0.720	8.0	7.3	260
Methylene chloride								
PCBs	0089	0.196	409	0.080	ND-LD 0.04 µg ^b	-	-	0.001
Aroclor 1242					ND-LD 0.08 µg ^b	-	-	0.001
Aroclor 1254					ND-LD 0.08 µg ^b	-	-	-
Aroclor 1260								
PNAH	0086	1.5	390	0.589	ND-LD 2 ng ^b	-	-	-
Benzo(a)anthracene					ND-LD 3 ng ^b	-	-	-
Benzo(a)pyrene					0.12	0.20	-	0.20
Benzene sol.					ND-LD 100 µg ^b	-	-	-
Chrysene					ND-LD 3 ng ^b	-	-	-
Fluoranthene					ND-LD 150 ng ^b	-	-	-
Pyrene								

TABLE D-2. (continued)

Substance monitored	IH Log No.	Flow rate (Lpm)	Sampling time (min)	Total volume (m ³)	Amount of substance (mg)	Concentration		NIOSH TLV (mg/m ³)
						during sampling (mg/m ³)	TWA ^a (mg/m ³)	
Load-out area								
Total dust	0104	1.49	360	0.536	0.43	0.80	-	10
	0103	1.48	420	0.622	0.42	0.68	0.59	10
Aluminum separator area								
Total dust	0106	1.50	360	0.540	0.66	1.2	-	10
	0105	1.49	420	0.626	0.57	0.91	0.80	10
Trace metals								
Beryllium	0111	1.51	360	0.544	ND-LD 0.05 µg ^b	-	-	0.002
Cadmium					ND-LD 0.2 µg ^b	-	-	0.05
Chromium					ND-LD 0.5 µg	-	-	0.05
Lead					0.0028	0.0052	-	0.05
Zinc (oxide fume)					0.0023	0.0042	-	5
Trace metals								
Beryllium	0110	1.49	420	0.626	ND-LD 0.05 µg ^b	-	-	0.002
Cadmium					ND-LD 0.2 µg ^b	-	-	0.05
Chromium					ND-LD 0.5 µg	-	-	0.05
Lead					0.0025	0.0040	0.0035	0.05
Zinc (oxide fume)					0.0023	0.0037	0.0032	5
Silica								
	0115	1.71	244	0.417	0.01	0.02	-	-
Asbestos								
	0121	1.49	5	7,500 cc	11,500	1.5 fibers/cc ^c	-	0.5 fibers/cc
PCB								
Aroclor 1242	0088	0.196	455	0.089	ND-LD 0.04 µg ^b	-	-	0.001
Aroclor 1254					ND-LD 0.08 µg ^b	-	-	0.001
Aroclor 1260					ND-LD 0.08 µg	-	-	-

TABLE D-2. (concluded)

Substance monitored	IH Log No. (4856-)	Flow rate (Lpm)	Sampling time (min)	Total volume (m ³)	Amount of substance (mg)	Concentration		NIOSH TLV (mg/m ³)
						Concentration during sampling (mg/m ³)	TWA ^a (mg/m ³)	
<u>Air classifier exit</u>								
Total dust	0108	1.49	360	0.536	0.56	1.0	-	10
	0107	1.50	420	0.630	0.70	1.1	0.97	10
Silica	0116	1.71	207	0.354	ND-LD 0.01 µg ^b	-	-	-
Asbestos	0119	1.49	5	7,500 cc	30,500 fibers	4 fibers/cc ^c		0.5 fibers/cc
<u>PNAHs</u>								
Benzo(a)anthracene	0085	2.01	420	0.844	ND-LD 2 ng ^b	-	-	-
Benzo(a)pyrene					ND-LD 3 ng	-	-	-
Benzene sol.					0.06	0.07	0.06	0.20
Chrysene					ND-LD 100 µg ^b	-	-	-
Fluoranthene					ND-LD 3 ng ^b	-	-	-
Pyrene					ND-LD 150 ng ^b	-	-	-
<u>Welding shed</u>								
Welding fume	0083	1.49	128	0.191	2.03	10.6	-	-

a When sampling time < 480 min, TWA = $\frac{(\text{conc. during sampling})(\text{sampling time})}{480}$.

Extrapolation not appropriate when sampling time < 420 min. When sampling time ≥ 480 min, TWA = conc. during sampling.

b None detected at the limit of detection specified.

c Measured concentration of total fibers. No asbestos confirmed in sample.

TABLE D-3. COMPREHENSIVE SAMPLING DATA AT PLANT C

Substance monitored	IH Log No. (4856)	Flow rate (Lpm)	Sampling time (min)	Total volume (m ³)	Amount of substance (mg)	Concentration during sampling (mg/m ³)	TWA ^a (mg/m ³)	NIOSH TLV (mg/m ³)
<u>Receiving pit area</u>								
Total dust	0151	1.52	480	0.730	2.23	3.05	3.05	10
	0152	1.52	480	0.730	1.01	1.38	1.38	10
Respirable dust	0166	1.71	475	0.812	0.30	0.37	0.37	5
	0167	1.72	600	1.03	0.54	0.52	0.52	5
Trace metals	0202	1.51	480	0.725				
Beryllium					ND-LD 0.05 µg ^b	-	-	0.002
Cadmium					ND-LD 0.2 µg ^b	-	-	0.05
Chromium					ND-LD 0.5 µg ^b	-	-	0.05
Lead					0.0031	0.0043	0.0043	0.05
Zinc (oxide fume)					0.0037	0.0051	0.0051	5
Pesticides	0214	1.50	233	0.394	ND	ND		
Asbestos	0177	0.984	5	5,000cc	4,916 fibers	1.0 fibers/cc ^c		0.5 fibers/cc
<u>Shredders</u>								
Total dust	0153	1.50	480	0.720	1.37	1.90	1.90	10
	0154	1.49	480	0.715	0.53	0.74	0.74	10
Respirable dust	0164	1.69	487	0.823	0.18	0.22	0.22	5
	0165	1.71	433	0.740	0.13	0.18	0.16	5

TABLE D-3. (continued)

Substance monitored	IH Log No. (4856)	Flow rate (Lpm)	Sampling time (min)	Total volume (m ³)	Amount of substance (mg)	Concentration during sampling (mg/m ³)	TWA ^a (mg/m ³)	NIOSH TLV (mg/m ³)
Trace metals	0201	1.50	480	0.720				
Beryllium					ND-LD 0.05 µg ^b	-	-	0.002
Cadmium					ND-LD 0.2 µg ^b	-	-	0.05
Chromium					ND-LD 0.5 µg	-	-	0.05
Lead					0.00076	0.0011	0.0011	0.05
Zinc (oxide fume)					0.0011	0.0015	0.0015	5
Welding fume	0195	1.73	180	0.311	1.95	6.27	-	-
	0196	1.69	143	0.242	1.50	6.20	-	-
Polychlorinated biphenyls (PCBs)	0191	0.200	478	0.096				
Aroclor 1242					ND-LD 0.01 µg ^b	-	-	0.001
Aroclor 1254					ND-LD 0.02 µg ^b	-	-	0.001
Aroclor 1260					ND-LD 0.04 µg	-	-	-
Polychlorinated biphenyls (PCBs)	0192	0.201	490	0.098				
Aroclor 1242					ND-LD 0.01 µg ^b	-	-	0.001
Aroclor 1254					ND-LD 0.02 µg ^b	-	-	0.001
Aroclor 1260					ND-LD 0.04 µg	-	-	-
Organics	0189	0.203	391	0.079				
Ethanol					ND-LD 41 µg ^b	-	-	1,900
Ethyl acetate					ND-LD 14 µg ^b	-	-	1,400
Methylene chloride					ND-LD 40 µg	-	-	260
Turpentine					0.060	0.76	-	560
Organics	0188	0.200	391	0.078				
Ethanol					ND-LD 41 µg ^b	-	-	1,900
Ethyl acetate					ND-LD 14 µg ^b	-	-	1,400
Methylene chloride					ND-LD 40 µg	-	-	260
Turpentine					0.058	0.74	-	560

TABLE D-3. (continued)

Substance monitored	IH Log No. (4856)	Flow rate (Lpm)	Sampling time (min)	Total volume (m ³)	Amount of substance (mg)	Concentration during sampling (mg/m ³)	TWA ^a (mg/m ³)	NIOSH TLV (mg/m ³)
Polynuclear aromatics (PNAHs)	0174	2.01	480	0.965	Analytical problems; no results			
Benzo(a)anthracene								-
Benzo(a)pyrene								-
Chrysene								-
Fluoranthene								-
Pyrene								-
Pesticides	0215	0.984	235	0.231	ND	ND		-
Silica	0171	1.71	480	0.821	0.04	0.049	0.049	-
<u>Metals separation</u>								
Total dust	0156 0155	1.49 1.53	480 480	0.715 0.734	0.39 2.52	0.55 3.43	0.55 3.43	10 10
Respirable dust	0163 0162	1.69 1.69	446 497	0.754 0.840	0.20 0.13	0.27 0.15	0.25 0.15	5 5
Trace metals	0200	1.51	480	0.725	ND-LD 0.05 µg ^b ND-LD 0.2 µg ^b ND-LD 0.5 µg ^b ND-LD 0.5 µg ^b ND-LD 0.5 µg ^b			
Beryllium								0.002
Cadmium								0.05
Chromium								0.05
Lead								0.05
Zinc (oxide fume)								5
Silica	0170	1.69	458	0.774	0.01	0.013	0.012	0.3
Asbestos	0176	0.984	5	5,000cc	9,833 fibers	2 fibers/cc ^c		0.5 fibers/cc

TABLE D-3. (continued)

Substance monitored	IH Log No. (4856)	Flow rate (Lpm)	Sampling time (min)	Total volume (m ³)	Amount of substance (mg)	Concentration during sampling (mg/m ³)	TWA ^a (mg/m ³)	NIOSH TLV (mg/m ³)
<u>Fuel processing</u>								
Total dust	0158	1.52	480	0.730	0.71	0.97	0.97	10
	0157	1.53	480	0.734	0.39	0.53	0.53	10
Respirable dust	0161	1.69	472	0.798	0.13	0.16	0.16	5
	0160	1.72	295	0.507	0.14	0.28	-	5
Trace metals	0199	1.52	480	0.730	ND-LD 0.05 µg ^b	-	-	0.002
Beryllium					ND-LD 0.2 µg ^b	-	-	0.05
Cadmium					ND-LD 0.5 µg ^b	-	-	0.05
Chromium					0.00072	0.00099	0.00099	0.05
Lead					0.00065	0.00089	0.00089	5
Zinc (oxide fume)								
Organics	0187	0.203	130	0.026	ND-LD 41 µg ^b	-	-	1,900
Ethanol					ND-LD 14 µg ^b	-	-	1,400
Ethyl acetate					ND-LD 40 µg ^b	-	-	260
Methylene chloride					ND-LD 11 µg ^b	-	-	560
Turpentine								
Organics	0186	0.203	227	0.046	ND-LD 41 µg ^b	-	-	1,900
Ethanol					ND-LD 14 µg ^b	-	-	1,400
Ethyl acetate					ND-LD 40 µg ^b	-	-	260
Methylene chloride					0.045	0.98	-	560
Turpentine								
Organics	0185	0.201	227	0.046	ND-LD 41 µg ^b	-	-	1,900
Ethanol					ND-LD 14 µg ^b	-	-	1,400
Ethyl acetate					ND-LD 40 µg ^b	-	-	260
Methylene chloride					0.029	0.63	-	560
Turpentine								

TABLE D-3. (concluded)

Substance monitored	IH Log No. (4856)	Flow rate (Lpm)	Sampling time (min)	Total volume (m ³)	Amount of substance (mg)	Concentration during sampling (mg/m ³)	TWA ^a (mg/m ³)	NIOSH TLV (mg/m ³)
Polynuclear aromatics (PNAHs)	0173	2.01	480	0.965	Analytical problems; no results			
Benzo(a)anthracene								-
Benzo(a)pyrene								-
Chrysene								-
Fluoranthene								-
Pyrene								-
Silica	0169	1.73	372	0.644	0.03	0.05	-	-
Asbestos	0175	0.984	4	4,000cc	3,685 fibers	1 fiber/cc ^c	-	0.5 fibers/cc

a When sampling time < 480 min, TWA = $\frac{(\text{conc. during sampling})(\text{sampling time})}{480}$

Extrapolation not appropriate when sampling time < 420 min; when sampling time > 480 min, TWA = conc. during sampling.

b None detected at the limit of detection specified.

c Measured concentration of total fibers. No asbestos confirmed in sample.

TABLE D-4. COMPREHENSIVE SAMPLING DATA AT PLANT D

Substance monitored	IH Log No. (4856--)	Flow rate (Lpm)	Sampling time (min)	Total volume (m ³)	Amount of substance (mg)	Concentration during sampling (mg/m ³)	TWA ^a (mg/m ³)	NIOSH TLV (mg/m ³)
<u>Receiving pit</u>								
Total dust	0247	1.50	480	0.720	2.07	2.88	2.88	10
	0263	1.52	480	0.730	1.37	1.88	1.88	10
<u>Respirable dust</u>								
	0227	1.69	438	0.740	0.30	0.41	0.37	5
	0254	1.69	431	0.728	0.28	0.38	0.35	5
<u>Crane deck</u>								
Total dust	0246	1.52	480	0.730	2.85	3.90	3.90	10
	0264	1.50	480	0.720	0.34	0.47	0.47	10
	0262	1.48	480	0.710	0.85	1.20	1.20	10
<u>Respirable dust</u>								
	0253	1.70	435	0.740	0.13	0.18	0.16	5
<u>Trace metals</u>								
Beryllium	0265	1.51	453	0.684	ND-LD 0.1 µg ^b	-	-	0.002
Cadmium					ND-LD 0.3 µg ^b	-	-	0.05
Chromium					0.00085	0.0012	0.0012	0.05
Lead					0.0041	0.0060	0.0057	0.05
Zinc (oxide fume)					0.0031	0.0045	0.0043	5
<u>Asbestos</u>								
	0235	1.01	15	15,000cc	2,460 fibers	0.16 fibers/cc ^c	-	0.5 fibers/cc
<u>Furnace level</u>								
Total dust	0245	1.47	480	0.706	0.51	0.72	0.72	10
	0261	1.47	480	0.706	0.11	0.16	0.16	10
<u>Respirable dust</u>								
	0236	1.69	432	0.730	0.24	0.33	0.30	5
	0228	1.70	444	0.755	0.12	0.16	0.15	5
	0252	1.71	370	0.633	0.06	0.09	-	5

(continued)

TABLE D-4. (continued)

Substance monitored	IH Log No. (4856-)	Flow rate (Lpm)	Sampling time (min)	Total volume (m ³)	Amount of substance (mg)	Concentration during sampling (mg/m ³)	TWA ^a (mg/m ³)	NIOSH TLV (mg/m ³)
<u>Furnace level (continued)</u>								
Polychlorinated biphenyls (PCBs)	0231	0.199	439	0.087				
Aroclor 1242					ND-LD 0.06 µg _b	-	-	0.001
Aroclor 1254					ND-LD 0.08 µg _b	-	-	0.001
Aroclor 1260					ND-LD 0.15 µg	-	-	-
<u>Polynuclear aromatic hydrocarbons (PNAH)</u>								
Benzo(a)anthracene	0232	2.03	480	0.974				
Benzo(a)pyrene					ND-LD 0.010 µg _b	-	-	-
Chrysene					ND-LD 0.006 µg _b	-	-	-
Fluoranthene					ND-LD 0.300 µg _b	-	-	-
Pyrene					ND-LD 0.010 µg _b	-	-	-
					ND-LD 0.400 µg	-	-	-
Hydrogen chloride	0269	1.01	60	0.061	ND-LD 27 µg ^b	-	-	7 ^d
	0270	1.01	30	0.030	0.020	0.67	-	7 ^d
Hydrogen cyanide	0240	2.49	60	0.15	ND-LD 0.1 µg ^b	-	-	5 ^e
	0273	1.01	110	0.111	0.001	0.009	-	5 ^e
	0272	2.48	122	0.303	ND-LD 0.13 µg	-	-	5 ^e
<u>Ash quench area</u>								
Respirable dust	0229	1.69	379	0.641	0.05	0.08	-	5
	0255	1.69	429	0.725	0.17	0.23	0.21	5

(continued)

TABLE D-4. (concluded)

Substance monitored	IH Log No. (4856-)	Flow rate (Lpm)	Sampling time (min)	Total volume (m ³)	Amount of substance (mg)	Concentration during sampling (mg/m ³)	TWA ^a (mg/m ³)	NIOSH TLV (mg/m ³)
Ash quench area (continued)								
PNAH	0256	2.03	480	0.974				
Benzo(a)anthracene					ND-LD 0.010 µg ^b	-	-	-
Benzo(a)pyrene					ND-LD 0.006 µg ^b	-	-	-
Chrysene					ND-LD 0.300 µg ^b	-	-	-
Fluoranthene					ND-LD 0.010 µg ^b	-	-	-
Pyrene					ND-LD 0.400 µg ^b	-	-	-
Hydrogen chloride	0268	1.01	35	0.035	0.022	0.63	-	7 ^d
	0267	1.01	35	0.035	ND-LD 33 µg ^b	-	-	7 ^d
Hydrogen cyanide	0274	1.01	120	0.121	0.00024	0.0020	-	5 ^e
	0271	2.48	127	0.315	0.0021	0.0067	-	5 ^e
Ash separation								
Total dust	0248	1.48	480	0.710	0.07	0.1	0.1	10

^a When sampling time < 480 min, TWA = $\frac{\text{(Conc. during sampling)}(\text{sampling time})}{480}$

Extrapolation not appropriate when sampling time < 420 min. When sampling time > 480 min, TWA = conc. during sampling.

^b None detected at the limit of detection specified.

^c Measured concentration of total fibers. No asbestos confirmed in sample.

^d Ceiling value for 15 min.

^e Ceiling value for 10 min.

TABLE D-5. COMPREHENSIVE SAMPLING DATA AT PLANT E

Substance monitored	III Log No. (4856-)	Flow rate (lpm)	Sampling time (min)	Total volume (m ³)	Amount of substance (mg)	Concentration		
						during sampling (mg/m ³)	TWA ^a (mg/m ³)	NIOSH TLV (mg/m ³)
<u>Tipping floor area</u>								
Total dust	0308	1.51	512	0.773	0.41	0.53	0.53	10
	0303	1.50	516	0.774	0.54	0.70	0.70	10
	0336	1.51	307	0.464	0.04	0.09	-	10
	0288	1.49	429	0.639	0.21	0.33	0.29	10
<u>Respirable dust</u>								
	0307	1.70	463	0.787	0.01	0.01	0.01	5
	0310	1.70	230	0.391	0.08	0.2	-	5
	0279	1.70	466	0.792	0.07	0.09	0.09	5
	0282	1.70	311	0.529	0.09	0.2	-	5
	0331	1.70	332	0.564	0.10	0.18	-	5
	0332	1.70	345	0.587	0.06	0.1	-	5
<u>Process area</u>								
Total dust	0305	1.49	526	0.784	0.26	0.33	0.33	10
	0304	1.49	507	0.755	0.50	0.66	0.66	10
	0334	1.50	311	0.467	0.17	0.36	-	10
	0287	1.51	497	0.750	0.22	0.29	0.29	10
	0284	1.49	480	0.715	0.64	0.90	0.90	10
	0333	1.49	312	0.465	0.08	0.2	-	10
	0335	1.49	322	0.480	0.16	0.33	-	10
	0285	1.49	480	0.715	0.05	0.07	0.07	10
	0283	1.50	480	0.720	0.09	0.01	0.01	10
	0306	1.49	500	0.745	0.30	0.40	0.40	10
<u>Respirable dust</u>								
	0314	1.70	470	0.799	0.13	0.16	0.16	5
	0309	1.70	360	0.612	0.02	0.03	-	5
	0281	1.70	475	0.808	0.07	0.09	0.09	5
	0280	1.70	478	0.813	0.04	0.05	0.05	5
	0329	1.70	359	0.610	0.04	0.07	-	5
	0330	1.70	359	0.610	0.07	0.1	-	5
<u>Trace metals</u>								
Beryllium	0277	1.49	492	0.733	ND-LD 0.1 µg ^b	-	-	0.002
Cadmium					ND-LD 0.15 µg	-	-	0.05
Chromium					0.0001	0.0001	0.0001	0.05
Lead					0.0008	0.001	0.001	0.05
Zinc (oxide fume)					0.00050	0.00068	0.00068	5
<u>Pesticides</u>								
	0324	1.50	180	0.270	ND	ND	ND	0.5 fibers/cc
<u>Asbestos</u>								
	0338	1.51	3	4500cc	2415 fibers	0.5 fibers/cc ^c	-	0.5 fibers/cc

^a When sampling time < 480 min, TWA = (conc. during sampling)(sampling time) / 480. Extrapolation not appropriate.

^b When sampling time < 420 min. When sampling time < 480 min, TWA = conc. during sampling.

^c None detected at limit of detection specified.

^d Measured concentration of total fibers. No asbestos confirmed in sample.

TABLE D-6. COMPREHENSIVE SAMPLING DATA AT PLANT F

Substance monitored	IH Log No. (4856-)	Flow rate (Lpm)	Sampling time (min)	Total volume (m ³)	Amount of substance (mg)	Concentration		NIOSH TLV (mg/m ³)	
						during sampling (mg/m ³)	TWA ^a (mg/m ³)		
<u>Tipping Floor</u>									
Total dust	0348	1.52	458	0.696	0.66	0.95	0.90	10	
Respirable dust	0343	1.72	475	0.817	0.17	0.21	0.21	5	
<u>Shredder Area</u>									
Total dust	0349	1.51	485	0.732	1.29	1.76	1.76	10	
Polychlorinated biphenyls (PCBs) Aroclor 1242 Aroclor 1254 Aroclor 1260	0360	0.0175	436	0.0076	ND-LD 0.01 µg _b ND-LD 0.01 µg _b ND-LD 0.03 µg _b	- - -	- - -	0.001 0.001 -	
<u>Boiler House</u>									
Total dust	0351	1.53	487	0.745	1.52	2.04	2.04	10	
	0385	1.50	427	0.641	3.41	5.32	4.73	10	
	0386	1.53	386	0.591	0.19	0.32	-	10	
	0388	1.52	407	0.619	2.62	4.23	-	10	
Respirable dust	0342	1.71	432	0.739	7.46	10.1	9.09	5	
	0344	1.70	449	0.763	0.31	0.41	0.38	5	
	0345	1.69	467	0.789	19.62	24.9	24.2	5	
	0346	1.50	420	0.630	0.18	0.29	0.25	5	
	0383	1.69	422	0.713	0.48	0.67	0.59	5	
	0384	1.72	353	0.609	0.72	1.2	-	5	

TABLE D-6. (continued)

Substance monitored	IH Log No. (4856--)	Flow rate (Lpm)	Sampling time (min)	Total volume (m ³)	Amount of substance (mg)	Concentration		
						during sampling (mg/m ³)	TWA ^a (mg/m ³)	NIOSH TLV (mg/m ³)
Trace metals	0396	1.53	420	0.643				
Beryllium					ND-LD 0.05 μg ^b	-	-	0.002
Cadmium					ND-LD 0.2 μg _b	-	-	0.05
Chromium					ND-LD 0.5 μg	-	-	0.05
Lead					0.0018	0.0028	0.0025	0.05
Zinc (oxide fume)					0.0066	0.010	0.0088	5
Hydrogen chloride	0354	1.01	149	0.150	0.049	0.33	-	7 ^c
	0355	1.01	170	0.172	0.290	1.69	-	7 ^c
	0392	1.01	217	0.219	0.136	0.62	-	7 ^c
	0393	1.01	194	0.196	0.205	1.05	-	7 ^c
Hydrogen cyanide	0357	1.15	149	0.171	ND-LD 0.22 μg ^b	-	-	5 ^d
	0358	1.15	170	0.196	0.00035	0.0018	-	5 ^d
	0389	1.15	217	0.250	ND-LD 0.15 μg _b	-	-	5 ^d
	0390	1.15	194	0.223	ND-LD 0.16 μg	-	-	5 ^d
Polynuclear aromatic hydrocarbons (PNAHs)	0363	2.33	479	1.116				
Benzo(a)anthracene					ND-LD 0.010 μg _b	-	-	-
Benzo(a)pyrene					ND-LD 0.010 μg _b	-	-	-
Chrysene					ND-LD 0.300 μg _b	-	-	-
Fluoranthene					ND-LD 0.010 μg _b	-	-	-
Pyrene					ND-LD 0.400 μg	-	-	-
Fuel Storage								
Total dust	0347	1.50	515	0.773	0.54	0.70	0.70	10
	0387	1.51	422	0.637	0.17	0.27	0.24	10

TABLE D-6. (concluded)

Substance monitored	IH Log No. (4856-)	Flow rate (Lpm)	Sampling time (min)	Total volume (m ³)	Amount of substance (mg)	Concentration		NIOSH TLV (mg/m ³)
						during sampling (mg/m ³)	TWA ^a (mg/m ³)	
Respirable dust	0382	1.71	375	0.641	1.36	2.12	-	5
Asbestos	0352	1.53	7	0.0107	ND-LD 2,457 fibers			0.5 fibers/cc

a When sampling time < 480 min, $TWA = \frac{(\text{Conc. during sampling})(\text{sampling time})}{480}$. Extrapolation not appropriate

when sampling time < 420 min. When sampling time $\geq$ 480 min, TWA = conc. during sampling.

b None detected at limit of detection specified.

c Ceiling value for 15 min.

d Ceiling value for 10 min.

TABLE D-7. COMPREHENSIVE SAMPLING DATA AT PLANT G

Substance monitored	IN Log No. (4856-)	Flow rate (lpm)	Sampling rate (min)	Total volume (m ³)	Amount of substance (mg)	Concentration during sampling (mg/m ³)	TWA ^a (mg/m ³)	NIOSH TLV (mg/m ³)
Ash House								
Respirable dust	0422	1.66	394	0.654	0.01	0.02	-	5
Total dust	0428	1.50	431	0.647	0.21	0.33	0.30	10
(Next to furnace dropout on belt)	0447	1.57	471	0.739	0.16	0.22	0.22	10
	0448	1.55	480	0.744	0.96	1.3	1.3	10
Charging Floor								
Asbestos	0452	0.983	27	27,000 cc	ND-LD 2,460 fibers ^b	-	-	0.5 fibers/cc
Organics ^c	0434	0.100	480	0.0480				
Heptane					0.02	0.4	0.4	340
Hexane					0.02	0.4	0.4	360
Nonane					0.03	0.6	0.6	-
Octane					ND-LD 0.01			350
Pentane					0.09	2	2	350
Respirable dust	0451	1.58	446	0.705	0.30	0.43	0.40	5
	0450	1.57	463	0.727	0.22	0.30	0.29	5
	0421	1.62	462	0.748	0.67	0.90	0.87	5
Total dust	0426	1.53	473	0.724	1.72	2.38	2.35	10
	0444	1.59	482	0.766	1.33	1.74	1.74	10
Trace metals	0405	1.50	466	0.699				
Beryllium					ND-LD 0.05 μ g/d	-	-	0.002
Cadmium					ND-LD 0.2 μ g/d	-	-	0.05
Chromium					ND-LD 0.6 μ g	-	-	0.05
Lead					0.005	0.007	0.007	0.05
Zinc (oxide fume)					0.0048	0.0069	0.0067	5
Furnace level								
Hydrogen chloride	0413	0.982	164	0.162	0.112	0.691	-	7 ^c
	0412	0.982	151	0.148	0.068	0.46	-	7 ^c
	0416	1.05	150	0.158	0.132	0.835	-	7 ^c
	0437	1.05	197	0.207	0.169	0.817	-	7 ^c

(continued)

TABLE D-7. (concluded)

Substance monitored	Ill Log No. (4856-)	Flow rate (lpm)	Sampling rate (min)	Total volume (m ³)	Amount of substance (mg)	Concentration during sampling (mg/m ³)	TWA ^a (mg/m ³)	NIOSH TLV (mg/m ³)
Hydrogen cyanide	0429	0.987	150	0.158	0.0002	0.001	-	5 ^f
	0430	0.987	197	0.194	0.0003	0.002	-	5 ^f
	0414	1.04	151	0.157	ND-1D 0.0002	-	-	5 ^f
Total dust	0427	1.55	497	0.770	0.27	0.35	0.35	10
	0446	1.50	481	0.721	0.11	0.15	0.15	10
<u>General area (maintenance)</u>								
Respirable dust	0418	1.62	475	0.770	0.16	0.21	0.21	5
Total dust	0424	1.55	437	0.677	0.55	0.81	0.74	10
<u>Tipping floor</u>								
Organics ^g	0435	0.095	480	0.046	0.01 ^d	0.2	0.2	340
Heptane					ND-1D 0.01 ^d	-	-	360
Hexane					ND-1D 0.01 ^d	-	-	-
Nonane					ND-1D 0.01 ^d	-	-	350
Octane					ND-1D 0.01 ^d	-	-	350
Pentane					0.02	0.4	0.4	5
Respirable dust	0420	1.71	381	0.652	0.30	0.46	-	5
	0449	1.64	373	0.612	0.55	0.90	-	5
Total dust	0425	1.53	442	0.676	0.38	0.56	0.52	10
	0445	1.51	481	0.726	0.59	0.81	0.81	10

^a When sampling time <480 min, TWA = (Conc. during sampling) (sampling time) / 480

Extrapolation not appropriate when sampling time <420 min. When sampling time >480 min, TWA = conc. during sampling.

^b Total fibers; no asbestos confirmed in sample.

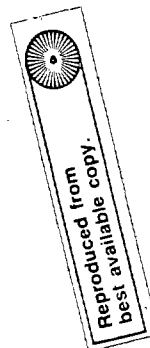
^c Total hydrocarbons reported as hexane for this sample was 0.43 mg.

^d None detected at the limit of detection specified.

^e Ceiling value for 15 min exposure.

^f Ceiling value for 10 min exposure.

^g Total hydrocarbons reported as hexane for this sample was 0.06 mg.



APPENDIX E

PLANT HEALTH AND SAFETY PROGRAMS

As part of the overall industrial hygiene characterization of the industry, plant health and safety programs of the facilities surveyed by MRI were reviewed. The health and safety program elements at Plants A through G are summarized in Table E-1, and the following paragraphs describe briefly the findings at each facility.

PLANT A

Plant A issues all employees hard hats, coveralls, safety glasses, safety shoes, dust masks, and organic vapor cartridge respirators. During the inspection of the plant most workers were observed to be wearing their hard hats, coveralls, and safety shoes. However, few of the employees were seen wearing dust masks, respirators, or safety glasses where needed. Hearing protection provided to the employees included ear plugs and ear muffs but no employees were observed using either of these devices. The facility also has available two Scott® Air-Pak units for emergency situations. Four of the plant staff are trained in the use of this equipment.

The company holds safety meetings for the plant employees each Thursday morning. At these weekly meetings, in addition to discussions, safety films (from Media Research Laboratories) are often shown.

The plant's safety committee consists of management personnel and three union representatives. One-hour safety committee meetings are held once per month. Potential hazards requiring attention and problems that have been corrected since the previous meeting are recorded in the monthly minutes. The committee routinely conducts safety inspections of one of the production trains each month.

To reduce lost time due to accidents, the safety committee has recommended action in several areas. A pocket-size booklet of safety hazard report forms has been distributed to each employee. These forms are designed to be completed by the worker who recognizes a hazard, with copies sent to the appropriate supervisor and the safety committee.

The committee also has developed written fire fighting procedures and has arranged fire fighting training (conducted by a certified fire academy) for selected employees. In addition, employees who complete a certified, 8-hr first aid course (on their own time) are fully reimbursed by the company for time and fees.

TABLE E-1. SUMMARY OF HEALTH AND SAFETY PROGRAM
ELEMENTS AT PLANTS A THROUGH G

Activity	Plants						
	A	B	C	D	E	F	G
Worker/Mgt Safety Committee	X	X	X	X	X		
Routine Safety/Health Meetings	X	X	X	X	X		
Routine Safety/Health Training Activities		X		X			
Personal Protective Equipment Provided	X	X	X	X	X	X	X
Written Safety Rules for Employees	X	X	X	X	X	X	
Separate Work and Leisure Clothes Lockers		X	X		X		
Previous Industrial Hygiene Surveys	X	X		X			
Lock-Out Program	X	X	X	X	X	X	

The safety committee has developed written work and operational area safety rules. The work rules require employees to wear special clothing, hard hats, and safety glasses while on the job. The company provides the required safety glasses and work clothing at no cost and reimburses employees for 50% (up to \$15) of the purchase price of safety shoes. Other safety equipment is available for employee use upon request, including rubber coats, boots, and pants; disposable ear plugs; gloves; and MSA 1/4-mask dust respirators or 3M disposable dust respirators. Also, a "lock-out" program has been developed as part of the written work rules. This program ensures that equipment cannot be operated until all employees working on it have each released a lock with their own key. In particularly hazardous areas, the maintenance supervisor has the only key for lock-out procedures.

Operational area safety rules have been designed to minimize the number of employees exposed to potential hazards in a particular area at a given time. As an example, employees must notify the control room operator before entering the tipping floor area. This allows the control operator to alert the front-end loader operator that personnel are coming onto the floor.

PLANT B

Plant B provides a three-locker system for employees. One locker is assigned for street clothes, one for work clothes, and a smaller locker for equipment. Work clothes are changed three times per week (more often if necessary) and are stored in a bin designated for dirty clothes until they are collected for cleaning by a commercial laundry. Shower facilities and a separate lunch and break room with an adjoining washroom are available specifically for the employees. New employee training includes a 1-day plant safety orientation program.

Industrial hygiene surveys for the plant were previously conducted by the parent company (about 1976-1977), and corporate industrial hygiene services are available from the parent company upon request. (No routine sampling program is now carried out.) Some administrative controls are used in conjunction with several job classifications. Pickers and spotters, for example, are rotated during the work shift, as are the front-end loader operators and the compactor operators. However, these rotations are primarily for safety reasons and maintaining adequate job performance; they are not done for industrial hygiene purposes.

PLANT C

Plant C has a safety committee which meets every month for about 1-1/2 to 2 hr. The committee consists of the safety manager, three shift supervisors, four hourly workers, and the personnel manager. Safety hazards which have been rectified and those needing attention are discussed and are entered in the minutes of the meetings. The safety manager conducts walk-through safety inspections of the plant prior to the safety committee meetings and recommends actions to the committee based on the inspection findings.

New employees are trained on-the-job by the shift supervisor. Equipment issued to each new employee by the company includes safety goggles or glasses,

disposable dust masks, a hard hat, safety shoes, uniforms, and gloves. Ear muffs for hearing protection are also available and are issued as needed. Each employee is trained in the use of a self-contained breathing apparatus (Scott® Air-Pak) for rescue operations.

New employees are issued a copy of the plant's safety manual, which defines the responsibilities of both supervisors and employees. It explains the operation of the safety committee and its inspection duties, accident investigation and recordkeeping, and fire prevention and protection procedures. The manual outlines general safety practices in the areas of transportation, maintenance, crane operations, machine guarding, and welding. It also discusses the correct use of personal protective equipment in designated areas and the plant's equipment lock-out safety policy. During the MRI survey, safety policies appeared to be generally followed, but the degree of enforcement was unclear.

Each employee is furnished with a set of company uniforms consisting of 11 pairs of pants and 11 shirts. At the end of each shift, dirty uniforms are left in the supply room; every Friday they are picked up for cleaning. Employees are provided with a locker to store clean uniforms and their street clothes. Showers adjacent to the locker rooms are used by employees at the end of their shift. A lunch and break room with a filtered air supply is available for the employees and is used by most of them. Sanitation was observed to be adequate.

Beyond the requirements for use of routine personal safety equipment, no other specific industrial hygiene practices are routinely employed at Plant C. No administrative or work practice controls appeared to be in effect at the facility during the survey. Plant management indicated that no previous industrial hygiene surveys of the plant had been conducted.

PLANT D

Plant D has an active safety committee which meets monthly. The committee consists of six workers and one supervisor who represent the areas of maintenance, operations, and administration. The committee conducts plant safety inspections on a bi-monthly basis. In addition, a safety engineer from Plant D's insurance carrier conducts quarterly safety inspections and prepares a written report of the findings.

A formal 20-hr supervisor's safety course has been established by the company and is available to all supervisory personnel. All employees are encouraged to participate in one of two company-financed first aid training courses offered by the National Safety Council and the local state's safety council. Four line workers and one supervisor usually attend each course. Because of this training, a minimum of two persons capable of rendering first aid are always at the plant during operating hours. The company also sponsors employee attendance at regional and national safety council meetings.

The company which operates Plant D has prepared an employee safety manual. It is issued to all new employees, who then review the manual with their

supervisor. The safety manual contains rules covering personnel protection, record keeping requirements, fire protection and prevention, laboratory safety (including material safety data sheets for chemicals and gases used at the facility), lock-out procedures, and special procedures to be followed when cutting or welding.

It is the general manager's responsibility to develop and direct the accident prevention program. The assistant chief engineer serves as the safety engineer, and the primary function of this position is to administer the accident prevention program.

All employees are issued hard hats, goggles, safety glasses, gloves, and ear plugs. The company also allots \$25 yearly for each employee towards the purchase of safety shoes. Other equipment available for use in specially posted areas includes ear muffs and dust respirators. In chemical handling areas special equipment is provided, such as safety showers, eye wash stations, clothing for handling chemicals (gloves and aprons), and full face shields.

All employees are trained to use a self-contained breathing apparatus. One Scott® Air-Pak is kept in each of the cabs of the overhead cranes (which are air-conditioned and heated with filtered air) in case of a fire emergency. Another air pack is located in the control room and is intended for general use.

Each employee is provided with seven uniforms (shirts and pants) and two jackets. A one-locker system is used, and dirty clothes are deposited in a dirty clothes hamper. The dirty clothes are dry cleaned.

Employees have a 30-min lunch break and can eat in the plant lunchroom, which is separate from the process areas and is air-conditioned. A 15-min clean-up period is provided at the end of each work shift. An air-conditioned shower and locker room with filtered air is available for all employees.

A 1-day industrial hygiene survey of Plant D was conducted in April 1980 by a private firm. This was the only industrial hygiene survey conducted at the facility prior to the visit by MRI. The results of the earlier survey were not available.

No ongoing industrial hygiene practices have been instituted by the plant management other than in the use of personal protective equipment.

PLANT E

The safety committee at Plant E meets once a month to review plant safety matters. The committee consists of two hourly workers and two management representatives.

New employee orientation includes information outlining the plant's basic safety program. The new employee is given a copy of his or her job description, which discusses operation of plant equipment. Safety considerations are covered in this context.

No safety manual covering the operation of Plant E was available.

Lock-out procedures and vessel entry procedures have been instituted at Plant E.

Mandatory safety equipment includes hard hats, safety glasses, and safety shoes. The hard hats and safety glasses are provided by the plant. Employees must pay \$10 for safety shoes the first year of employment and \$5 the second year; they receive free safety shoes after three or more years of employment. Other safety equipment available as needed includes: welding hoods or goggles, gloves, raingear, respirators, dust masks, acid goggles, full-face shields, and emergency air packs.

Employees are furnished their work uniforms. At the end of a shift, dirty uniforms are collected in separate numbered lockers and are replaced with clean uniforms by a contract uniform supply service. The locker room has showers and is supplied with fresh filtered air. A lunch and break room with a filtered air supply is available for use by the employees.

The plant is equipped with extensive fire fighting and fire prevention equipment.

Beyond the required use of routine personal safety equipment, no other industrial hygiene practices are routinely employed at Plant E. No administrative or work practice controls were observed during the survey.

Plant management indicated that no previous industrial hygiene surveys of the plant had been conducted.

PLANT F

When Plant F began operations, a volunteer safety committee consisting of management, first-line supervision, and representatives from each plant area was organized to conduct two inspections per month. Duties of the committee included formulating safety rules with effective follow-up, making systematic inspections, reviewing circumstances and causes of accidents, and recommending corrective actions. Unfortunately, this committee no longer functions. The plant safety director does make inspections, however, as time permits or when potential problems are reported.

A safety procedures manual has been written for employee use. Responsibilities of the company, management, and employees are spelled out to achieve maximum safety results. The manual discusses a variety of topics, including safety training, accident or injury recordkeeping, accident investigation, medical and first aid treatment, fire prevention and protection, specific safety rules for all plant areas, and emergency procedures. Rescue training in the use of self-contained breathing apparatus and safety equipment has been provided by the local fire department for 17 employees.

Operational areas of Plant F are restricted as a means of protecting employees. Only authorized personnel are permitted in these operational areas.

Doors to the storage pit are locked. Maintenance lock-out procedures require that employees involved in equipment repair and maintenance have their own assigned lock. On the receiving floor, personnel are required to reject 13 categories of hazardous materials and 12 categories of nonprocessable materials when they are found in the incoming waste.

Employees are required to use a variety of personal protective equipment. The company furnishes at no cost to the employee safety shoes, hard hats, eye protection, disposable ear plugs, half mask cartridge respirators and disposable dust masks, and 11 sets of pants, shirts, and jackets (laundered weekly) and gloves. For those employees working with boiler feed chemicals rubber gloves, boots, and clothing are provided.

The plant has a washroom with locker and shower facilities. A separate room for lunches and breaks is also provided. No cafeteria service is available, but there are several vending machines.

No industrial hygiene surveys have been conducted by the company or other agencies. The company has an agreement with Mine Safety Appliances Company to provide a respiratory protection training program, which includes written policies and procedures, for ash pullers.

PLANT G

Plant G does not have a formal safety program. Instead, safety-related matters are discussed at Monday morning supervisors' meetings and are handled primarily as a management item. Similarly, no provision is made for regular and routine safety inspections of the facility. It is expected that any safety hazards or potentially hazardous situations will be noticed and corrected by a supervisor, or brought to the attention of the supervisor by one of the employees.

Training of new employees is accomplished by an apprenticeship period served with a veteran plant worker. Health and safety procedures are learned in this manner rather than through an introductory or ongoing training course. The city where the plant is located has a division which can assist plant management in employee health and safety education, but from the survey it was unclear how the two interact. The city division does not make safety inspections of the plant, nor does it appear to monitor the safety program.

Personal protective equipment such as hard hats, safety glasses, dust masks, gloves, etc., are available for each employee from the plant storeroom, at company expense. During the MRI survey, however, no one inside the plant was observed wearing a hard hat or hearing protection, even where protection seemed needed. Signs were observed at entrances designating certain portions of the plant as hard hat areas. The use of safety glasses is apparently not mandatory since many workers wore no glasses of any kind.

An administrative control is used for one work location within Plant G. The worker stationed in the ash separation house is rotated approximately

every 2-1/2 hr because of the monotony and noise associated with that particular work location. No other administrative controls are known to be used at the plant.

No other industrial hygiene practices were mentioned by the plant management or observed by the investigators. The MRI survey was the first industrial hygiene survey of the Plant G facility since it began operation.

APPENDIX F

EMPLOYMENT AND MEDICAL RECORDKEEPING PRACTICES

This section describes the employment and medical recordkeeping practices of Plants A through G. These data were collected to aid in evaluating the possibility of conducting epidemiological and medical studies. The amount of information obtained from the representatives of the plants' management or from city or county government (in those cases where the plants were city or county owned) varied. No attempt was made to persist in obtaining information beyond that which was voluntarily provided because the survey team recognized that the surveys were being completed through the goodwill of the facilities' management.

PLANT A

The medical surveillance program at Plant A consists of a preemployment physical examination for new employees and mandatory annual physicals for all employees. The physicals consist of routine tests including blood chemistry, urinalysis, baseline audiogram, and chest X ray. Information identifying the physicians performing the physicals was not disclosed, but the physicians appear to be private practitioners. Requests for copies of the forms used for recording results of the physicals were denied.

Approximately 23 accidents have been reported since the plant began operation in November 1975. According to plant officials, all accidents are reported to a city personnel office, which handles insurance and workers' compensation claims. The majority of the accidents involved punctures and cuts, although workers reported back injuries also from the operation of replacing hammers in the shredders. When injured, the employee has the option of being treated by a physician of personal choice. A sample accident report form is shown as Figure F-1.

Employee records are maintained by the city personnel department. Access to the records by the survey team for review was not granted. Information was obtained to estimate the number of former employees (with the exception of the laborers' job classifications) in discussions concerning job mobility and work turnover rates. There have been two plant superintendents, two operation supervisors, one senior maintenance-electrical worker, five senior maintenance workers, eight maintenance workers, three truck drivers, four senior equipment operators, and three clerks. No reliable estimates of laborer category turnover could be achieved without access to personnel files. The utility engineer is a newly created position which has been occupied by the same person since its inception.

ACCIDENT REPORT

1. Name of person injured _____

2. Address, street, etc. _____

3. Occupation when injured _____

4. Age _____ Married or single _____ Children under 16 years _____

5. Place where accident occurred _____

6. Date of accident _____ Day of week _____ Hour of day _____

7. Why did accident happen? (describe fully) _____

8. What was done to prevent recurrence of this type of accident? _____

9. Nature of injury (describe fully) _____

10. Names of witnesses to accident _____

11. Attending physician or hospital where sent _____

12. Date when disability, if any, commenced _____

13. Date of last day of disability, if ended _____

14. Date injured returned to work _____

15. Remarks: _____

Date _____

Employee Injured _____

Date _____

Immediate Supervisor _____

Figure F-1. Sample accident report form.

PLANT B

The medical surveillance program at the Plant B consists of a comprehensive preemployment physical which includes the workers medical and occupational history. Physicals are performed by an independent clinic, and the results are recorded on a form provided by the parent company (Figure F-2). Baseline pulmonary function and audiometric tests are included. In March 1979, Plant B conducted a tetanus prevention program during which all employees were inoculated. It is now policy for all new employees to receive tetanus inoculation prior to commencing work.

When the facility began operation in April 1977, 20 people were employed. The number of employees increased slowly through 1978 when 60 employees were working at the facility. In 1979, employee layoffs caused the number of workers to be reduced to the current employment number of about 31.

Job turnover, excluding supervisory personnel is high. A single job category turnover of 200 to 300% per year is not uncommon.

The total number of Occupational Safety and Health Administration (OSHA) reportable injuries and illnesses in 1977 was 23. Of these, 20 were injuries occurring in the utility classification, two in maintenance, and one in welding. Injuries were primarily limited to muscle strains or pulls, and cuts.

In 1978, 40 OSHA reportable injuries occurred. Information concerning accidents by job classification was not available. The types of injuries and illnesses reported included burns, strains, pulls, impacted toes and fingers, and several cases of minor skin rash.

In 1979, the parent company began consolidation of its accident reports as it instituted a computerized reporting system. Table F-1 presents a detailed breakdown of OSHA illness and injury cases at Plant B for the period January 1 to July 31, 1979. Information for the period August 1, 1979 to the present was not available.

PLANT C

The medical surveillance program at Plant C consists of a comprehensive pre-employment physical for each employee, including an investigation of the individual's occupational and medical history. The physicals are performed by an independent clinic, and the results are recorded on forms provided by the employer. A copy of the medical history record is presented in Figure F-3. Audiometric and spirometric testing are included in the examination. Tetanus inoculation is required for all new employees before starting work. Following 1 year of employment, each employee is required to take a follow-up physical. After this second physical, regular physical exams are required at 2-year intervals.

The work force at Plant C is comprised of 61 line employees and 6 managers. Of the 67 employees, 26 have worked at Plant C less than 1 year, 18 for more than 1 year but less than 2 years, and 23 for more than 2 years. There appears to be a low turnover rate at this facility. Many of the present employees have been employed at Plant C since start-up.

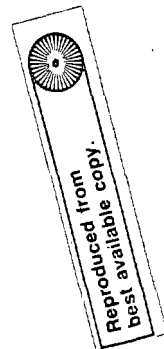
Figure F-2. PRE-PLACEMENT HEALTH EXAMINATION

HEIGHT	FT.	INCHES	WEIGHT	BUILD	TEMPERATURE
				☐ SLENDER ☐ MEDIUM ☐ HEAVY ☐ OBSE	

CLINICAL EVALUATION		VISION TESTER USED -	0/D - 20/	0/S - 20/	CORRECTED 0/D - 20/	0/S - 20/	COLOR VISION
AD- NON- MAL	CHECK EACH ITEM IN APPROPRIATE COLUMN, ENTER "N" IF NOT EVALUATED						
	1. HEAD, FACE, NECK AND SCALP						
	2. NOSE						
	3. SINUSES						
	4. MOUTH AND THROAT						
	5. EARS (GENERAL, AUDIOMETRIC, SPECIAL FORM)						
	6. THROAT (PERFORMANCE)						
	7. EYES (GENERAL RECORD ONLY)						
	8. OPHTHALMOSCOPIC (IF INDICATED)						
	9. PUPILS (EQUALITY AND REACTION)						
	10. OCULAR MOTILITY (ASYMMETRIC PARALLEL MOVE)						
	11. LUNGS AND CHEST (INCLUDE BREASTS)						
	12. HEART (TAP, SIZE, SOUND & B.P.)						
	13. VASCULAR SYSTEM (VARICOSES, ETC.)						
	14. ABDOMEN AND VISCERA (INCLUDE HERNIA)						
	15. ANUS & RECTUM (HISTORICAL IF INDICATED)						
	16. ENDOCRINE SYSTEM						
	17. G.U. SYSTEM						
	18. UPPER EXTREMITIES (STRENGTH, RANGE OF MOTION)						
	19. FEET						
	20. LOWER EXTREMITIES (STRENGTH, RANGE OF MOTION)						
	21. SPINE, OTHER MUSCULOSKELETAL						
	22. IDENTIFYING BODY MARKS, SCARS, TATTOOS						
	23. SKIN, LYMPHATICS						
	24. NEUROLOGIC						

LABORATORY FINDINGS				OTHER TESTS:
URINALYSIS: A. SPECIFIC GRAVITY	SEROLOGY, (SPECIFIC TESTS, DATE & RESULT)	EKG, (IF INDICATED)	BLOOD TYPE & RH FACTOR, (IF INDICATED)	CHEST X-RAY - Required (PLACE, DATE, FILM NO. & RESULT)
B. ALBUMIN				
C. SUGAR				
D. MICROSCOPIC				

UNEMPLOYABLE AT THIS TIME	DATE
☐ FIT FOR SPECIFIC JOB ☐ NOT RECOMMENDED ☐	



PHYSICIAN EXPLAIN YOUR ABOVE RECOMMENDATION

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(continued)

Figure F-2. (Continued)

MILITARY SERVICE - CONNECTED DISABILITIES									
NATURE OF DISABILITY	%	AMOUNT RECEIVED PER MO.	BRANCH OF SERVICE	SERIAL NO.	CLAIM NO.	V.A. REGIONAL OFFICE			
HOSPITALIZATION:		WHY?	DATE?	WHERE?					
OCCUPATIONAL HISTORY									
HAVE YOU EVER WORKED FOR THE AMERICAN CAN COMPANY BEFORE? ☐ YES ☐ NO WHICH PLANT? DATE:									
COMPANIES & KINDS OF WORK DONE LIST MACHINES AND MATERIALS YOU HAVE HANDLED NO. OF YEARS									
ALL OCCUPATIONAL ILLNESS AND INJURIES									
DATE	NATURE OF ILLNESS OR INJURIES				NAME OF COMPANY & CITY				
HAVE YOU EVER FILED FOR COMPENSATION OR PENSION OR OTHER BENEFITS DUE TO SICKNESS OR ACCIDENT? ☐ YES ☐ NO IF "YES" WHEN?									
WHERE? ☐ NONE HOW MUCH DISABILITY INSURANCE ARE YOU RECEIVING NOW? PER MONTH \$									
ALL HOSPITALIZATIONS - ACCIDENTS - SICKNESS (EXCEPT OCCUPATIONAL)									
DATE	NATURE		DATE	NATURE					
HAVE YOU BEEN ILL IN THE PAST TWO YEARS? (ILLNESS NOT SHOWN ABOVE)									
WHEN DID YOU LAST SEE A DOCTOR?				FOR WHAT?					
ALL PHYSICAL DEFECTS OR ABNORMALITIES AT THIS TIME									
PARTS OF BODY EXTENT OF DEFECT									
☐ RIGHT HAND ☐ LEFT HAND									

I hereby certify that to the best of my knowledge the foregoing answers are complete and correct.

DATE

DATE

DATE

(continued)

Figure F-2. (continued)

[illegible][illegible]

117. DO YOU SMOKE?	☐ YES	☐ NO	IF "YES" STATE TYPE AND QUANTITY			
118. DO YOU TAKE ANY DRUGS?	☐ YES	☐ NO	IF "YES" STATE TYPE, QUANTITY AND FREQUENCY			
119. DO YOU TAKE ANY MEDICATION?	☐ YES	☐ NO	IF "YES" STATE TYPE, QUANTITY AND FREQUENCY			
120. DO YOU INHALE OR ALCOHOLIC BEVERAGES?	☐ YES	☐ NO	IF "YES" STATE TYPE, QUANTITY AND FREQUENCY			
121. WHERE WERE YOU IN THE MILITARY SERVICE?	☐ US	☐ ABROAD	IF "YES" DATES SERVED FROM			
122. WHAT TYPE OF MILITARY DUTY HAD YOU?	☐ REGULAR	☐ OTHER	MILITARY SERVICE	☐ YES	☐ NO	
123. HAVE YOU EVER BEEN REJECTED IN CASE OF MEDICAL RECORD?	☐ YES	☐ NO	REASON FOR REJECTION			
IMMUNIZATION & YEAR:						

(continued)



Figure F-2. (continued)

PERIODIC OR RE-EXAMINATION

[illegible]

TABLE F-1. OSHA INJURY AND ILLNESS CASES AT PLANT B
(January 1 to July 31, 1979)

Case	No of cases	Percent of total cases
<u>Description</u>		
Lost time on regular workday	6	85.7
Lost time - could not perform all duties	1	14.3
Lost time - weekend on temporary job	0	0.0
Lost time - weekend less than fulltime	0	0.0
Fatality	0	0.0
Lost time - permanent transfer to another job	0	0.0
Lost time - termination	0	0.0
Medical treatment - no lost time	0	0.0
Loss of consciousness - no lost time	0	0.0
Permanent transfer - no lost time	0	0.0
Termination - no lost time	0	0.0
Medical treatment outside facility - no lost time	0	0.0
Total	7	
<u>Type of injury/illness</u>		
OSHA injury	7	100.0
OSHA illness - skin	0	0.0
OSHA illness - dust disease lungs	0	0.0
OSHA illness - respiratory condition (toxic agent)	0	0.0
OSHA illness - poisoning (toxic material)	0	0.0
OSHA illness - physical agent	0	0.0
OSHA illness - repeated trauma	0	0.0
OSHA illness - other	0	0.0
Total	7	

(continued)

TABLE F-1. (continued)

Case	No. of cases	Percent of total cases
<u>Age group</u>		
Under 20	0	0.0
20-24	2	28.6
25-29	2	28.6
30-34	0	0.0
35-39	1	14.3
40-44	1	14.3
45-49	1	14.3
50-54	0	0.0
55-59	0	0.0
60 and over	0	0.0
Total	7	
<u>Sex</u>		
Male	6	85.7
Female	1	14.3
Total	7	
<u>Length of service on job</u>		
Less than 6 months	5	17.4
6-11 months	0	0.0
1-4 years	2	28.6
5-9 years	0	0.0
10-14 years	0	0.0
15 years and over	0	0.0
Total	7	
<u>Work shift</u>		
First	2	28.6
Second	5	71.4
Third	0	0.0
Unknown	0	0.0
Total	7	

(continued)

TABLE F-1. (continued)

Case	No. of cases	Percent of total cases
<u>Job title or activity</u>		
Mech-heating	3	42.9
Rewinder helper	2	28.6
Laborer	1	14.3
Clean-up	1	14.3
Total	7	
<u>Agency item</u>		
Machine not listed	3	42.9
Scrap metal	1	14.3
Sheet steel	1	14.3
Stair or step	1	14.3
Hand truck	1	14.3
Total	7	
<u>Part of body affected</u>		
Face	1	14.3
Skull	1	14.3
Neck	1	14.3
Arm, upper	1	14.3
Finger(s)	1	14.3
Shoulder	1	14.3
Knee	1	14.3
Total	7	
<u>Nature of injury/illness</u>		
Fracture	3	42.9
Sprains, strains	2	28.6
Scratches, abrasions	1	14.3
Concussion	1	14.3
Total	7	

(continued)

TABLE F-1. (concluded)

Case	No. of cases	Percent of total cases
<u>Incident category</u>		
Caught-in/under/between	2	28.6
Overexert/body reaction	2	28.6
Fall from elevation	1	14.3
Slip without fall	1	14.3
Struck by falling object	1	14.3
Total	7	
<u>Agency category</u>		
Material work handled	4	57.1
Dollies, hand trucks	1	14.3
Building and structures	1	14.3
Metal	1	14.3
Total	7	
<u>Unsafe act</u>		
Housekeeping	2	28.6
Improper loading, placing, mixing	2	28.6
Improper lifting/carrying	1	14.3
Failure to use personal protective equipment	1	14.3
Other	1	14.3
Total	7	
<u>Unsafe condition</u>		
Other	4	57.1
Housekeeping poor	2	28.6
No unsafe condition	1	14.3
Total	7	
<u>Contributing factor</u>		
Unattention to hazard	6	85.7
Lack knowledge/skill	1	14.3
Total	7	

MEDICAL HISTORY RECORD										FOR DEPARTMENT USE ONLY	
NAME: LAST FIRST MIDDLE										DATE HIRED	
ADDRESS: STREET APT CITY STATE ZIP										EMPLOYEE NUMBER	
PHONE: NUMBER										CLASSIFICATION	
SOCIAL SECURITY NO.										DEPARTMENT	
SEX: ☐ MALE ☐ FEMALE										SUPERVISOR	
MARRIAGE STATUS: ☐ MARRIED ☐ DIVORCED ☐ SINGLE ☐ WIDOWED ☐ SEPARATED											
PERSONAL PHYSICIAN:											
NAME: PHONE NO.:											
ADDRESS: NUMBER STREET CITY											
RELATIONSHIP: HOME PHONE BUSINESS PHONE											
WHOM TO NOTIFY IN CASE OF EMERGENCY:											
PERSONAL HISTORY RECORD											
APPLICANT NOTE - READ CAREFULLY											
DO YOU HAVE NOW OR HAVE YOU EVER HAD:											
Answer every question (Y/N)											
YES NO											
1. CORRECTIVE LENSES											
2. AN ARTIFICIAL EYE											
3. EYE TROUBLE											
4. COLOR BLINDNESS											
5. A HEARING AID											
6. EAR, NOSE OR THROAT TROUBLES											
7. SINUS INFECTION											
8. HAY FEVER											
9. CHRONIC OR FREQUENT COLDS											
10. EXTREME SENSITIVITY TO INSECT BITES											
11. HISTORY OF HEAD INJURY											
12. LOSS OF MEMORY OR AMNESIA											
13. PERIODS OF UNCONSCIOUSNESS											
14. SKIN TROUBLES OR RASHES											
15. DEPRESSION OR EXCESSIVE WORRY											
16. NERVOUS OR MENTAL TROUBLE											
EXPLAIN FULLY ITEMS CHECKED "YES" IF FOLLOWED BY AM () AND GIVE YEAR OF MOST RECENT OCCURRENCE (Indicate by number)											
21. DIZZINESS OR FADING SPELLS											
22. FREQUENT HEADACHES											
23. EPILEPSY OR FITS											
24. CARDIAC (HEART) TROUBLE											
25. PAIN OR PRESSURE IN CHEST											
26. SHORTNESS OF BREATH											
27. ASTHMA											
28. TUBERCULOSIS											
29. CHRONIC COUGH											
30. EVER LIVED WITH ANYONE WHO HAD TUBERCULOSIS											
31. CUPPING UP BLOOD											
32. EVER HAD OR PRESSURE FOR LOW											
33. ALLERGIES											
34. FREQUENT INDIGESTION											
35. ULCERS											
36. STOMACH, LIVER OR INTESTINAL PROBLEMS											
37. TUMOR OR CANCER											
38. APPETITE HEADACHE											
39. KIDNEY TROUBLE											
40. DIABETES											
41. RUPTURE OR HERNIA											
42. PARALYSIS											
43. ARTHRITIS OR RHEUMATISM											
44. BONE, JOINT OR OTHER DEFORMITY											
45. WOMAN A BRACE OR BACK SUPPORT											
46. LOSS OF ARM, LEG, FINGER, OR TOE											
47. PAINFUL OR THICK SHOULDER OR ELBOW											
48. RHEUMATIC FEVER											
49. SWOLLEN OR PAINFUL JOINTS											
50. FREQUENT BACK PAIN OR BACKRACHES											
51. THICK OR LOCKED KNEE											
52. FOOT TROUBLES											
53. WEIGHT LIFTING RESTRICTION											
54. ANY DRUG OR NARCOTIC HABIT											
55. FREQUENT TROUBLE SLEEPING											
56. TETANUS TOXOID											
57. DIPHTHERIA TOXOID											
58. WHOOPING COUGH VACCINE											
59. POLIO VACCINE											
60. MALARIA VACCINE											
61. OTHER											
LATEST IMMUNIZATIONS											
VACCINATION SMALL POX											
YEAR											
FEMALES ONLY											
61. ARE YOU NOW PREGNANT?											
62. DO YOU NOW HAVE ANY DISORDER OR DISEASE OF THE FEMALE ORGANS?											
63. DO MENSTRUAL PAINS OR CRAMPS EVER MAKE YOU STAY IN BED?											
IF YES, HOW OFTEN?											
HOW LONG?											

Figure P-3. Plant C Employee Medical Data Form.

FAMILY HISTORY - Have your parents, brothers, or sisters, ever been afflicted with:		NERVOUS OR MENTAL DISORDER		YES	NO	TUBERCULOSIS		YES	NO	ASTHMA, HAY FEVER, HIVES		YES	NO	EPILEPSY (IFTS)		YES	NO
CHECK EACH ITEM "YES" OR "NO". EVERY ITEM CHECKED YES MUST BE FULLY EXPLAINED IN BLANK SPACE BELOW (Indicate by number)																	
YES	NO	1. HAVE YOU BEEN REFUSED EMPLOYMENT OR BEEN UNABLE TO HOLD A JOB BECAUSE OF:															
		A. SENSITIVITY TO CHEMICALS, DUST, SUNLIGHT, ETC. ?															
		B. INABILITY TO PERFORM CERTAIN MOTIONS ?															
		C. OTHER MEDICAL REASONS ?															
		2. HAVE YOU EVER WORKED WITH RADIOACTIVE SUBSTANCES?															
		3. HAVE YOU EVER BEEN DENIED LIFE INSURANCE?															
		4. HAVE YOU HAD ANY OPERATIONS?															
		5. HAVE YOU BEEN ADVISED TO HAVE AN OPERATION WHICH HAS NOT YET BEEN PERFORMED?															
		6. HAVE YOU EVER BEEN A PATIENT (COMMITTED OR VOLUNTARY) IN A MENTAL HOSPITAL OR SANITARIUM?															
		7. HAVE YOU CONSULTED OR BEEN TREATED BY CLINICS, PHYSICIANS, HEALERS, OR OTHER PRACTITIONERS WITHIN THE PAST 5 YEARS?															
		8. HAVE YOU EVER BEEN REJECTED FOR MILITARY SERVICE BECAUSE OF PHYSICAL, MENTAL, OR OTHER REASONS?															
		9. HAVE YOU EVER BEEN DISCHARGED FROM MILITARY SERVICE BECAUSE OF PHYSICAL, MENTAL, OR OTHER REASONS?															
		10. ARE YOU NOW RECEIVING, OR HAVE YOU EVER RECEIVED ANY AWARD, COMPENSATION OR DISABILITY PENSION FOR WORK CONNECTED INJURY OR ILLNESS. ?															
		11. DO YOU INDULGE IN ALCOHOLIC BEVERAGES? IF YES, RARELY ☐ MODERATELY ☐ FREQUENTLY ☐ EXCESSIVELY ☐															
		12. HAVE YOU EVER SOUGHT PROFESSIONAL OR OTHER HELP WITH REGARD TO THE TO THE EXCESSIVE USE OF ALCOHOL ?															
		13. DO YOU REGULARLY TAKE ANY MEDICATION OR DRUG (PRESCRIBED OR OTHERWISE?)															
		14. ARE YOU ALLERGIC TO, OR HAVE YOU EVER HAD A REACTION TO ANY DRUG OR MEDICINE?															
I HEREBY CERTIFY THAT THE FOREGOING ANSWERS AND STATEMENTS ARE COMPLETE AND TRUE, THAT THEY ARE CORRECTLY AND FULLY RECORDED, AND THAT NO MATERIAL CIRCUMSTANCE OR INFORMATION HAS BEEN WITHHELD OR OMITTED CONCERNING MY PAST AND PRESENT STATE OF HEALTH AND MEDICAL HISTORY. I AUTHORIZE ANY OF THE DOCTORS, HOSPITALS, OR CLINICS MENTIONED ABOVE TO FURNISH T.S.C. A COMPLETE TRANSCRIPT OF MY MEDICAL RECORDS IF NEED ARISES.																	
REVIEWED BY		SIGNATURE OF APPLICANT										DATE		DATE			
COMMENTS (FOR OFFICIAL USE ONLY)																	

Figure F-3. (concluded)

The OSHA reportable injuries and illnesses at Plant C in 1976 totaled 24. All 24 were injuries. Of these injuries, 16 were sustained by employees in the maintenance department and 7 by employees in the operations department. For a breakdown of injuries by type and department, see Table F-2.

Sixteen OSHA reportable injuries occurred in 1977 at Plant C. These injuries included 13 employees in the maintenance department, 2 employees in the operations department, and 1 employee in the transportation department (see Table F-3).

Twenty-three OSHA reportable injuries occurred at Plant C in 1978. Of these, 10 injuries occurred in the operations department, 9 in maintenance, and 4 in engineering. Table F-4 contains the number and types of injuries.

Eight OSHA reportable injuries occurred in Plant C during 1979. Of these, 5 of the injuries occurred in the maintenance department and 3 took place in the operations department (Table F-5).

Six OSHA reportable injuries had occurred during the first two months of 1980. Of these 6 incidents, 4 occurred in the operations department, 1 in maintenance, and 1 in transportation (Table F-6).

Table F-7 is a summary of the OSHA reportable injuries for Plant C from 1976 through February 1980. Employees of the maintenance department sustained the highest number of injuries. Sixty percent of all the reported injuries occurred in this department, which correlates with the mobility of these workers and the nature of their duties.

PLANT D

No medical surveillance program was in effect at Plant D prior to or at the time of this survey. Plant management indicated that preemployment and periodic physicals were expected to be instituted in August 1980. According to the plant safety manager, these physicals would include the "normal" pre-employment tests as well as audiometric testing.

Some details concerning OSHA reportable injuries and illnesses were obtained. It was determined that OSHA reportable injuries and illnesses numbered 39 in 1977, 30 in 1978, and 26 in 1979. Data for January 1 through July 1, 1976 and January 1 through July 1, 1980 were not available.

Table F-8 is a list of OSHA reportable injuries and illnesses at Plant D for 1978. Such information was not available for 1977 or 1979.

PLANT E

Plant E does not provide preemployment or periodic physical examinations for its employees. No audiometric testing of employees is conducted.

OSHA injury and illness data were available for portions of 1979 and 1980. Between August 1 and December 31, 1979, there were 21 OSHA reportable injuries and illnesses. Of these, all but one were injuries.

TABLE F-2. OSHA REPORTABLE INJURIES FOR PLANT C - 1976

Type of injury	Department			
	Maintenance	Operations	Engineering	Transportation
Muscle strain or pull	2	2		
Laceration	6	1		
Burn	2			
Fracture	2			
Contusion	4	1		
Foreign object in eye	2	1		
Twisted arm		1		
Welding flash		1		
Total ^a	18	7	0	0

^a One laceration with a broken bone.

TABLE F-3. OSHA REPORTABLE INJURIES FOR PLANT C - 1977

Type of injury	Department			
	Maintenance	Operations	Engineering	Transportation
Muscle strain or pull	1	1		1
Laceration	4			
Burn	2			
Fracture	3			
Contusion	2	1		
Foreign object in eye				
Infection	1			
Total	13	2	0	1

TABLE F-4. OSHA REPORTABLE INJURIES IN PLANT C - 1978

Type of injury	Department			
	Maintenance	Operations	Engineering	Transportation
Muscle strain or pull		1		
Laceration	2	3	1	
Burn	1			
Fracture	2	3	1	
Contusion	4	1	1	
Foreign object in eye		2		
Damaged nerve	—	—	1	
Total	9	10	4	0

TABLE F-5. OSHA REPORTABLE INJURIES IN PLANT C - 1979

Type of injury	Department			
	Maintenance	Operations	Engineering	Transportation
Muscle strain or pull	1	1		
Laceration		1		
Burn				
Fracture	1	1		
Contusion	2			
Foreign object in eye				
Welding flash	1			
Total	5	3	0	0

TABLE F-6. OSHA REPORTABLE INJURIES FOR PLANT C -
JANUARY-FEBRUARY 1980

Type of injury	Department			
	Maintenance	Operations	Engineering	Transportation
Muscle strain or pull		2		
Laceration	1			
Burn				
Fracture		2		
Contusion				1
Foreign object in eye				
Total	1	4	0	1

TABLE F-7. SUMMARY OF OSHA REPORTABLE INJURIES FOR PLANT C -
JANUARY 1, 1976, THROUGH FEBRUARY 28, 1980

Type of injury	Department			
	Maintenance	Operations	Engineering	Transportation
Muscle strain or pull	4	7	0	1
Laceration	13	5	1	0
Burn	5	0	0	0
Fracture	8	6	1	0
Contusion	12	3	1	1
Foreign object in eye	2	3	0	0
Twisted limb		1		
Welding flash	1	0	0	0
Damaged nerve	0	0	1	0
Infection	1	0	0	
Total	46	25	4	2

TABLE F-8. OSHA REPORTABLE INJURIES AND ILLNESSES FOR 1978 AT PLANT D

Type of injury	Job category			Total
	Laborers	Maintenance	Operations	
Foreign body in eye	6	3	5	14
Laceration	0	1	2	3
Welding flash	1	1	0	2
Burn	0	1	1	2
Bruise or sprain	2	1	0	3
General pain	1	1	0	2
Respiratory difficulty	1	0	0	1
Multiple injuries, body	<u>0</u>	<u>0</u>	<u>1</u>	<u>1</u>
Total	11	8	9	28 ^a

^a In one instance, it was not possible to determine from the records the nature of an injury to a finger of an operations worker. Additionally, a supervisor reported ear irritation due to elements in the air. Including these two cases, the reportable injuries and illnesses for 1978 would total 30.

These injuries are described in more detail in Table F-9. The one illness reported was caused by exposure to a physical agent. From January 1 through August 19, 1980, 15 OSHA reportable injuries and illnesses were believed to have occurred (see Table F-10).

The work force at Plant E is comprised of 81 hourly and 15 salaried employees. The work force was only recently increased to this total, so estimates on turnover are not yet available. However, based on a previous total of 75 employees, turnover was estimated to be 8 to 10%.

PLANT F

The medical program at Plant F requires that all potential employees receive a comprehensive preemployment physical exam, including a complete occupational history (Plant F uses the same medical history form as Plant C) that documents previous exposure to hazardous conditions and contaminants. Physicals are performed by an outside clinic.

The actual medical exam is comprised of urinalysis; audiogram; posterior-anterior chest X ray; back X-ray series--posterior-anterior, lateral, and lumbo-sacro-spot film; basic spirometry, showing forced vital capacity and forced expiratory volume; urine/drug profile; complete blood count and blood chemistry series; tuberculin test; tetanus immunization; and a test for color blindness. An annual follow-up exam includes all the above except back X ray.

There are first aid stations and kits at various locations in the plant. Although the plant does not have a nurse or physician, however, a major hospital is located within 5 min of the plant.

Total OSHA reportable injuries and illnesses for 1979 were 14. All were injuries. Of these, 7 occurred in the skilled classification and 7 in utility classification. This information is detailed in Table F-11. Six injuries involved the eye, 5 were punctures, 2 were strains, and 1 resulted from electrical shock.

PLANT G

Since employees at Plant G are usually transferred to the facility from other locations within the municipal services department, a preemployment physical is not a requirement before beginning work at the plant. A medical surveillance program is also not a part of existing plant management practices.

Although the medical and employment records were said to be kept at the city's administrative offices, they were not made available to the MRI investigators.

TABLE F-9. OSHA REPORTABLE INJURIES FOR PLANT E
August 1 to December 31, 1979

Type of injury	Department		
	Production	Maintenance	Materials
Muscle strain or pull	1	1	0
Foreign object/eye	0	1	0
Contusion	5	2	0
Sprain	0	2	1
Chemical burn	1	1	0
Concussion	0	1	0
Torn tendon (knee)	0	1	0
Unknown	<u>1</u>	<u>2</u>	<u>0</u>
Total	8 ^a	11	1

^a Does not include one OSHA reportable illness.

TABLE F-10. OSHA REPORTABLE INJURIES FOR PLANT E
January 1 to August 19, 1980

Type of injury	Department		
	Production	Maintenance	Instrument
Muscle strain or pull	2	1	0
Foreign object/eye	0	2	0
Contusion	1	0	0
Sprain	0	0	0
Chemical burn	1	1	1
Laceration	1	1	0
Torn ligament (knee)	0	1	0
Unknown	<u>0</u>	<u>3</u>	<u>0</u>
Total	5	9	1

TABLE F-11. OSHA INJURY AND ILLNESS CASES AT PLANT F
August 1 to December 31, 1979

	No. of cases	Percent of total cases
<u>Description of case</u>		
Lost time on regular workday	6	85.7
Lost time - could not perform all duties	1	14.3
Lost time - weekend on temporary job	0	0.0
Lost time - weekend less than full time	0	0.0
Fatality	0	0.0
Lost time - permanent transfer to another job	0	0.0
Lost time - termination	0	0.0
Medical treatment - no lost time	0	0.0
Loss of consciousness - no lost time	0	0.0
Permanent transfer - no lost time	0	0.0
Termination - no lost time	0	0.0
Medical treatment outside facility - no lost time	0	0.0
Total	7	
<u>Type of injury/illness</u>		
OSHA injury	14	100.0
OSHA illness - skin	0	0.0
OSHA illness - dust disease lungs	0	0.0
OSHA illness - respiratory condition (toxic agent)	0	0.0
OSHA illness - poisoning (toxic material)	0	0.0
OSHA illness - physical agent	0	0.0
OSHA illness - repeated trauma	0	0.0
OSHA illness - other	0	0.0
Total	14	

APPENDIX G

MICROBIOLOGICAL SAMPLING AND ANALYTICAL METHODS

The sampling and analytical methods employed by MRI during this study are presented with a discussion of sampling methods, analytical procedures for aerobic bacteria and molds, and analytical procedures for human viruses.

SAMPLING METHODS

Solid samples were aseptically collected with sterile gloves and placed in sterile, labeled Whirl-Pak® bags. The samples for bacteriological analysis were then placed in an ice chest containing Blue Ice® until shipment at day's end. Samples for virus analysis were placed in an ice chest containing excess dry ice and also held for shipment at day's end.

Aerosol samples were taken using two biological sampling devices, i.e., the raised-jet, all-glass impinger (AGI-30)* fitted with a Porton preimpinger,† and the Sci-Med, Model M-3A, Large Volume Air Sampler.‡

The AGI-30 impinger was included in the aerosol sampling protocol as a reference sampling device. To compensate for the AGI-30's low sampling rate (12.5 L/min), a cluster of four AGI-30 impinger/preimpinger combinations was used to increase the total amount of air sampled.

Preimpingers were included with the AGI-30's for two purposes. First, the preimpinger removes particulates greater than 5 µm in diameter, which helps prevent clogging of the AGI-30's critical orifice. Second, the preimpinger, operated with 5 ml of collection menstruum, allows for a more gradual rehydration of the aerosol particles collected by the AGI-30. The impinger and preimpinger menstrooms were aseptically composited following each sampling interval. Volume losses due to evaporation were compensated for by adding rinsings from the impinger.

The LVAS was sanitized in a clean area immediately prior to sample collection. The sanitation procedure is presented below. The LVAS was then transported to the sampling site and placed on a platform that positioned

* Ace Glass Company, Vineland, New Jersey, Catalog No. 7540-10.

† Ace Glass Company, Catalog No. I-1033. Originally described by May and Druett (1953).

‡ Sci-Med Environmental Systems, Inc., 8050 Wallace Road, Eden Prairie, Minnesota 55344.

the inlet 5 ft (1.5 m) above the floor. The instrument was operated at 1,000 L/min with an electrical potential of 14 kv. Menstruum throughput rate was set near each instrument's maximum (~ 8 ml/min) because of the dusty conditions inside the plant.

LVAS SANITATION PROCEDURE

1. Clean turntable with laboratory detergent and rinse thoroughly.
2. Wipe down internal and external surfaces with 70% ethanol.
3. Close instrument top and cover the air inlet and exhaust with sterile squares of aluminum foil.
4. Flush LVAS lines and turntable with 1% (v/v) Clorox® solution for approximately 30 min.
5. Flush LVAS with sterile 1% (w/v) thiosulfate for approximately 30 min.
6. Flush LVAS with sterile deionized water for approximately 30 min.
7. Insert the LVAS tubing ends into sterile Whirl-Pak® bags and seal.

Two collection menstruums were used during the Plant D survey. Gelatin-milk solution (White et al., 1975) containing approximately 1% Dow Corning Anti-foam A was employed with the AGI-30 sampling train. Eagle's Basal Medium (BME) with Hank's salts and 10% (v/v) heat-inactivated calf serum was used with the LVAS.

Following collection, the liquid aerosol samples were aseptically transferred to sterile glass shipping bottles. Each bottle was labeled with its appropriate sample number and stored in an ice chest containing multiple Blue Ice® packs. Temperatures in the ice chests ranged from 4 to 7°C. The samples were air shipped on a daily basis to the testing laboratories for analysis the following day.

ANALYTICAL PROCEDURES FOR AEROBIC BACTERIA AND MOLDS

Quantitative microbiological assays were conducted by the spread-plate technique except where noted. All other general methodology conformed to American Public Health Association, American Society of Clinical Pathologists, Center for Disease Control, or Standard Method's (APHA, 1976) recommendations. The guidelines used for determining the number of presumptive isolates to be confirmed are presented below.

Solid waste samples were processed by first diluting 10.0 g of solid waste 1:20 with Standard Methods (APHA, 1976) phosphate-buffered dilution water adjusted to pH 7.0. The material was then blended at low speed for 10 min in a sterile blender. The homogenate was filtered through two layers of sterile gauze to remove the larger particulates. The filtrate was collected and processed along with the liquid aerosol samples.

BASIS FOR SELECTING THE NUMBER OF
PRESUMPTIVE COLONIES TO BE
CONFIRMED

Presumptive colonies/plate	Presumptive-positive colonies picked for verification
1 to 10	All
11 to 25	50%
≥ 26	12 Colonies or 10%, whichever is greater

Aerobic Total Bacteria Count

Aerobic total bacteria counts were conducted to serve as a relative index for comparing resource recovery plants in the event that the pathogens might be found sporadically or not at all. The counts were determined using tryptic soy agar with 50 units/ml mycostatin (Fletcher, 1979). The plates were incubated for 2 days at 35°C prior to enumeration.

Total Mold Count

Total mold counts were determined on malt extract agar containing 100 µg/ml each of chlorotetracycline and chloramphenicol (Speck, 1976). The plates were incubated at 20 to 25°C (room temperature) prior to enumeration.

Fecal Coliform Assays

Fecal coliform assays were included for use as a relative index at resource recovery plants. Fecal coliform determinations were conducted by the most probable number method (MPN) (American Public Health Association et al., 1976). The MPH's were confirmed by streaking the gas-positive EC medium tubes onto eosin methylene blue (EMB) agar and observing the appropriate reactions. Gram stains were also conducted on certain colonies.

Staphylococcus aureus

Staphylococcus aureus was enumerated on Baird-Parker agar medium containing egg yolk-tellurite enrichment (Raymond et al., 1978). The media were incubated at 35°C for 48 hr prior to enumeration. All black colonies with or without a clear lipase zone were enumerated presumptively as *Staph. aureus* count was adjusted according to the final confirmation percentage and reported as the final count.

Klebsiella sp.

The *Klebsiella* were enumerated on MacConkey-Inositol-Carbenicillin agar (MCIC) (Bagley and Seidler, 1978). The plates were incubated for 20 to

24 hr at 35°C prior to counting. All pink and red colored colonies were counted as presumptive Klebsiella. Presumptive isolates were transferred to tryptic soy agar for purity and stock purposes. The isolates were then confirmed and speciated according to the scheme depicted in Figure G-1. Confirmation tests included MRVP, motility, ornithine decarboxylase, malonate utilization, and rapid indole production.

Salmonella and Shigella

Analyses for Salmonellae and Shigellae were conducted by both spread-plate and enrichment techniques (see Figure G-2). Bismuth sulfite, Hektoen enteric, and XLD agars were the primary plating media for spread-plate determinations. All plates were incubated at 35°C and examined at both 24- and 48-hr intervals. Presumptive positive colonies were counted and picked by appropriate category for confirmation.

Enrichment media consisted of selenite cystine broth for Salmonellae (Gabis et al., 1977) and GN broth for Shigellae. The selenite cystine broth was incubated at 35°C for 48 hr. Presumptive Salmonella and Shigella isolates were then tested for confirmation.

Presumptive Salmonellae isolates were screened for appropriate triple sugar iron agar (K, A, + G, + H₂S),* urea hydrolysis (-), and rapid indole (-) reactions. Isolates giving correct reactions for these tests were further screened with malonate utilization (-) and lysine decarboxylase (-) tests. Isolates giving appropriate reactions were serologically tested with Salmonella antisera.

Presumptive Shigella isolates were tested for correct reactions in triple sugar iron agar (K, A, -G, -H₂S),* urea hydrolysis (-), and glucose fermentation (acid only). Selected isolates were then serologically tested with Shigella antisera. Positive reactors were then further characterized by the following tests: MRVP (MR + VP-), lysine decarboxylase (-), citrate utilization (-), motility (-), indole (+ or -), and acetate utilization (-).

Mycobacterium

Liquid aerosol samples for Mycobacterium analysis (10 ml) were decontaminated with an equal volume of 4% H₂SO₄ for 15 min (Vestal, 1975). The samples were neutralized and then concentrated by centrifugation at 2,000 rpm for 30 min. The supernatant was decanted leaving ~ 0.5 ml of the bottom fluid or pellet. The sediment/pellet was diluted with 4.5 ml sterile Dubos broth containing 50 µg/ml Amphotericin B. From this 1:10 dilution, 0.1-ml aliquots were transferred to two tubes of Lowenstein Jensen Gruft medium (Gruft, 1971), two tubes of GIBCO mycobacterial selective medium,† and 5 to 10 ml Dubos broth containing 50 µg/ml Amphotericin B.

* K = alkaline, A = acid, G = gas, and H₂S = hydrogen sulfide.

† Lowenstein Jensen media base - 2.0 µg/ml lincomycin, 35 µg/ml nalidixic acid, and 0.4 µg/ml cycloheximide.

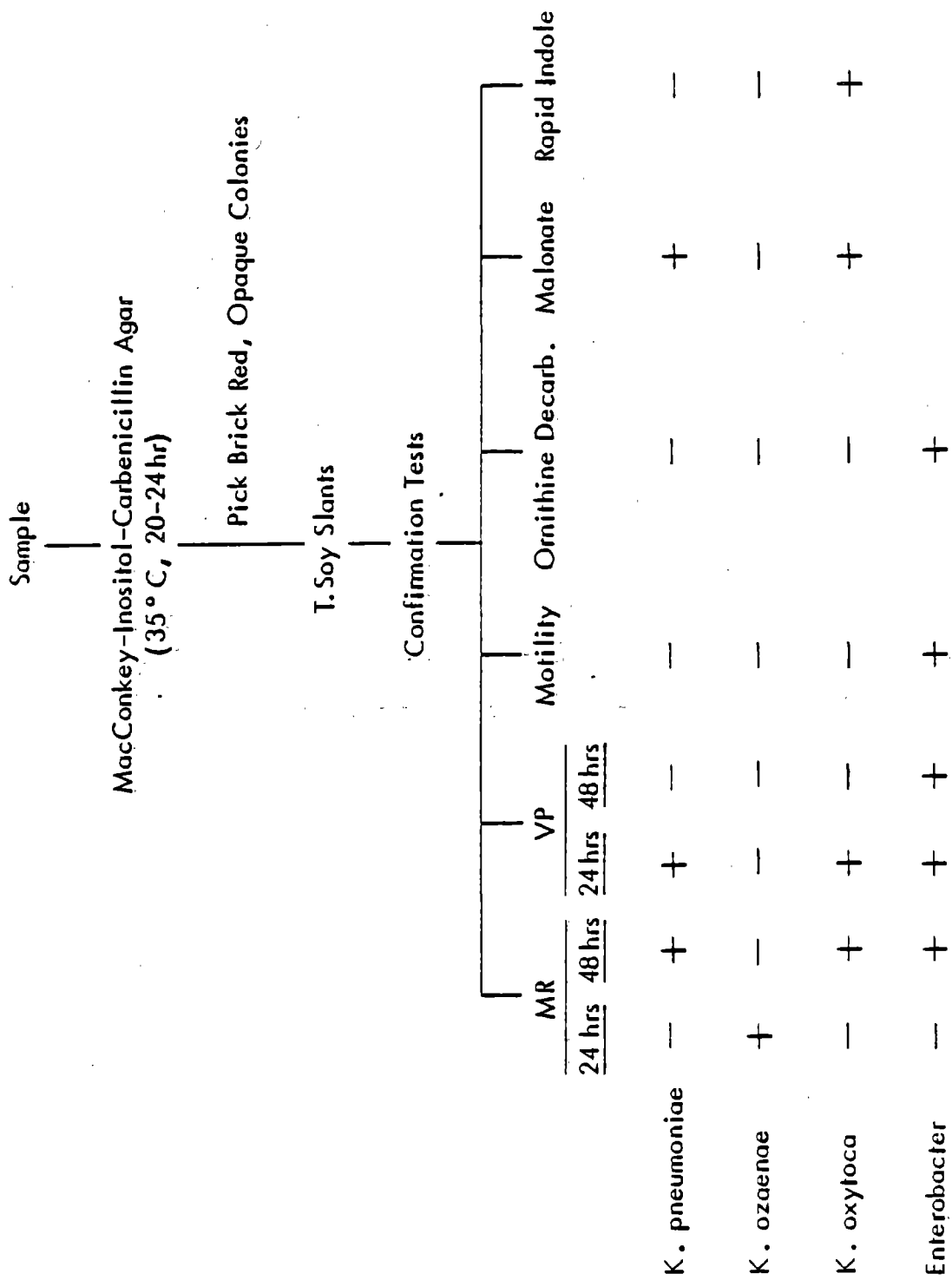


Figure G-1. Spread plate and enrichment techniques.

Isolation Scheme for Salmonella and Shigella

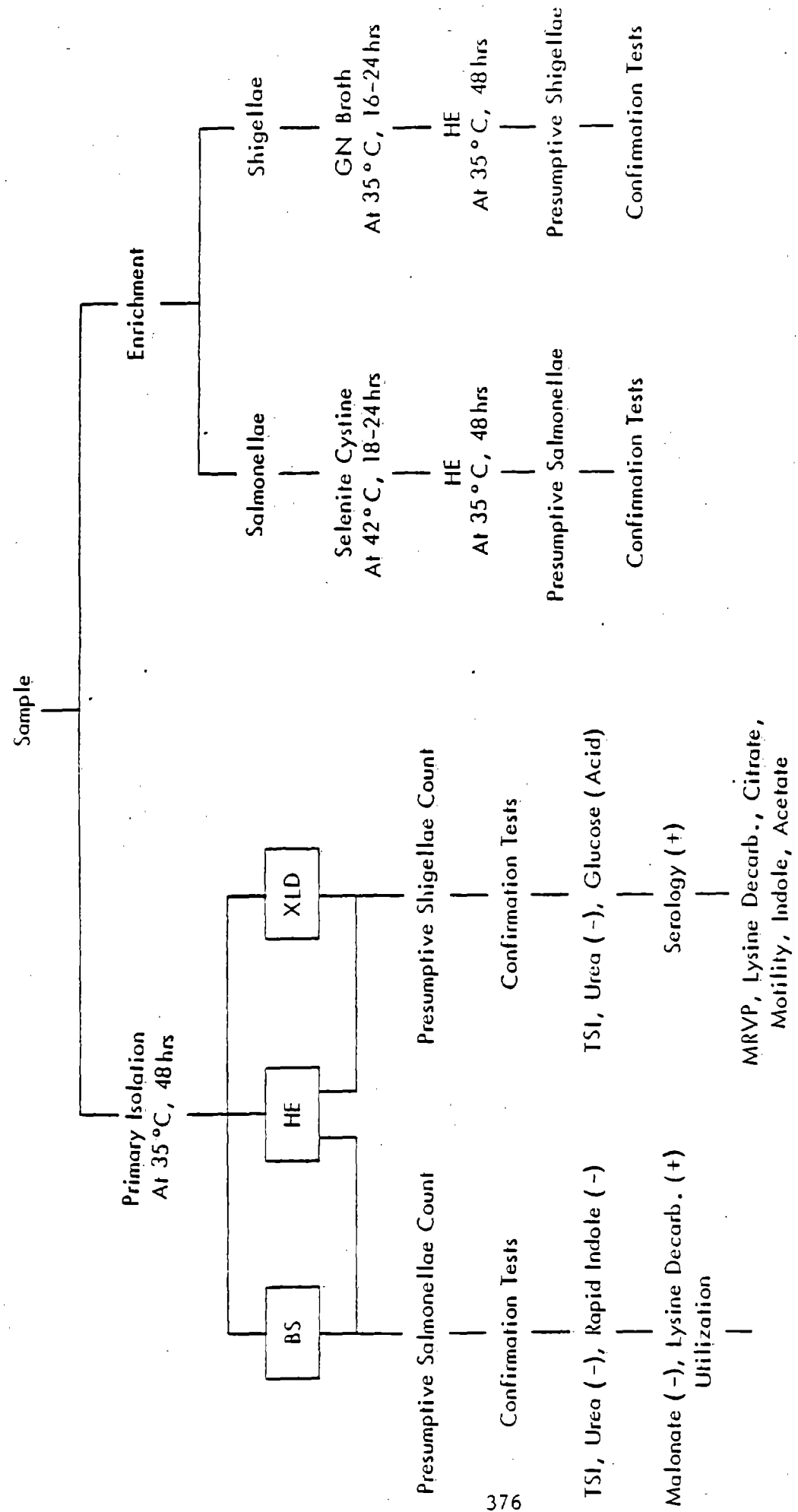


Figure G-2. Isolation scheme for Salmonella and Shigella.

Solid sample homogenate (15 ml) was transferred to sterile screw-capped tubes and centrifuged 10 min at 700 to 800 rpm. The supernatant (10 ml) was transferred to a sterile 50-ml centrifuge tube and processed as for liquid samples.

The inoculated media were incubated in the presence of CO₂ at 35°C for up to 6 weeks. Subcultures from the Cubos broth were made after 1 week to Lowenstein Jensen Graft media and incubated for up to seven additional weeks. All cultures were examined at weekly intervals. Verification of presumptive Mycobacterium isolates were conducted in accordance with CDC recommendations (Vestal, 1975).

Streptomyces

Starch casein salt agar plates were used to quantitate Streptomyces (Mackay, 1977). The medium contained the following antibiotics: nystatin (50 µg/ml); cycloheximide (50 µg/ml); polymixin B (5 µg/ml); and penicillin G (3 µg/ml). The plates were incubated at 25 to 28°C for 10 days. Confirmation of presumptive isolates was by gram stain, morphology, and lysozyme sensitivity (Haley et al., 1978).

Nocardia sp.

Brain heart infusion agar plates containing 5% sheep blood, 50 µg/ml carbenicillin, 50 µg/ml chloramphenicol, and 50 µg/ml Amphotericin B were used to quantitate Nocardia sp. The plates were incubated at 35°C in air for 7 to 14 days. Confirmation of presumptive isolates was conducted on the basis of cellular morphology, gram reaction, and lysozyme resistance (Haley et al., 1978).

Aspergillus fumigatus

Aspergillus fumigatus levels were determined using 2% malt extract agar containing 20 µg/ml gentamicin (Ajello, 1979; Austwick, 1974; and Mullins et al., 1976). Plates were incubated at 42°C for 72 hr prior to enumeration. Only black and blue-grey colonies were counted. Presumptive A. fumigatus isolates were verified by colony texture, color, and rate of growth on sabourand's dextrose agar. Conidiophore morphology was verified by microscopic observation with lactophenol cotton blue stain (Haley et al., 1978).

Aspergillus flavus

Aspergillus flavus was assessed using Aspergillus differential medium containing 20 µg/ml gentamicin (Ajello, 1979; Bothast et al., 1978; and Reiss, 1976). The plates were incubated at room temperature (25 to 28°C) for 3 days. Mold colonies producing a bright orange or yellow-orange pigment were counted as presumptive A. flavus. Presumptive isolates were confirmed by the same methods as used for A. fumigatus.

ANALYTICAL QUALITY CONTROL

Rigid quality control (QC) measures were taken with the microbiological sampling program. These measures included the normal routine monitoring of QC parameters as required by license at the analytical labs. In addition, the following parameters were included in this program: quantitative microbial shipping controls, sampling instrument sterility checks, sample pH determinations, and selected positive blind controls for analytical verification. Shipment of the etiologic agent "unknowns" complied with all applicable Department of Transportation hazardous materials regulations.

Quantitative microbial shipping controls were prepared by inoculating a wild biotype of *E. coli* on a plate count agar slant, with a 10 to 11 cm slope contained in a 16 x 150 screw-cap tube on the day prior to use. The entire slope was streaked during inoculation to ensure confluent growth over the entire surface. The slant was incubated at 35°C for 18 to 24 hr. The growth was harvested by adding 2.0 ml sterile, buffered, dilution water from a 99-ml water blank designated "A." The growth was suspended by gently scraping the slope surface with the pipet and then shaking the suspension. The bacterial suspension was then poured into bottle "A." To ensure complete removal of the culture, 2 ml of "A" was again pipetted into the culture tube, shaken, and added to bottle "A." Bottle "A" was vigorously shaken and serially diluted 1:100 for two further dilutions "B" and "C." The normal bacterial concentration of dilution "C" following this procedure was approximately 2.5×10^3 cells/ml.

Aliquots (2.0 ml) of dilution "C" were used to spike sterile aerosol collection menstruum in the field just prior to shipment of the day's specimens. The menstruum was then assayed in triplicate on tryptic soy agar by the spread-plate technique. Upon arrival at the sample's destination, the sample was also assayed in triplicate using the same methodology. Comparison of the counts prior to shipment and upon receipt provides information on whether microbial growth or die-off might have occurred during shipment.

ANALYTICAL PROCEDURES FOR HUMAN VIRUSES

Sample Processing

Both solid waste and liquid aerosol samples were analyzed for human virus content. The frozen samples were thawed quickly under cold running water and processed immediately. All analytical procedures, unless otherwise specified, conformed to general virology procedures detailed in the literature (Lenette et al., 1979; Behbehani, 1972).

Liquid aerosol samples were processed for viral studies by low-speed centrifugation at 350 xg for 30 min (1.8 ks) in an International refrigerated centrifuge. The supernatant was saved and ultracentrifuged at 70,000 xg for 3 hr in a Beckman Model L5-50 ultracentrifuge. The pellets were saved and resuspended to 6.0 ml in Hank's balanced salt solution (HBSS) containing fungizone (5 µg/ml), penicillin (200 units/ml), and streptomycin (200 µg/ml). This processing represented a concentration of 16- to 41-fold the original specimen.

Solid samples were suspended in HBSS and homogenized in a sterial Waring blender at low speed. The homogenate was then processed as described above for liquid-aerosol samples.

Inoculation of Specimens into Cell Cultures

The concentrated samples were quantitatively screened by inoculating 0.2-ml aliquots into roller tube cultures of the following cell lines: five tubes, primary monkey (*Cynomolgus*) kidney cells (PMK); three tubes, human embryonic lung (HEL); and three tubes, Madin Darby canine kidney (MDCK). Target virus susceptibilities of each cell line are presented below. All of the tubes were incubated at 36 to 37°C and were either rolled or kept stationary. The tubes were observed daily for the presence of viruses.

TISSUE CULTURE CELL LINE SUSCEPTIBILITIES^a

Cell line	Viral susceptibility
Primary monkey kidney (<i>Cynomolgus</i>)	Coxsackie B viruses Enchoviruses Polioviruses Influenza viruses Parainfluenza viruses
Human embryonic lung (HEL)	Adenoviruses Rhinoviruses Herpesviruses
Madin Darby canine kidney (MDCK)	Influenze viruses Parainfluenza viruses

^a Each cell line may exhibit broader susceptibilities to viruses other than those presented, and cross-susceptibilities may occur.

The growth of all the viruses listed above, except influenza and parainfluenza, is detected by the appearance of cytopathic effects (CPE). The hemagglutination test with fluids collected from inoculated tubes 5 days after inoculation using 0.4% guinea pig red blood cells at room temperature is used to detect the growth of influenza virus. The hemadsorption test performed on the cell monolayers of the inoculated tubes 5 days postinoculation with 0.4% guinea pig red blood cells at room temperature and at 4°C is used for detection of the parainfluenza viruses. When a tube or tubes showed CPE or $\pm$ CPE, a second passage in the same type of cells was made. The procedures for these tests are described in the literature (Lennette and Schmidt, 1979).

Inoculation of Specimens into Newborn Mice

A second portion of the sample concentrate was inoculated into litters of suckling mice for the isolation of Coxsackieviruses, particularly type A.

Newborn litters were randomized and divided into groups of 10 to 12 mice, and these groups were given to mothers showing no tendency to cannibalize their young. Each newborn mouse was inoculated both intraperitoneally and subcutaneously (into the interscapular space) with 0.05 ml of specimen. The mice were examined daily for signs of paralysis over a period of 14 days. Mice showing paralysis or found dead 24 to 36 hr after inoculation were harvested and passaged into newborn mice as described above.

Electron Microscopy

A third portion of the concentrated specimen was examined by transmission electron microscopy for the presence of viruses not recoverable in cell or animal culture. These viral agents would include rotaviruses (Zissis et al., 1978; Bishop et al., 1979), Norwalk (Greenberg et al., 1979), or Norwalk-like viruses (Appleton et al., 1977), and caliciviruses (McSeiggan et al., 1978).

The specimens were prepared by adding a 0.05-ml drop of sample concentrate to a 3.05-mm, 400-mesh TEM grid previously coated with Formvar. The drop was left on the grid for 1 to 2 min and then blotted. The grid was then stained with 2% phosphotungstic acid for 1 min and blotted. Finally, the grid was examined with a Zeiss Model EM-10B, TEM. Ten random squares of the grid were examined at 50,000, 63,000, and 80,000X magnification. When a particle or particles resembling viruses were observed, they were photographed for closer examination.

APPENDIX H. OSHA PELs, NIOSH AND ACGIH TLVs

Contaminants	OSHA mg/m ³	NIOSH mg/m ³	ACGIH mg/m ³
Total dust	15	10	10
Respirable dust	5	5	5
Cadmium (dust)	0.002	0.002	0.002
Chromium (metal and insol. salts)	1	0.05	0.05
Lead	0.05	0.05	0.15
Zinc (oxide fume)	5 as Zn	5 as Zn	5 as ZnO
Silica (total)	$\frac{30}{\% \text{ SiO}_2 + 2}$	-	$\frac{30}{\% \text{ SiO}_2 + 3}$
PCB's			
Aroclor 1242	1	0.001	1
Aroclor 1254	0.5	0.001	0.5
Aroclor 1260	-	-	-
Asbestos	2 fibers/cc; 10 fibers/cc ^a	0.5 fibers/cc	0.2 ^b ; 0.5 ^c ; 2 ^d
Benzene	30	3	30
Ethyl alcohol	1900	1900	1900
Heptane	2000	340	1600
Hexane	1800	360	180
Ethyl acetate	1400	1400	1400
Methylene chloride	1750	260	360
Benzo (a) anthracene	-	-	-
Benzo (a) pyrene	-	-	-
Chrysene	-	-	-
Fluoranthene	-	-	-
Pyrene	-	-	-
Welding fume	-	-	5
Turpentine	560	560	560
Polynuclear aromatic hydrocarbons	0.2 ^e	0.2 ^e	0.2 ^e
Hydrogen chloride	7 ^a	7 ^a	7 ^a
Hydrogen cyanide	11	5 (as 10 min ceiling)	10 ^a
Nonane	-	-	1050
Octane	2350	350	1450
Pentane	2950	350	1800
Carbon monoxide	55	40	55

^a 15-min ceiling.

^b For crocidolite.

^c For amosite.

^d From chrysotile and other forms.

^e benzene soluble fraction.

