EPA-650/2-75-044

May 1975 Environmental Protection Technology Series

ST. LOUIS REFUSE PROCESSING PLANT: EQUIPMENT, FACILITY, AND ENVIRONMENTAL EVALUATIONS

U.S. Environmental Protection Agency
Office of Research and Development
Washington, D.C. 20460

EPA-650/2-75-044

ST. LOUIS REFUSE PROCESSING PLANT:

EQUIPMENT, FACILITY,

AND ENVIRONMENTAL EVALUATIONS

by

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Contract No. 68-02-1324
Task 4
ROAP No. 21AQQ-010
Program Element No. 1AB013

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Prepared for

U. S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF RESEARCH AND DEVELOPMENT AND
OFFICE OF SOLID WASTE MANAGEMENT PROGRAMS
WASHINGTON, D. C. 20460

May 1975

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Publication No. EPA-650/2-75-044

ABSTRACT

This report describes partial results of the following tests and evaluations at the St. Louis refuse processing plant from September 1974 to January 1975: plant mass and energy balances; equipment and plant performance evaluations; an analysis of plant operating costs; particulate emission tests on the hammermill and air classification system dust collection cyclones; a pollution evaluation of plant washdown water; and a plant sound survey. The plant operated satisfactorily during the evaluation period, with about 80% of the incoming refuse converted to refuse fuel, on both a mass and energy basis. No major equipment breakdowns occurred. Plant operating and maintenance costs ranged from $2.58 to $14.80/ton of refuse produced, with costs varying primarily as a function of tonnage. Particulate emissions from the hammermill cyclone discharge were less than 0.01 gr/dscf; those from the air classifier cyclone discharge averaged 0.209 gr/dscf (about 1.25 lb/ton of refuse processed). Over 80% by weight of these particles had mean diameters greater than 10 μm. Washdown water samples showed significant increases in TSS, BOD, and COD; however, the small quantity of effluent (2,000 gal., twice/week) can be handled easily by the average municipal waste treatment facility. At eight of the 17 plant positions at which sound measurements were taken, sound levels were in excess of 90 dBA, the maximum OSHA level for continuous 8-hr exposure.

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ACKNOWLEDGMENTS

This report was prepared for the Environmental Protection Agency under Contract No. 68-02-1324. It describes the work carried out by Midwest Research Institute (MRI) at the St. Louis Refuse Processing Plant for the period of 23 September 1974 through 30 November 1974. The results of sound tests performed on 20 and 21 January 1975 are also presented.

This EPA-sponsored test and evaluation work was directed by James D. Kilgroe of the Control System Laboratory, Robert Holloway of the Resource Recovery Division and Carlton Wiles of the Solid and Hazardous Waste Research Laboratory.

Mr. Doug Fiscus, Mr. Paul Gorman and Dr. L. J. Shannon were the principal authors of this report. Many other MRI personnel assisted in compilation and analysis of the data. Actual equipment tests and refuse sampling were carried out at the processing plant by Mr. Steve Howard and Lynn Cook, under the direction of Mr. Doug Fiscus (MRI Field Manager). Most of the laboratory analysis of the refuse samples was done by Ralston Purina--Research 900--in St. Louis. Also, the conduct of this test and evaluation program at the processing plant would not have been possible without the excellent cooperation and assistance provided by Mr. Wayne Sutterfield (Refuse Commissioner - City of St. Louis) and his staff, especially Mr. John Molitar and Mr. Nick Young.

Approved for:

MIDWEST RESEARCH INSTITUTE

for H. M. Hubbard, Director
Physical Sciences Division

6 June 1975

SUMMARY

BACKGROUND

Early in 1974, the Environmental Protection Agency (EPA) contracted with Midwest Research Institute (MRI) to design and implement a detailed study for evaluation of the St. Louis-Union Electric Refuse Fuel Project. This program was primarily directed to evaluation of the equipment and facilities, and assessment of environmental emissions at both the processing plant and power plant. The extensive data collection and testing necessary under this program to make the required evaluations were begun on 23 September 1974. This interim report presents the results of the test and evaluation program at the processing plant for the period 23 September to 30 November 1974. It also presents the results of special sound tests performed on 20 and 21 January 1975.

PROCESSING PLANT EVALUATIONS

Information required for evaluation of the equipment and facilities and for environmental impacts was collected at the processing plant during the period 23 September through 30 November 1974. Data on plant material flows, operating parameters, costs and character of the plant material flows were obtained. The following paragraphs describe the plant operating mode (processing rate) during the test periods and present important data and results.

One of the more important parts of the test plan, and certainly the one that provided the greatest amount of data, was characterization of plant material flows. Daily sampling of individual process streams with analyses of samples was conducted to determine:

Heating value (Btu/lb),

Moisture (%),

Bulk density (lb/ft^3),

Ash (%),

Size,

Composition (percent of wood, paper, plastic, glass, metal, etc.),

Metals analyses (percent of Fe, Al, Pb, Cu, Ni and Zn), and

Proximate and ultimate analyses of refuse fuel.

The above characteristics were determined on either a daily basis or a weekly basis for at least the four major input/output streams during 7 of the 10 test weeks, in order to characterize the plant flows as completely as possible. The analysis results are tabulated in the appendix of this report. Sampling of each process stream normally involved collection of samples at 2-hr intervals, four times each day. The four individual samples were combined into a daily composite sample on which analyses were performed. However, the reliability of the results using this sampling method was not known. Therefore, additional special sampling sequences were undertaken for the purpose of statistically evaluating the results obtained by the normal sampling method. These statistical evaluations indicated that the results obtained by the normal sampling method could be expected, with 95% confidence, to be within 10 to 15% of the actual mean value for most analysis parameters (e.g., heating value, moisture, etc.). This degree of reliability was considered to be acceptable for the purposes of this test program.

Although sampling and analyses were an important part of the effort at the processing plant during the subject test period, other important information and data were collected during each week, especially those weeks when the plant was operated at specific production rates.

In the first 2 weeks of the test period the plant was operated at maximum capacity (300 tons/8-hr day) and it was demonstrated that the plant was capable of sustaining this rate over a 2-week period. Subsequent testing was conducted at a processing rate of at least 150 tons/8-hr day for 3 weeks, followed by 5 weeks at variable rates that ranged from approximately 100 to 200 tons/8-hr day. No major equipment breakdowns occurred during these periods. Planned shutdowns did occur to perform normal maintenance, including 1 week for repair of refuse handling equipment at the power plant.

In addition to monitoring daily plant production rates, records were kept of the quantity of all input/output streams and bin inventories. These data were used to compute weekly material balances for the plant and they were also used, along with sample analysis results previously discussed, to compute plant energy balances. Plant output weights averaged 6.8%

less than the plant input weights. No single item was identified to account for this apparent loss but it is suspected that errors in weighing refuse fuel trucks may have occurred. Ignoring the error in mass balance, the refuse fuel output stream represented, on the average, 79.8% of the weight of raw refuse and 82.3% of the energy contained in the raw refuse.

During the 10-week test period (23 September through 30 November) records were kept of plant operating costs (operating and maintenance labor, operating supplies, parts and electrical power, etc.). These records were used to compute weekly production (operating) costs on the basis of dollars per ton of refuse fuel produced. These weekly costs ranged from \$2.58 up to \$14.80/ton and the overall cost for the 10-week period was \$6.20/ton. This overall cost reflects 1 week when there was no production and several weeks when the plant was purposely operated at considerably less than design capacity (300 tons/8-hr day). The lowest operating cost of \$2.58/ton represented those 2 weeks when the plant was operated near design capacity and no unscheduled shutdowns occurred. Therefore, if the plant were normally operated near design capacity, operating costs should be less than \$6.20/ton, but probably more than \$2.58/ton because some unscheduled downtime and maintenance is to be expected.

ENVIRONMENTAL TESTS

Although most of the work at the processing plant during the 10-week test period was directed to collection of data on plant operations and sampling and analysis of refuse streams, the program did include environmental testing with emphasis on determination of emissions from the air density separator (ADS) cyclone and hammermill (HM) cyclone and an evaluation of processing plant sound levels. The most important result of the air emission sampling was that the emissions from the ADS cyclone averaged 50 lb/hr. At a nominal processing rate of 40 tons/hr, this represents an emission factor of 1.25 lb/ton of processed refuse. In all cases, at least 80% of the particles were above 10 μm in size. The ADS emission rate is significant, indicating a need to reduce emissions, possibly by equipment redesign, or more likely by installation of a suitable particulate control device.

The major sound-level contributors are the hammermill, air-density separator (ADS) heavies discharge, nuggetizer and magnetic belt feed to the nuggetizer, ADS fan exhaust, the front-end loader used to push raw refuse onto the receiving belt, and the dumping of raw-refuse trucks. In general, the higher sound levels occur below 2,000 Hz frequency, with the exception of the nuggetizer in combination with the magnetic-separation belt-feed to the nuggetizer.

The maximum processing-equipment sound level was 103 dB at 4,000 Hz center band frequency next to the nuggetizer feed duct. The maximum plant sound level was 110 dB at 63 Hz center band frequency inside the raw-refuse receiving building when the raw-refuse trucks were dumping.

No location at which an employee must spend a continuous 8 hr was found to be above 90 dBA. Several locations have sound levels above 90 dBA, but these do not require the continuous presence of any single employee.

INTRODUCTION

The St. Louis Union Electric System is the first demonstration plant in the U.S. to process raw municipal waste for use as a supplementary fuel in power plant boilers. In addition to producing a fuel, ferrous metals are recovered from the waste for use as a scrap charge in steel production. Two separate facilities comprise the system--a processing plant operated by the City of St. Louis, and two identical boilers (tangentially fired), which were modified to fire shredded air classified refuse along with coal at the Union Electric Company's Meramec Plant near St. Louis.

This demonstration facility has been in operation for over 2 years and has shown that such a system is a workable method for utilizing raw refuse as a supplementary fuel, and that some saleable by-product (ferrous metal) can also be recovered. Since the St. Louis facility has been in operation, several similar facilities have been placed under construction or are being planned in other cities. Because of that and the growing interest in this resource recovery method, EPA has expanded their program at St. Louis to permit a more detailed study of the performance and characteristics of the operations, including environmental aspects.

EPA contracted with MRI to conduct a test and evaluation program at the St. Louis demonstration facility. This program includes equipment and facilities evaluations and environmental assessments at both the refuse processing plant operated by the City of St. Louis and the refuse firing facility operated by Union Electric Company's Meramec Plant.

This interim report presents the results of test and evaluation activity at the processing plant during the period 23 September to 30 November 1974. The results of sound tests performed in January 1975 are also included. In order, the report presents (a) test methodology, (b) equipment and facilities evaluation, and (c) environmental evaluations.

METHODOLOGY

The test and evaluation program that is being conducted by MRI at the processing plant is primarily directed to two areas:

1. Equipment and Facilities Evaluation, and

2. Environmental Evaluations.

The objectives of this evaluation program, stipulated in Table 1, served as the basis for development of appropriate test schedules and procedures. Briefly, the schedules and procedures consisted of the following:

1. Two-week intensive sampling and analysis at a processing rate of 300 tons/8-hr day (23 September to 6 October 1974).

2. Three-week baseline sampling and analysis at a processing rate of at least 150 tons/8-hr day (7 October to 27 October 1974).

3. One week of air and water pollution testing at a processing rate equivalent to 300 tons/8-hr day while processing plant testing was in progress (18 November to 22 November 1974).

4. Continuing sample analyses and compilation of data, on a weekly basis, to describe plant inputs/outputs, maintenance requirements, operating costs, etc. (23 September to 30 November and continuing thereafter).

5. A survey of the sound levels in the refuse processing plant (20 and 21 January 1975).

The 2-week intensive sampling period involved daily sampling of eight process streams as designated in Figure 1. Sampling of these streams consisted of collecting a sample from each stream ($\sim$ 1/3 ft^3), at approximately 2-hr intervals and combining the resultant four individual samples into a composite daily sample. The daily composite samples, for each of the eight streams, were then analyzed as specified in Table 2.

Table 1. PROCESSING PLANT--OBJECTIVES OF EQUIPMENT AND FACILITIES EVALUATION AND ENVIRONMENTAL EVALUATION

1. Material balance to determine amount (by weight) of material entering plant versus amounts of refuse fuel and by-products produced.

2. Determine heating value of material entering plant versus heating value of refuse fuel produced (i.e., determine how much of potential heating value may be lost in by-product streams).

3. Characterization of various material flows as to:

   Moisture content
   Bulk density
   Size analysis
   Heating value
   Composition (percent-paper, plastic, wood, glass, magnetic metal, other metals, other organics, miscellaneous)
   Chemical analyses (ash, Fe, Al, Cu, Pb, Ni, Zn)

4. Characterization of equipment as to:

   Horsepower (nameplate and actual)
   RPM
   Air flow (blowers)
   Belt width and speed (conveyors)
   Grate size (hammermill)
   Downtime and maintenance requirements or modifications
   Physical size of equipment, etc.

5. Use the above information to evaluate the system and its components. This evaluation will identify operability as well as capability in terms of:

   Shredding size
   Separation efficiency (energy recovery)
   Ferrous metal recovery efficiency
   Operating hours and downtime
   Power and supplies required
   Operating labor required
   Maintenance labor required
   Electric power required per ton of refuse fuel produced
   Total costs per ton of refuse fuel produced

6. Quantify and characterize air, liquid and solid waste effluents from the processing plant to include:
   Air emissions from ADS cyclone
   Air emissions from HM cyclone
   Effluent from area washdown activities
   Reject material hauled to landfill

7. Characterization of sound levels at the processing plant.

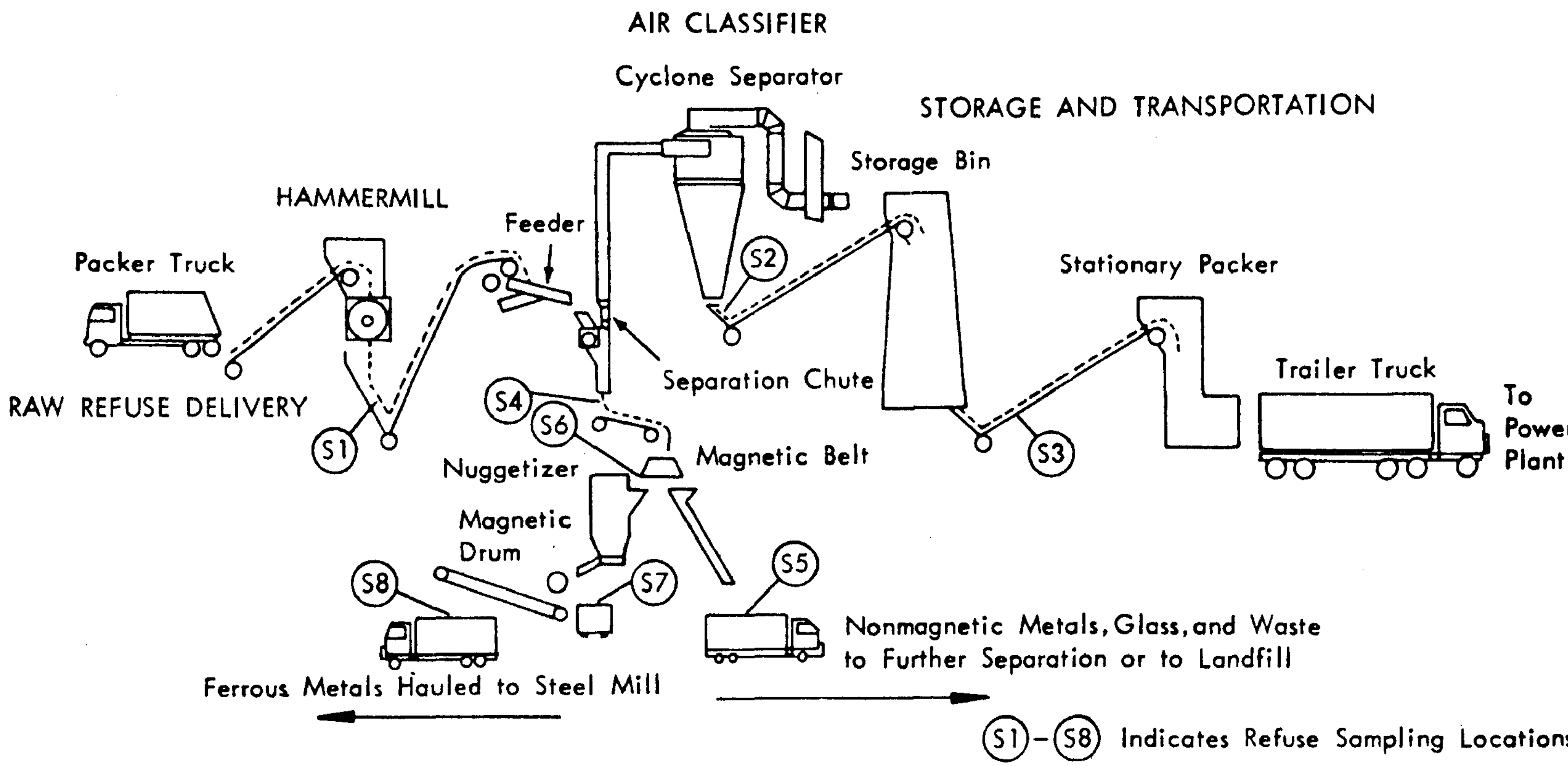


Figure 1. Flow diagram of processing plant and refuse sampling locations.

Table 2. SAMPLING AND ANALYSIS PERFORMED
(Intensive)

Stream identification	Moisture	Bulk density	Size	Heating value	Proximate analysis	Ultimate analysis	Composition[c]	Metals analysis
S1 - Hammermill discharge	X	X	X	X			X	X[a]
S2 - Cyclone separator bottoms	X	X	X	X	X	X	X	X[a]
S3 - Storage bin discharge	X	X		X	X	X	X	X[a]
S4 - Air classifier bottoms	X	X	X	X			X	X[b]
S5 - Magnetic belt rejects	X	X	X	X			X	X[b]
S6 - Nuggetizer feed	X	X	X				X	X[b]
S7 - Magnetic drum rejects	X	X		X			X	X[b]
S8 - Ferrous metal by-product	X	X	X	X			X	X[b]

a/ Chemical analyses to determine percent Fe, Al, Cu, Pb, Ni, and Zn.
b/ Visual analysis for metallic components (wt % - tin cans, ferrous metal, Al and Cu).
c/ Composition will include determination of percent magnetic material, as well as major constituents.

A reduced "baseline" sampling and analysis scheme was used during the 3-week period that followed the 2-week intensive period. The same four samples per day schedule was followed, but only four input/output streams were sampled as specified in Table 3. Daily composite samples of these four streams were analyzed, except that metals analyses were done only on weekly composite samples.

The baseline sampling and analysis schedule was also carried out during the 1 week of environmental testing at the processing plant. After the 3-week baseline sampling period, daily analysis of samples was discontinued and instead, two daily samples were collected and utilized for preparing weekly composite samples for analysis in order to minimize analysis costs.

In addition to collection and analyses of refuse samples, plant operating data and costs were compiled for each weekly test period. This data, along with the analyses results, were used for evaluating the equipment and facilities as described in the next section of this report.

Table 3. SAMPLING AND ANALYSES PERFORMED[a]
(Baseline)

Stream identification	Moisture	Bulk density	Size	Heating value	Proximate analysis	Ultimate analysis	Composition[b]	Metals analysis[a]
S1 - Hammermill discharge	X	X	X	X			X	X[b]
S2 - Cyclone separator bottoms	X	X	X	X	X	X	X	X[b]
S5 - Magnetic belt rejects	X	X	X	X			X	X[c,e]
S8 - Ferrous metal by-product	X	X	X	X			X	X[c]

a/ Analyses to be performed on daily composite samples except that metals analysis will be done only on weekly composite samples.

b/ Chemical analyses to determine percent Fe, Al, Cu, Pb, Ni, and Zn.

c/ Visual analysis for metallic components (wt % - tin cans, ferrous metal, Al and Cu).

d/ Composition will include determination of percent magnetic material, as well as major constituents.

e/ Includes analysis for percent organics and volatile material for samples taken during week of environmental tests.

Note: After 3-week baseline sampling period, analyses were performed only on weekly composite samples including stream S7 (magnetic drum rejects). However, daily sampling and analyses were performed during week of environmental tests.

EQUIPMENT AND FACILITIES EVALUATION

Data were collected at the processing plant over the 10-week time period of 23 September 1974 through 30 November 1974 according to the test program shown below:

Week No.	Specified Daily Raw Refuse Processed - Tons	Refuse Sampling Schedule
1,2	300	daily (8 streams sampled)
3,4,5	150 +	daily (4 input/output streams sampled)
6,7	nonspecified	none - environmental testing at U. E.
8	nonspecified	none - prepare for environmental testing at processing plant
9	as required for normal tons/hr rate (300 tons/day)	daily - environmental tests at processing plant
10	nonspecified	weekly composite for 5 input/output streams

Even though refuse samples were not taken during weeks 6, 7, and 8, plant material flows, man-hours, and costs were recorded.

All of the refuse sample analyses results and plant operating data collected during the above weeks were compiled and analyzed with the aim of meeting the objectives of the equipment and facilities evaluation as listed previously in Table 1. With these objectives in mind, the results have been summarized and are presented in the following sections of this report. The detailed data from the entire test period are tabulated in the appendix.

PLANT OPERATIONS AND COSTS

A daily log of plant production rates and plant activity during the 10-week test period is presented in Table 4. Because the bulk of the plant equipment is located outside, ambient temperature and humidity were recorded (Figure 2) for each test day to show the environment in which the equipment was operating.

Table 4. PROCESSING PLANT DAILY ACTIVITY

(Averages are for days plant is processing, not work days per week)
(Test days are days refuse samples taken)

Day	Date 1974 Mo.	Date 1974 Day	Weather	Test day	Raw refuse processed Tons/Day	Raw refuse processed Tons/Hr	Comments
Week 1							
Mon	9	23	Clear	1	284.6	31.0	
Tues	9	24	"	2	303.0	40.4	
Wed	9	25	"	3	312.3	41.2	
Thurs	9	26	Fog	4	309.2	39.9	
Fri	9	27	Cloudy	5	319.9	41.3	
	Average				305.8	38.8	
Week 2							
Mon	9	30	Clear	6	309.7	44.2	
Tues	10	1	"	7	325.1	40.6	
Wed	10	2	"	8	312.0	38.6	
Thurs	10	3	"	9	297.5	40.6	
Fri	10	4	"	10	299.8	41.4	
	Average				308.8	41.1	
Week 3							
Mon	10	7	Clear	11	176.0	28.5	
Tues	10	8	"	12	177.3	28.7	
Wed	10	9	"	13	182.9	37.2	
Thurs	10	10	"	14	184.5	42.6	
Fri	10	11	"	15	182.6	47.7	
	Average				180.7	36.9	
Week 4							
Mon	10	14	Rain	-	-	-	Holiday - Columbus Day
Tues	10	15	Clear	16	205.9	39.8	
Wed	10	16	"	17	200.6	33.4	
Thurs	10	17	"	18	191.9	42.6	
Fri	10	18	Cloudy	19	178.8	35.8	
	Average				194.3	37.9	

Table 4. (Continued)

Day	Date 1974 Mo.	Day	Weather	Test day	Raw refuse processed Tons/Day	Tons/Hr	Comments
Week 5							
Mon	10	21	Clear	20	177.7	29.6	
Tues	10	22	"	21	81.1	32.4	
Wed	10	23	Cloudy	22	179.6	35.9	
Thurs	10	24	"	23	176.2	37.1	
Fri	10	25	"	24	161.8	46.2	
	Average				155.3	36.2	
Week 6							
Mon	10	28		-	0	0	Holiday for U.E. - Veterans Day for U.E.
Tues	10	29		-	110.2	31.5	
Wed	10	30		-	25.3*	22.1*	Regrind Experiment* (Not included in averages)
Thurs	10	31		-	0	0	Not in operation-Change mill grates, clean up
Fri	11	1		-	157.4	29.6	
	Average				133.8	30.6	
Week 7							
Mon	11	4		-	0	0	Planned maintenance outage for U.E.
Tues	11	5		-	-	-	Holiday - Election Day
Wed	11	6		-	0	0	Planned maintenance outage for U.E.
Thurs	11	7		-	0	0	Planned maintenance outage for U.E.
Fri	11	8		-	0	0	Planned maintenance outage for U.E.
	Average						
Week 8							
Mon	11	11		-	-	-	Holiday - Veterans Day for city employees
Tue	11	12		-	123.1	32.8	
Wed	11	13		-	115.9	26.9	
Thurs	11	14		-	114.5	38.2	
Fri	11	15		-	111.2	23.6	
	Average				116.2	30.4	

Table 4. (Concluded)

Day	Date 1974 Mo.	Day	Weather	Test day	Raw refuse processed Tons/Day	Tons/Hr	Comments
Week 9							
Mon	11	18	Clear	25	88.2	27.9	
Tues	11	19	Cloudy	26	280.5	35.4	Environmental testing at processing plant
Wed	11	20	Clear	27	287.6	32.9	Environmental testing at processing plant
Thurs	11	21	"	28	234.6	34.3	Environmental testing at processing plant
Fri	11	22	"	29	173.9	31.2	Environmental testing at processing plant
	Average				212.9	32.3	
Week 10							
Mon	11	25	Clear	30	265.1	33.9	Hot bearing on ADS fan
Tues	11	26		-	0	0	Replaced ADS fan bearing
Wed	11	27	Clear	31	197.9	25.5	
Thurs	11	28		-	-	-	Holiday - Thanksgiving
Fri	11	29		-	0	0	Not in operation - General maintenance
	Average				231.5	29.7	

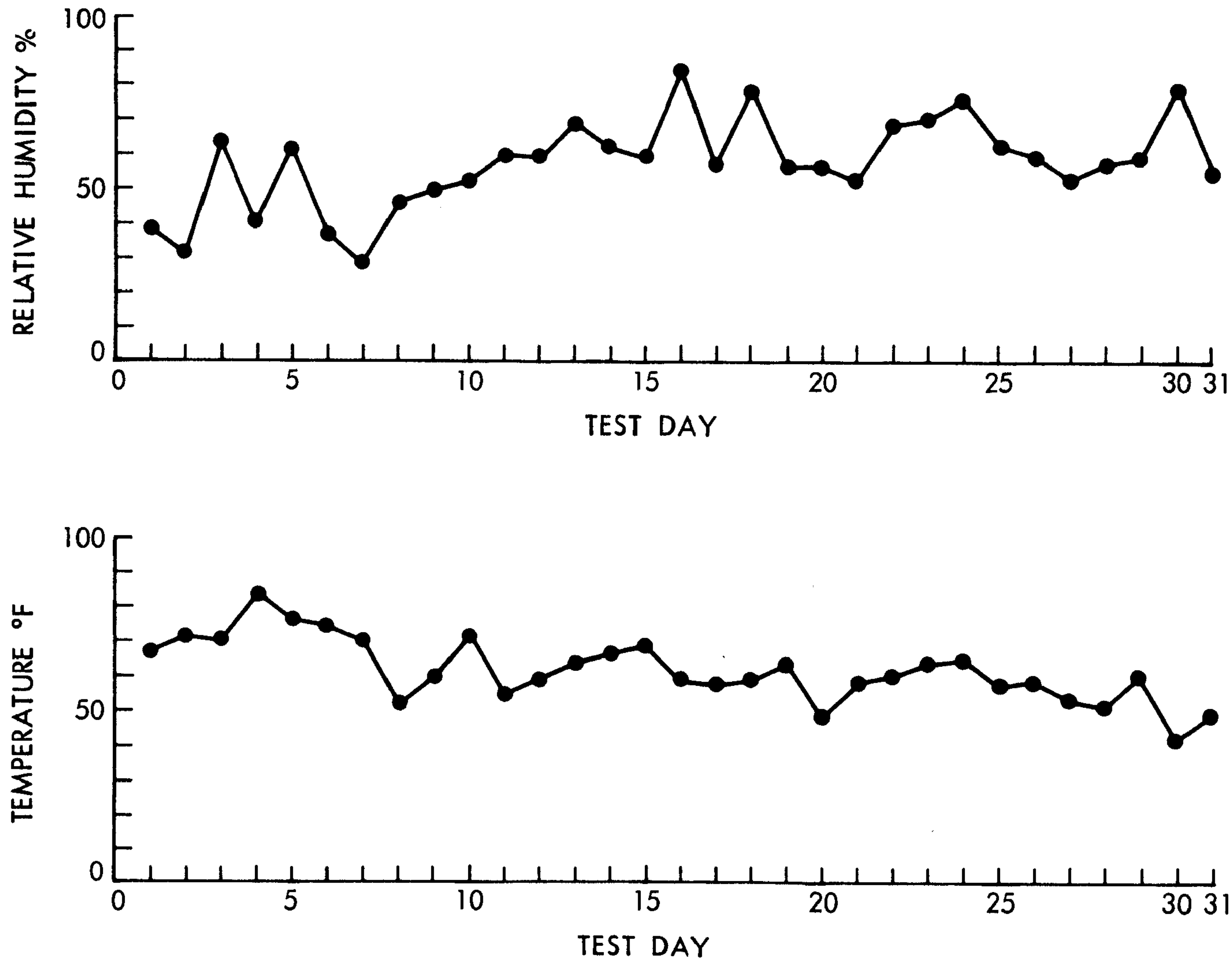


Figure 2. Daily variations in midday ambient temperature and relative humidity.

The plant processing rates listed in Table 4 have been plotted in Figure 3 to depict fluctuations and are based on actual time the plant operated (i.e., not including downtime).

The required daily tonnage amounts were met except for 22 October 1974, where due to miscommunications, only 81.1 tons instead of 150 tons of raw refuse were delivered to the processing plant. This was not a serious factor because the weekly average was still above 150 tons/day and there was no large drop in the 22 October hourly processing rate.

As shown in Figure 3, the processing rate becomes more variable at lower daily tonnages and there appears to be a slight trend of processing rate decreasing with a decrease in daily tonnage. Statistical analysis of the data yielded only a 61% correlation between tons per hour and tons per day. However, it is important to point out that while tons of refuse processed is primarily a function of the number of hours the plant operates, more variability in the processing rate is to be expected when the daily tonnage required is reduced. Part of the reason for this is the design of the hammermill interlock system which shuts off the raw refuse feed conveyors if the maximum motor load on the hammermill is exceeded for too long. Therefore, to minimize the frequency of such shutoffs, the operators may decrease the speed of the raw refuse feed conveyors based on the daily tonnage required.

Processing rate is controlled by an operator's visual observation of the hammermill motor current via an ampmeter. The operator's objective is to keep the hammermill operating as close as possible to the maximum motor current. Feed rate to the hammermill is controlled by a variable speed drive on the raw refuse receiving belt conveyor. The hammermill has a nominal capacity of 45 tons/hr. The daily rates varied from 52 to 106% of this design rate, with the average being 79%. An individual day may have a high processing rate. However, due to the variabilities of incoming raw refuse and the human operator's alertness, it would be difficult to greatly improve the average processing rate over a long time span.

A summary of plant operations and operating costs for each weekly test period has been tabulated in Table 5. Cost data were obtained from the City of St. Louis, but these are kept on a monthly basis so it was necessary to prorate the monthly data in order to establish weekly cost data.

The weeks in November showed an increase in total costs. Part of this increase was due to a single large payment of $1,386 for hammermill parts. Also, there were increased labor costs for the month and a larger than usual number of smaller bills for parts and supplies.

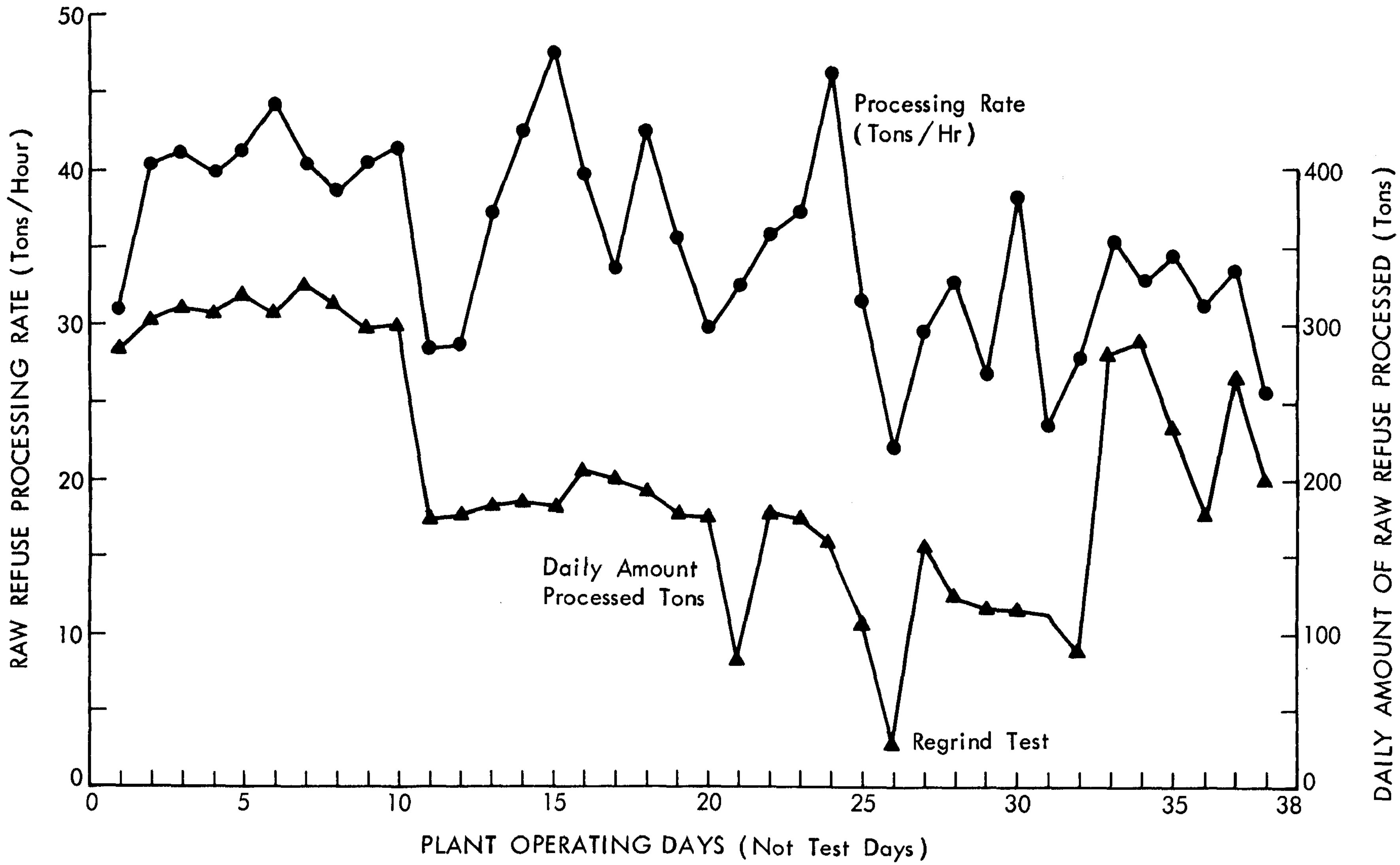


Figure 3. Daily variations in amount and rate of raw refuse processed.

Table 5. WEEKLY SUMMARY OF PROCESSING PLANT OPERATIONS AND COSTS[c/]

	9-23	9-30	10-7	10-14	10-21	10-28	11-4	11-11	11-18	11-25
Actual processing time (hr)	39.8	37.7	25.4	20.7	21.8	14.0	0	15.8	32.2	15.6
Plant downtime (hr)	1.1	5.3	1.0	7.7	4.2	5.7	0	2.0	1.9	2.9
Total plant time on processing days (hr)	40.9	43.0	26.4	28.4	26.0	19.7	0	17.8	34.1	18.5
Days processing performed	5	5	5	4	5	3	0	4	5	2
Days no processing performed	0	0	0	0	0	2	4	0	0	2
Possible working days	5	5	5	4	5	5	4	4	5	4
Refuse received (tons)	1,529.0	1,544.1	903.3	777.2	776.4	292.9	0	464.7	1,064.8	463.0
Refuse fuel produced (tons)	1,185.6	1,195.4	719.1	586.2	625.0	245.4	0	393.8	898.7	347.9
Fe metal produced (tons)	77.1	93.8	58.1	38.3	37.2	15.0	0	25.1	54.9	22.9
Operating labor (man-hours)[a/]	324.5	348.5	337.5	282.5	380.5	424.0	200.5	326.5	396.8	284.0
Maintenance labor (man-hours)	149.0	124.5	107.0	91.5	131.5	120.0	139.0	109.5	104.3	112.0
Total direct labor	473.5	473.0	444.5	374.0	512.0	544.0	339.5	436.0	501.1	396.0
Electric power used (kw-hr)	33,600	34,080	23,040	19,440	20,400	14,000	7,660	16,500	27,120	17,520
Maintenance parts cost ($)	243	210	202	162	202	317	623	623	779	623
Operating supplies, fuel, power, misc.	644	606	596	477	596	738	1,042	1,042	1,303	1,042
Salaries and benefits ($)[b/]	2,173	2,266	2,290	1,832	2,290	2,592	3,041	3,041	3,802	3,041
Total plant operating costs ($)	3,060	3,082	3,088	2,471	3,088	3,647	4,706	4,706	5,884	4,706
Total direct labor (man-hours/ton)	0.40	0.40	0.62	0.64	0.82	2.22	-	1.11	0.56	1.14
Total electric power (kw-hr/ton)	28.3	28.5	32.0	33.2	32.6	57.0	-	41.9	30.2	50.4
Total cost ($/ton)	2.58	2.58	4.29	4.22	4.94	14.86	-	11.95	6.54	13.53

a/ Includes direct supervision. Does not include clerical and indirect supervision.
b/ Salaries and benefits include clerical and indirect supervision.
c/ No costs for landfill of refuse fuel are included because these were incurred only for purposes of maintaining desired production rates for test purposes.

During the week of 4 November, there was no plant production, which precluded calculation of dollars per ton costs for that week. It is important to point out that yearly costs divided by total yearly tons, would of course take into account costs from weeks with no production. The weekly costs ranged from $2.58/ton to $14.80/ton. The overall cost for the period 23 September through 29 November 1974 was $6.20/ton (computed as total cost divided by total tonnage of refuse fuel). This overall cost of $6.20/ton reflects 1 week with no production and several weeks when the plant was operated at considerably less than design capacity. However, if the plant were normally operated at near design capacity of 300 tons/8 hr as was done in the 2 weeks of 23 September and 30 September 1974, operating costs per ton of refuse fuel produced could be expected to be less than $6.20/ton but probably more than $2.58/ton. It is extremely doubtful that a cost of $2.58/ton could be achieved over the long term because a certain amount of downtime days will be required for equipment maintenance.

Cost data on a dollar per ton basis and power usage (kw-hr/ton) from Table 5 have been plotted in Figure 4. Statistical analysis of the data showed good correlation between electric power, costs and tonnage. Correlation coefficients were 98 and 93%, respectively, for kilowatt-hour per ton and dollar per ton. These results are shown in Figure 4.

The important conclusion is that the rate of both electric power consumption and total costs are a function of tonnage. Lowest rates occur at the highest weekly tonnage.

The best fit curve equations corresponding to the correlation coefficients are shown in Figure 4. Both curves are of the form: $\text{rate} = \frac{h_1}{\text{tons}} + h_2$

where h_1 and h_2 are constants. The significance between the two curves is that h_2 for kilowatt-hour per ton is much larger than for dollars per ton. A portion of electric power is used for lighting, heat, air conditioning and maintenance, which is not a function of tons processed. Therefore, kilowatt-hour per ton reaches its minimum value before dollars per ton. The data in Figure 4 should be used with a degree of caution because only a limited number of data points comprise the correlation. Additional data are needed to confirm the implications of Figure 4. Furthermore, the curves in Figure 4 should not be used to predict results beyond the range of weekly tons shown in Figure 4. For example, a significant increase in tonnage may require more employees which would change the cost curve equation.

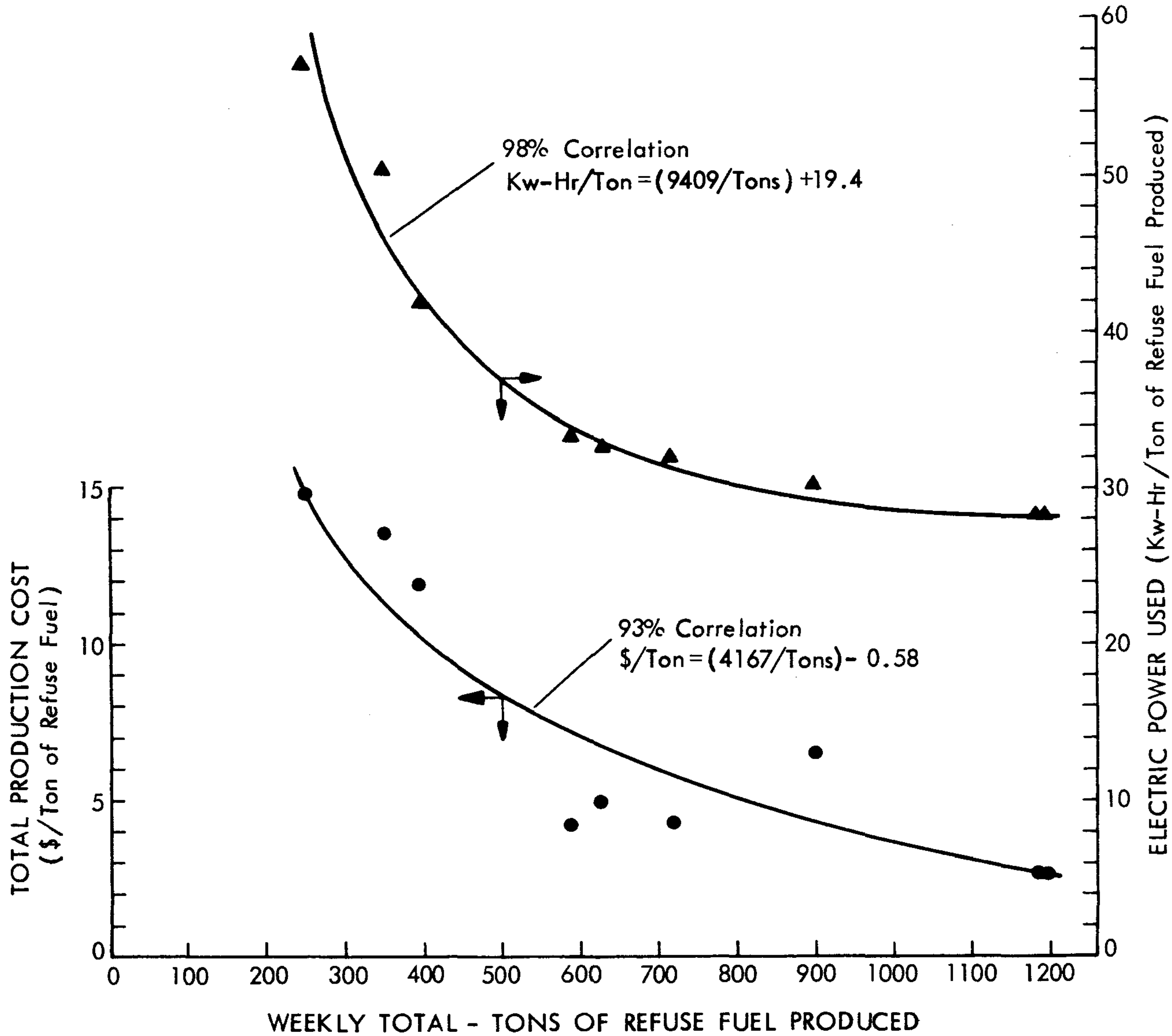


Figure 4. Total cost per ton and kilowatt-hour per ton versus total weekly tonnage of refuse fuel produced.

EQUIPMENT DOWNTIME AND MAINTENANCE

There were no major equipment failures during this 10-week test period. Table 6 defines the plant downtime. There were incidents that caused the plant to cease operations at time periods when it would otherwise not be required. Therefore, the total weekly time required to handle a given amount of refuse is the sum of the actual processing time and the downtime.

Table 7 lists the major items of maintenance performed that were not counted as downtime. Such maintenance occurred either during the plant operating time, before or after the plant was actually processing refuse, or on the days when the plant was not processing refuse. It is interesting to note that maintenance man-hours comprised about 25% of the total direct labor shown in Table 5.

CHARACTERIZATION OF PLANT EQUIPMENT

The refuse processing facility is made up of several major pieces of equipment as well as many conveyors, etc. In order to characterize these items, their physical size has been described in the appendix (Table A-1). Since most of the items of equipment are electrically driven, the electrical characteristics of each has also been tabulated in the appendix (Table A-2). By far the largest power users are the hammermill (1,250 hp), ADS fan (200 hp), storage bin discharge screw conveyor (150 hp), and the nuggetizer (100 hp).

All motors, except the hammermill, operated at less than their full load current rating. The hammermill, storage bin discharge screw conveyor, nuggetizer, and air density separator (ADS) fan motor currents were measured daily because of their large size and possible varying load. Figure 5 depicts these daily readings.

Hammermill current fluctuates rapidly due to the varying composition of the incoming raw refuse. Also, the large mass of the mill rotor acts as a flywheel. Large pieces of metal or other hard-to-mill refuse in the stream try to slow the rotor speed, causing a rapid increase in motor current. By the time the motor current peaks, the hard-to-mill refuse has passed the mill, but the rotor coasts due to its flywheel effect, which in turn causes a quick decrease in motor current. The motor electric power circuit is fitted with a dial ampmeter. It is possible to read the high and low points of the fluctuating meter dial. However, it is impossible to determine average current draw from this meter. Therefore, the maximum and minimum amperage were recorded and are shown in Figure 5.

Table 6. WEEKLY SUMMARY OF PLANT DOWNTIME DURING PROCESSING DAYS

Week of 1974 Month	Day	Downtime hours	Equipment	Description
9	23	1.1		Plant shut down to await tour group from Suwa, Japan
9	30	4.3	Nuggetizer	Sheared bolts on breaker bars
		1.0	Storage bin	Discharge screw conveyor plugged
		5.3	Total	
10	7	1.0	Trucks	Shut down to change mag. belt reject trucks
10	14	0.7	Trucks	Shut down to change mag. belt reject trucks
		0.5	Mag. belt	Reject hopper plugged
		1.5	Vibrating conv.	Replace bearing on mill discharge conv.
		1.5	-	General maintenance
		3.5	ADS	Surge bin plugged due to drive motor mount breaking loose
		7.7	Total	
10	21	2.0	Hammermill	Replace oil pump coupling
		1.2	Storage bin	Overfilled one end - cross belt was not reversed
		1.0	Vibrating conv.	Replace broken spring clamp on mill discharge conv.
		4.2	Total	
10	28	0.8	ADS drag conv.	Remount and tighten loose drive chain
		0.4	ADS fan	Tighten loose mounting bolts
		4.5	Vibrating conv.	Clean out and re-start plugged mill discharge conv.
		5.7	Total	
11	11	0.8	Trucks	Shut down to change mag. belt reject trucks
		0.2	Vibrating conv.	Tighten loose mounting bolts on mill discharge conv.
		1.0	ADS	Surge bin plugged
		2.0	Total	
11	18	0.3	ADS fan	Clean fan - heavy vibration noticed
		0.3	ADS	Surge bin plugged
		1.3	Hammermill	Fire in mill - assume due to hot metal
		1.9	Total	
11	25	1.0	ADS drag conv.	Clean out and re-start plugged conv.
		1.9	ADS	Surge bin plugged
		2.9	Total	

Table 7. WEEKLY SUMMARY OF MAJOR PLANT MAINTENANCE NOT COUNTED AS DOWNTIME

Week of 1974 No.	Day	Equipment	Description
9	23	Hammermill	Hammer retipping, replacement of 18 hammers
		Stationary packer	Welded plate on packer
		ADS	Clean fan
		Nuggetizer	Clean fan, turn wear plate around, inspection
		Magnetic belt	Mistracked and jammed, realigned and reject hopper cleared
9	30	Hammermill	Hammer retipping
10	7	Hammermill	Hammer retipping, replacement of 14 hammers
10	14	Hammermill	Hammer retipping, hammer replacement
		Magnetic drum	Repair hole in feed chute
10	21	Hammermill	Fire in refuse collected behind discharge, hammer retipping
10	28	Hammermill	Replace oil lines, change oil
		Hammermill feed conv.	Replace bolt, replace seal
		Nuggetizer	Lubricate, tighten bolts, clean fan
		Conveyor belts	Clean
		Storage bin	Install new lugs on auger
		Magnetic belt	Lubricate
		ADS	Clean fan
11	4	Hammermill	Hammer retipping, change air filter on oil cooler
		ADS	Clean, parts fabrication
		Storage bin	Lubricate auger machinery
		Nuggetizer	Lubricate, clean fan, tighten bolts
		Union Electric	Replace conveyor coupling, feeder inspection
		Receiving facility	General maintenance
		Payloader	Maintenance and motor repair
11	11	Hammermill	Drain water from oil cooler, hammer retipping
		Hammermill feed conv.	Adjustments
		ADS	Clean fan, replace inspection door seals
		Nuggetizer	Tighten bolts, clean fan
		Storage bin	Clean auger traversing tracks
		Conveyor belts	Replace seals
11	18	Hammermill	Fire in refuse collected behind discharge, hammer retipping
		ADS	Clean fan, clean pneumatic control system
		Nuggetizer	Replace anchor bolt, lubricate
		Conveyor belts	Replace coverings
		Surge bin	Remove plastic lining
		Packer truck	Repair broken oil lines
11	25	Hammermill	Hammer retipping
		Hammermill feed conv.	Bolt tightening on vibrator, seal fabrication
		ADS	Air compressor maintenance (pneumatic control system), repair scalping roll on surge bin, fan bearing replacement
		Stationary packer	Change oil, repair hook-up
		Nuggetizer	Repair inspection door

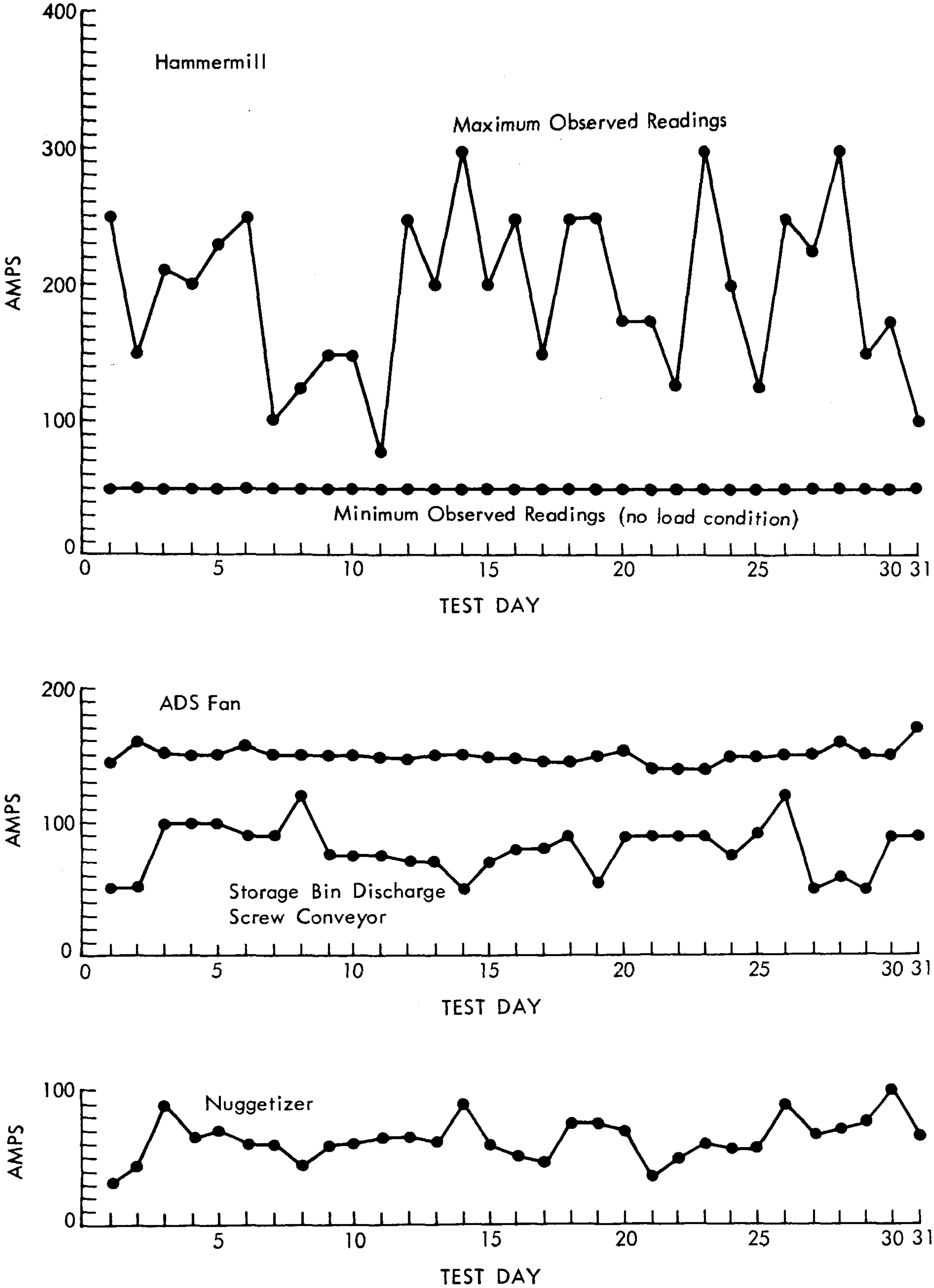


Figure 5. Daily variations in motor current.

Rated motor current is 155 amps, while the actual current varied between 50 and 300 amps. At no time did the current stay above 155 amps long enough to trip the motor overload protection circuit.

The hammermill bearings are of prime interest since a major plant shutdown had occurred before the start of the test period due to a bearing failure. Bearing skin temperature is an indication of upcoming bearing failure. Daily skin temperatures were recorded and reported in Figure 6. The bearing manufacturer considers 175°F as the maximum safe skin temperature. The highest temperature reached during the test period was 156°F. The trend is for the outboard bearing away from the motor to run a few degrees hotter. This may be because it is the newest bearing, having been replaced during the previous bearing failure, and therefore it had not worn in as much as the older bearing. Conversely, the mill rotor is directly coupled to the motor shaft and the motor bearings may be supporting a small amount of the inboard bearing load causing cooler inboard bearing temperatures.

ADS air flow rates were monitored daily by measuring the pressure drop across a fixed orifice plate. Variations in the air flow rates are a reflection of control condition changes that were made on the basis of visual observations to obtain good separation efficiencies with daily changes in refuse properties. Wet and dry bulb temperature readings were taken to determine ambient and ADS air discharge relative humidity. This information is reported in Figure 7. Relative humidity of the fan discharge was always above the ambient humidity, showing that the air stream picks up moisture from the refuse as it passes through the ADS system.

During the week of environmental testing, the relative humidity of the hammermill dust collection cyclone exhaust was found to be 100%. Therefore, there is also a moisture loss from the refuse as it passes through the hammermill. These moisture losses account in part for apparent discrepancies between material input and output weights at the processing plant.

PLANT MATERIAL FLOW AND CHARACTERIZATION

Material flow through the plant is defined by eight different flow streams. Each stream was given a number to aid in sample indentification. Table 8 presents a description of the eight material streams and the point at which they were sampled (also see Figure 1).

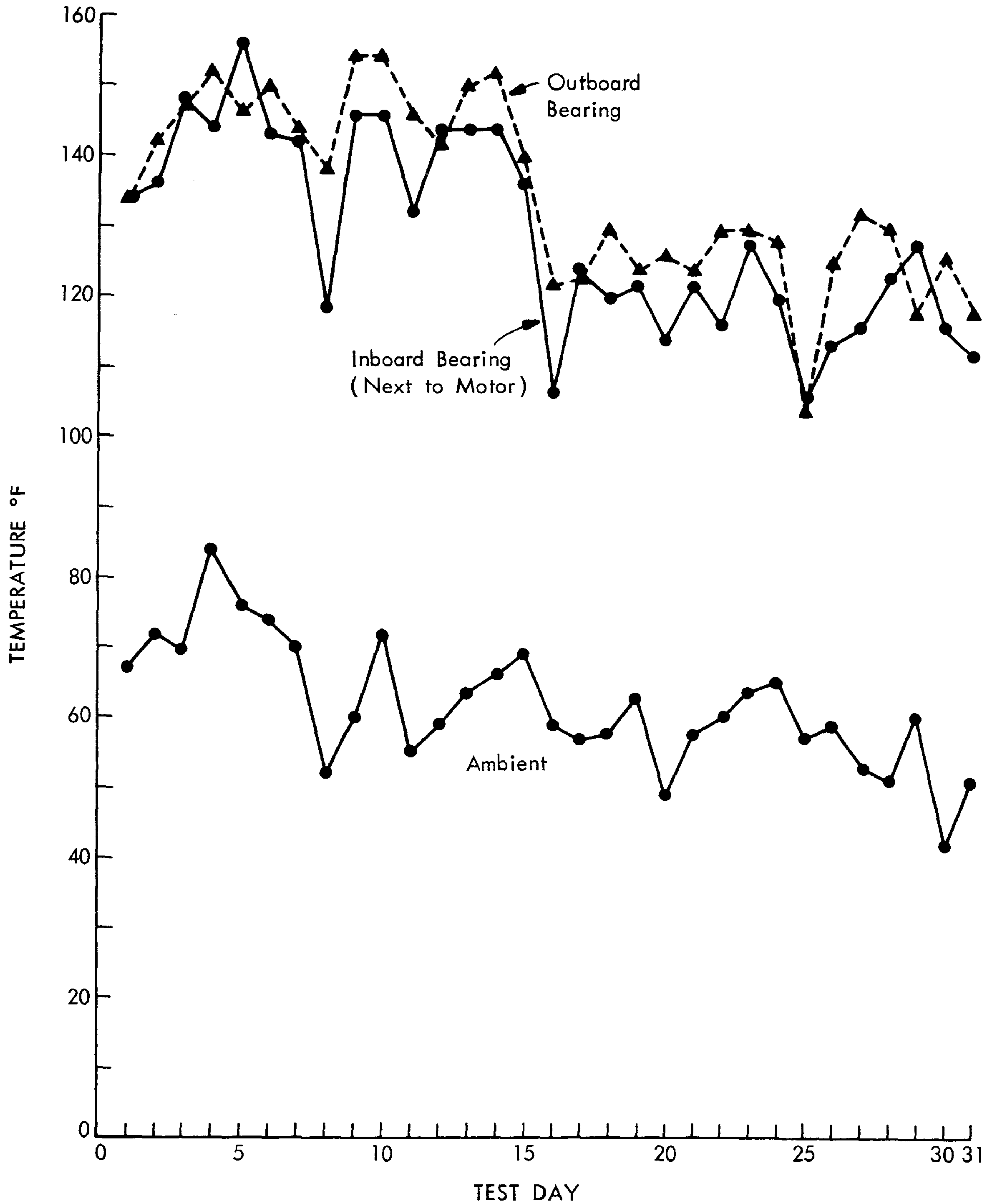


Figure 6. Daily variations in hammermill bearing skin temperatures and ambient temperatures.

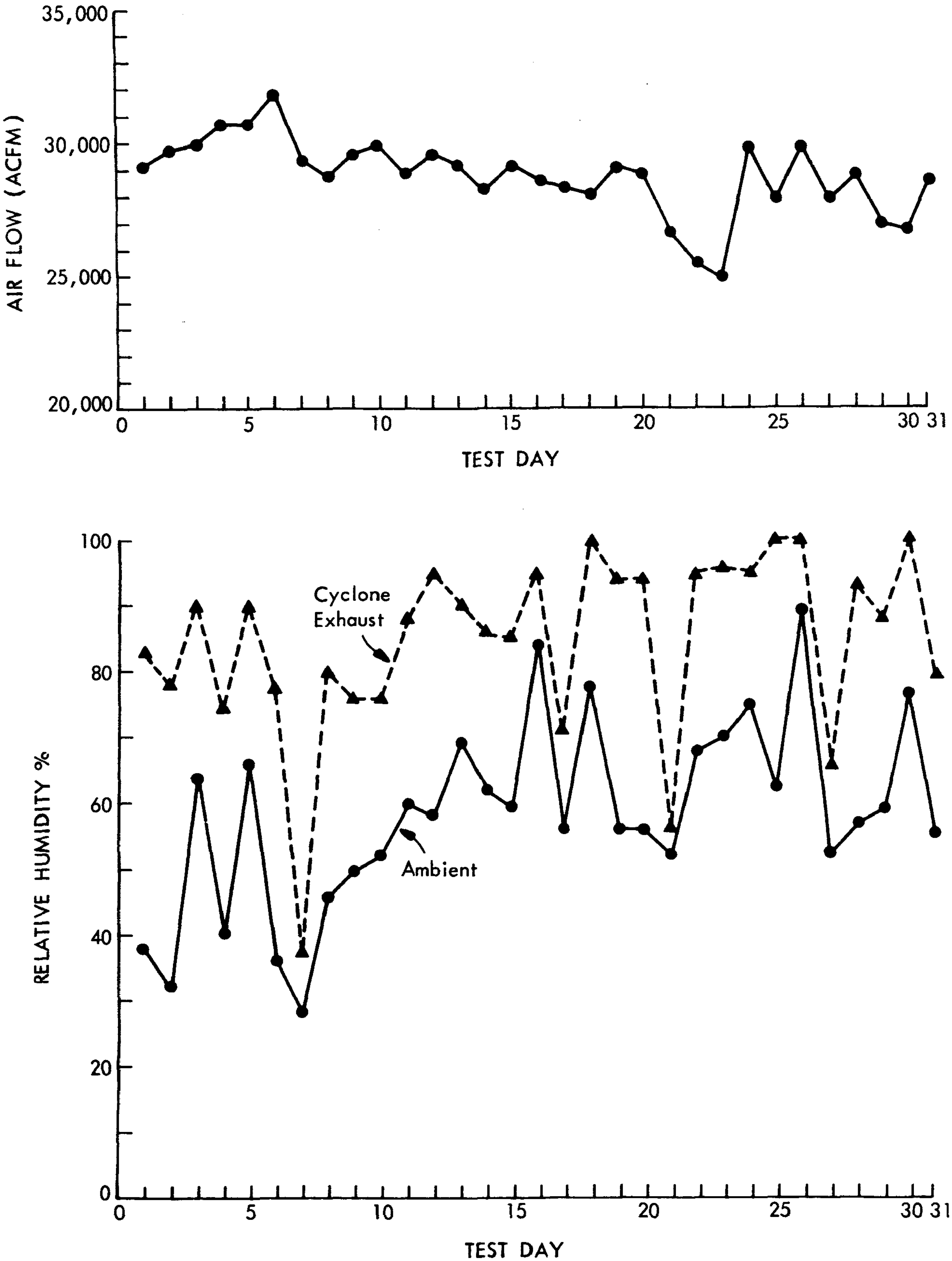


Figure 7. Daily variations in ADS cyclone exhaust air flow rate and relative humidity, and ambient relative humidity.

Table 8. PLANT FLOW STREAM DESCRIPTION

Stream	Description	Sampling point
S1 Mill discharge	Milled refuse discharge from hammermill.	Discharge of milled refuse belt conveyor into ADS surge bin.
S2 Cyclone discharge	Refuse fuel produced (ADS system lights or air flow supported portion of the air classified milled refuse)	Discharge of refuse fuel belt conveyor into storage bin.
S3 Storage bin discharge	Refuse fuel discharged from storage bin and conveyed to truck packer.	Discharge of storage bin load-out belt conveyor into packer bin.
S4 ADS heavies	That portion of the milled refuse not supported by air flow in the air density separation system.	Discharge of ADS air column onto belt conveyor.
S5 Magnetic belt rejects	That portion of S4 that cannot be magnetized and is taken to city landfill.	Discharge of material from reject hopper into receiving truck.
S6 Nuggetizer feed	That portion of S4 that can be magnetized.	Discharge of magnetic belt conveyor into nuggetizer receiving chute.
S7 Magnetic drum rejects	Product coming from the the nuggetizer that cannot be magnetized	Material in reject pile on concrete slab below magnetic drum.
S8 Ferrous metal	Steel scrap by-product sold to steel mill.	Discharge of Fe metal belt conveyor into receiving truck.

A daily record was kept of the quantity of all input/output streams for the purposes of making plant material balances. Also, as previously mentioned, samples of each stream were obtained for the purpose of characterizing these streams. Results of this work are presented in the form of weekly summaries of tonnage and stream characteristics in Tables 9a through 9h. Table 9i shows the average characteristics of the streams over the period in which streams were sampled.

The actual weight of the storage bin discharge (S3), magnetic belt rejects (S5), magnetic drum rejects (S7), and ferrous metal by-products (S8) was determined. The amount of refuse fuel produced each day (S2) was calculated from the S3 shipments and the storage and packer bins daily beginning and ending inventories.

Tables 9a through 9h list tonnages for the mill discharge (S1). However, this is actually the total of the raw refuse weights delivered to the processing plant as determined by weighing the refuse trucks. As discussed previously, the samples identified as raw refuse were taken after they had passed through the hammermill. Therefore, the S1 tonnages are for raw refuse, while the sample analysis results are for milled raw refuse. There is a difference in these two streams in that the milled refuse will have experienced a weight and moisture loss passing through the hammermill. The weight loss is due to pickup of moisture and particulates by the mill dust collection system and spillage of milled refuse. This weight loss probably does not exceed 2% of the incoming material.

For comparison purposes in Tables 9a through 9h, the nuggetizer feed (S6) was calculated as the sum of S7 + S8. ADS heavies (S4) was calculated as the sum of S6 + S5. S3 was determined by weighings of the packer trucks that transport the refuse fuel to the power plant. S2 was calculated from S3 and weekly estimates of the storage bin inventory.

Besides quantifying each process stream, Tables 9a through 9h also include weekly averages of the analysis results in order to characterize the streams. These averages were computed from the daily sample analysis results tabulated in the appendix (Tables A-3a through A-3v) except for the following:

1. Chemical analysis of metals was done on a daily basis only for weeks 23 September and 30 September 1974. Thereafter, this analysis was performed only on a weekly composite sample to reduce analysis cost.

Table 9a. SUMMARY OF PROCESSING PLANT MATERIAL FLOWS AND CHARACTERISTICS FOR WEEK OF 23 SEPTEMBER 1974

	S1 Mill discharge	S2 Cyclone discharge	S3 Storage bin discharge	S4 ADS heavies	S5 Magnetic belt rejects	S6 Nuggetizer feed	S7 Magnetic drum rejects	S8 Ferrous metal by-products
Quantity (tons)	1,529.0	1,185.6	1,160.1	193.5	115.2	78.3	1.2	77.1
Heating value (Btu/lb)[a]	4,598.9	4,920.2	4,879.8	2,566.9	2,558.8		3,003.3	2,230.7
Bulk density (lb/ft^3)	7.5	6.4	7.4	39.1	38.2	38.7	56.5	58.6
Moisture (wt %)	27.96	27.86	27.76	5.57	19.56	0.29	2.75	0.26
Composition (wt %) (Tr = trace)								
Paper	52.0	58.9	62.0	1.0	4.9	Tr	0.1	0
Plastic	8.0	3.9	6.8	0.6	3.8	0.1	0.4	0
Wood	1.5	2.1	2.1	2.6	4.3	0	1.0	0
Glass	1.3	1.5	0.7	4.1	17.6	0	0	0
Magnetic metal[b]	1.6	0.2	0.2	76.8	32.2	99.6	80.3	99.3
Other metal	0.6	0.1	0.9	3.2	3.2	0.04	15.6	0.02
Organics	2.5	3.8	0.5	4.1	11.5	0	0.1	0
Miscellaneous[c]	33.9	29.6	26.7	7.5	22.5	0.3	2.5	0.7
Chemical analysis (wt %)								
Ash	25.97	18.90	19.06					
Fe (Fe_2O_3)	5.92	1.23	1.13					
Al (Al_2O_3)	1.58	1.34	1.41					
Cu (CuO)	0.28	0.37	0.06					
Pb (PbO)	0.06	0.04	0.04					
Ni (NiO)	0.03	0.01	0.02					
Zn (ZnO)	0.27	0.07	0.09					
Visual analysis (wt %)								
Fe				10.82	4.12	10.14	15.58	15.04
Tin cans				51.71	10.37	86.46	59.27	83.62
Al				2.31	3.01	0.10	16.40	0.08
Cu				0.16	0.42	0.002	0.83	0.002
Size (inches)								
Percent larger than 2.5 in.	7.4	3.0		3.2	1.6	1.5		0
Percent less than 2.5 in.	92.6	97.0		96.8	98.4	98.5		100.0
Percent less than 1.5 in.	82.4	92.0		86.0	94.1	78.8		99.5
Percent less than 0.75 in.	59.2	71.2		19.5	64.9	8.6		63.2
Percent less than 0.375 in.	38.7	47.6		6.6	35.7	0.7		9.4
Percent less than 0.187 in.	24.2	31.3		2.1	12.1	0.4		1.0
Percent less than 0.094 in.	16.6	20.0		1.1	5.0	0.1		0.2
Particle size								
Geometric mean diameter inches	0.50	0.35		0.96	0.49	1.14		0.64
Geometric standard deviation	3.03	3.00		1.77	2.31	1.43		1.56

a/ Values shown are higher heating values and represent complete combustion of all components, including metals. Therefore, the values shown for those streams comprised mostly of metal (S4-S8), are not representative of heat that could be recovered in the utility boiler combustion process.

b/ Because the ferrous metal (and other dense components) are such a small part of some streams (e.g., S1), especially on a volume basis, considerable inaccuracies may occur in the composition analysis due to the relatively small sample volumes.

c/ Miscellaneous category is comprised of small or otherwise unidentifiable material.

Table 9b. SUMMARY OF PROCESSING PLANT MATERIAL FLOWS AND CHARACTERISTICS FOR WEEK OF 30 SEPTEMBER 1974

	S1 Mill discharge	S2 Cyclone discharge	S3 Storage bin discharge	S4 ADS heavies	S5 Magnetic belt rejects	S6 Nuggetizer feed	S7 Magnetic drum rejects	S8 Ferrous metal by-products
Quantity (tons)	1,544.1	1,195.4	1,163.0	233.2	138.2	95.0	1.2	93.8
Heating value (Btu/lb)[a]	4,646.9	4,887.1	4,844.5	2,584.3	2,750.5		3,177.3	2,223.0
Bulk density (lb/ft^3)	8.4	7.0	8.8	38.0	37.2	38.8	57.2	59.1
Moisture (wt %)	26.68	26.30	26.94	4.10	13.84	0.33	0.34	0.12
Composition (wt %) (Tr = trace)								
Paper	67.4	59.5	64.6	2.0	4.6	0.1	Tr	0
Plastic	4.2	5.9	6.1	1.2	2.3	Tr	0.2	0
Wood	2.7	2.0	2.6	2.9	11.2	0	0.3	0
Glass	3.2	1.1	1.2	9.0	14.5	0	0	0
Magnetic metal[b]	2.2	0.3	0.04	62.1	28.2	99.9	86.5	98.8
Other metals	0.4	0.5	0.3	4.4	10.2	0	12.7	0.1
Organics	1.7	1.8	0.6	10.9	16.2	0	0.2	0
Miscellaneous[c]	18.6	29.1	24.1	8.3	17.8	Tr	0.04	1.1
Chemical analysis (wt %)								
Ash	22.91	19.87	19.32					
Fe (Fe_2O_3)	4.66	1.22	1.15					
Al (Al_2O_3)	1.83	1.70	1.65					
Cu (CuO)	0.04	0.03	0.04					
Pb (PbO)	0.05	0.09	0.05					
Ni (NiO)	0.06	0.06	0.02					
Zn (ZnO)	0.15	0.12	0.08					
Visual Analysis (wt %)								
Fe				7.87	3.02	14.01	13.58	14.60
Tin cans				48.30	19.03	83.89	66.31	84.59
Al				2.29	4.18	0.004	15.90	0.07
Cu				0.43	0.60	0	0.66	0.06
Size (inches)								
Percent larger than 2.5 in.	0	0		0	0.6	0.5		0.1
Percent less than 2.5 in.	100.0	100.0		100.0	99.4	99.5		99.9
Percent less than 1.5 in.	97.0	98.7		96.0	90.6	82.3		99.7
Percent less than 0.75 in.	72.1	83.2		30.7	58.1	13.4		54.6
Percent less than 0.375 in.	45.1	58.6		12.2	29.2	1.3		7.7
Percent less than 0.187 in.	23.7	38.3		3.9	10.2	0.4		0.5
Percent less than 0.094 in.	11.6	24.5		1.7	4.0	0.2		0.2
Particle size								
Geometric mean diameter inches	0.39	0.26		0.77	0.56	1.07		0.69
Geometric standard deviation	2.49	2.69		1.86	2.27	1.48		1.57

a/ Values shown are higher heating values and represent complete combustion of all components, including metals. Therefore, the values shown for those streams comprised mostly of metal (S4-S8), are not representative of heat that could be recovered in the utility boiler combustion process.

b/ Because the ferrous metal (and other dense components) are such a small part of some streams (e.g., S1), especially on a volume basis, considerable inaccuracies may occur in the composition analysis due to the relatively small sample volumes.

c/ Miscellaneous category is comprised of small or otherwise unidentifiable material.

Table 9c. SUMMARY OF PROCESSING PLANT MATERIAL FLOWS AND CHARACTERISTICS FOR WEEK OF 7 OCTOBER 1974

	S1 Mill discharge	S2 Cyclone discharge	S3 Storage bin discharge	S5 Magnetic belt rejects	S7 Magnetic drum rejects	S8 Ferrous metal by-products
Quantity (tons)	903.3	719.1	761.7	72.5	1.1	58.1
Heating value (Btu/lb)[a]	5,420.9	5,557.1		2,391.3		2,274.9
Bulk density (lb/ft^3)	7.0	5.6		36.0		62.0
Moisture (wt %)	17.34	18.70		12.00		0.09
Composition (wt %) (Tr = trace)						
Paper	49.9	57.6		6.6		Tr
Plastic	7.4	5.7		6.5		0.04
Wood	2.1	3.3		8.2		0
Glass	4.2	2.5		18.5		0
Magnetic metal[b]	3.9	0.8		15.9		99.7
Other metals	0.3	1.1		7.5		0.1
Organics	3.2	1.2		16.7		0
Miscellaneous[c]	29.1	27.9		20.2		0.02
Chemical analysis (wt %)						
Ash	21.94	20.64				
Fe (Fe_2O_3)	1.60	0.88				
Al (Al_2O_3)	1.41	1.78				
Cu (CuO)	0.05	0.02				
Pb (PbO)	0.10	0.09				
Ni (NiO)	0.02	0.02				
Zn (ZnO)	0.08	0.09				
Visual analysis (wt %)						
Fe				4.35		12.33
Tin cans				10.85		87.94
Al				1.97		0.08
Cu				2.32		0.03
Size (inches)						
Percent larger than 2.5 in.	0.6	0.2		2.2		0
Percent less than 2.5 in.	99.4	99.8		97.8		100.0
Percent less than 1.5 in.	96.4	96.7		97.8		98.9
Percent less than 0.75 in.	71.6	78.0		71.3		50.8
Percent less than 0.375 in.	45.8	53.3		41.7		8.8
Percent less than 0.187 in.	28.2	34.2		16.2		0.8
Percent less than 0.094 in.	18.1	23.4		6.9		0.2
Particle size						
Geometric mean diameter inches	0.36	0.29		0.42		0.71
Geometric standard deviation	2.77	2.84		2.34		1.60

a/ Values shown are higher heating values and represent complete combustion of all components, including metals. Therefore, the values shown for those streams comprised mostly of metal (S4-S8), are not representative of heat that could be recovered in the utility boiler combustion process.

b/ Because the ferrous metal (and other dense components) are such a small part of some streams (e.g., S1), especially on a volume basis, considerable inaccuracies may occur in the composition analysis due to the relatively small sample volumes.

c/ Miscellaneous category is comprised of small or otherwise unidentifiable material.

Table 9d. SUMMARY OF PROCESSING PLANT MATERIAL FLOWS AND CHARACTERISTICS FOR WEEK OF 14 OCTOBER 1974

	S1 Mill discharge	S2 Cyclone separator bottoms	S3 Storage bin discharge	S5 Magnetic belt rejects	S7 Magnetic drum rejects	S8 Ferrous metal by-products
Quantity (tons)	777.2	586.2	572.1	60.7	1.0	38.3
Heating value (Btu/lb)[a]	4,612.2	4,838.1		2,508.1		2,235.0
Bulk density (lb/ft^3)	8.7	6.7		31.2		61.3
Moisture (wt %)	25.80	28.98		16.78		0.14
Composition (wt %)						
Paper	51.6	53.5		12.5		0
Plastic	2.3	5.5		3.2		0
Wood	5.4	3.4		14.4		0
Glass	2.9	1.2		12.3		0
Magnetic metal[b]	7.1	0		21.5		99.7
Other metals	0.2	0.6		2.1		0.1
Organics	3.1	6.6		12.2		0
Miscellaneous[c]	26.1	29.1		23.0		0.2
Chemical analysis (wt %)						
Ash	22.19	16.25				
Fe (Fe_2O_3)	0.73	0.59				
Al (Al_2O_3)	1.53	1.21				
Cu (CuO)	0.03	0.02				
Pb (PbO)	0.04	0.04				
Ni (NiO)	0.02	0.02				
Zn (ZnO)	0.05	0.05				
Visual analysis (wt %)						
Fe				1.66		10.49
Tin cans				9.54		87.88
Al				2.52		0.08
Cu				0.85		0
Size (inches)						
Percent larger than 2.5 in.	0	0		0		0
Percent less than 2.5 in.	100.0	100.0		100.0		100.0
Percent less than 1.5 in.	98.1	98.5		98.0		100.0
Percent less than 0.75 in.	78.0	81.9		79.9		49.8
Percent less than 0.375 in.	54.2	57.6		38.4		7.8
Percent less than 0.187 in.	33.1	36.9		13.6		0.5
Percent less than 0.094 in.	20.0	23.0		5.5		0.2
Particle size						
Geometric mean diameter inches	0.30	0.27		0.42		0.71
Geometric standard deviation	2.70	2.71		2.06		1.56

a/ Values shown are higher heating values and represent complete combustion of all components, including metals. Therefore, the values shown for those streams comprised mostly of metal (S4-S8), are not representative of heat that could be recovered in the utility boiler combustion process.

b/ Because the ferrous metal (and other dense components) are such a small part of some streams (e.g., S1), especially on a volume basis, considerable inaccuracies may occur in the composition analysis due to the relatively small sample volumes.

c/ Miscellaneous category is comprised of small or otherwise unidentifiable material.

Table 9e. SUMMARY OF PROCESSING PLANT MATERIAL FLOWS AND CHARACTERISTICS FOR WEEK OF 21 OCTOBER 1974

	S1 Mill discharge	S2 Cyclone separator bottoms	S3 Storage bin discharge	S5 Magnetic belt rejects	S7 Magnetic drum rejects	S8 Ferrous metal by-products
Quantity (tons)	776.4	625.0	640.0	67.7	1.2	37.2
Heating value (Btu/lb)[a/]	4,959.1	5,312.4		3,174.6		2,232.1
Bulk density (lb/ft^3)	6.7	5.9		31.6		63.0
Moisture (wt %)	18.96	20.60		13.02		0.71
Composition (wt %)						
Paper	48.1	57.8		7.9		0
Plastic	6.6	4.0		4.5		0.1
Wood	2.2	3.1		4.8		0
Glass	3.7	1.4		15.2		0
Magnetic metal[b/]	3.2	0.4		13.0		99.6
Other metals	0.4	0.7		6.5		0.04
Organics	4.3	3.8		27.2		0
Miscellaneous[c/]	31.6	28.7		20.8		0.3
Chemical analysis (wt %)						
Ash	23.90	18.70				
Fe (Fe_2O_3)	0.49	0.52				
Al (Al_2O_3)	1.36	1.42				
Cu (CuO)	0.01	0.01				
Pb (PbO)	0.04	0.07				
Ni (NiO)	0.01	0.02				
Zn (ZnO)	0.05	0.06				
Visual analysis (wt %)						
Fe				5.36		13.66
Tin cans				11.91		85.04
Al				18.07		0.08
Cu				3.23		0.006
Size (inches)						
Percent larger than 2.5 in.	0	0		5.9		0
Percent less than 2.5 in.	100.0	100.0		94.1		100.0
Percent less than 1.5 in.	97.4	96.6		93.4		99.4
Percent less than 0.75 in.	72.8	73.3		61.2		57.1
Percent less than 0.375 in.	47.1	47.2		32.0		7.9
Percent less than 0.187 in.	30.3	30.7		12.2		0.8
Percent less than 0.094 in.	16.1	21.8		5.3		0.1
Particle size						
Geometric mean diameter inches	0.33	0.33		0.53		0.68
Geometric standard deviation	2.81	2.87		2.38		1.57

a/ Values shown are higher heating values and represent complete combustion of all components, including metals. Therefore, the values shown for those streams comprised mostly of metal (S4-S8), are not representative of heat that could be recovered in the utility boiler combustion process.

b/ Because the ferrous metal (and other dense components) are such a small part of some streams (e.g., S1), especially on a volume basis, considerable inaccuracies may occur in the composition analysis due to the relatively small sample volumes.

c/ Miscellaneous category is comprised of small or otherwise unidentifiable material.

Table 9f. SUMMARY OF PROCESSING PLANT MATERIAL FLOWS AND CHARACTERISTICS FOR WEEK OF 18 NOVEMBER 1974

	S1 Mill discharge	S2 Cyclone discharge	S3 Storage bin discharge	S5 Magnetic belt rejects	S7 Magnetic drum rejects	S8 Ferrous metal by-products
Quantity (tons)	1,064.8	898.7	922.1	83.5	1.2	54.9
Heating value (Btu/lb)[a/]	5,216.8	5,189.5		2,145.3	2,796.4	2,235.9
Bulk density (lb/ft^3)	6.1	4.7		39.3	62.9	60.9
Moisture (wt %)	18.24	21.84		14.84	0.21	0.09
Composition (wt %) (Tr = trace)						
Paper	55.9	65.2		4.0	0	Tr
Plastic	5.0	7.2		3.8	0.7	Tr
Wood	5.8	2.1		6.4	0.4	0
Glass	1.8	0.5		23.3	0	0
Magnetic metal [b/]	5.2	0		3.9	89.8	99.8
Other metals	0.4	0.4		3.5	9.0	0.1
Organics	1.3	2.6		31.8	0	0
Miscellaneous [c/]	24.6	22.1		23.3	0.1	0.1
Chemical analysis (wt %)						
Ash	22.40	17.46				
Fe (Fe_2O_3)	2.03	0.53				
Al (Al_2O_3)	1.05	1.46				
Cu (CuO)	0.02	0.01				
Pb (PbO)	0.03	0.05				
Ni (NiO)	0.01	0.02				
Zn (ZnO)	0.04	0.07				
Visual analysis (wt %)						
Fe				2.00	12.89	12.15
Tin cans				6.87	72.96	68.64
Al				4.06	11.59	0.60
Cu				0.18	0.36	0.04
Size (inches)						
Percent larger than 2.5 in.	0	1.9		0.9		0
Percent less than 2.5 in.	100.0	98.1		99.1		100.0
Percent less than 1.5 in.	97.2	92.4		94.9		97.3
Percent less than 0.75 in.	70.0	65.6		67.7		48.5
Percent less than 0.375 in.	42.3	39.7		34.9		5.8
Percent less than 0.187 in.	24.3	24.0		11.9		0.5
Percent less than 0.094 in.	17.0	16.3		4.5		0.2
Particle size						
Geometric mean diameter inch	0.38	0.41		0.49		0.74
Geometric standard deviation	2.69	2.87		2.23		1.58

a/ Values shown are higher heating values and represent complete combustion of all components, including metals. Therefore, the values shown for those streams comprised mostly of metal (S4-S8), are not representative of heat that could be recovered in the utility boiler combustion process.

b/ Because the ferrous metal (and other dense components) are such a small part of some streams (e.g., S1), especially on a volume basis, considerable inaccuracies may occur in the composition analysis due to the relatively small sample volumes.

c/ Miscellaneous category is comprised of small or otherwise unidentifiable material.

Table 9g. SUMMARY OF PROCESSING PLANT MATERIAL FLOWS AND CHARACTERISTICS FOR WEEK OF 25 NOVEMBER 1974

	S1 Mill discharge	S2 Cyclone discharge	S3 Storage bin discharge	S5 Magnetic belt rejects	S7 Magnetic drum rejects	S8 Ferrous metal by-products
Quantity (tons)	463.0	347.9	333.7	35.1	0.6	22.9
Heating value (Btu/lb)[a]	5,063.5	5,541.7		3,461.0	2,774.7	2,235.7
Bulk density (lb/ft^3)	6.0	5.2		34.7	62.1	61.7
Moisture (wt %)	20.20	17.40		14.90	0.26	0.08
Composition (wt %)						
Paper	74.5	59.8		7.0	0	0
Plastic	10.6	4.7		2.7	0.5	0
Wood	2.7	2.2		10.3	0	0
Glass	2.7	3.2		27.8	0	0
Magnetic metal[b]	3.2	0		19.6	91.7	99.9
Other metals	0.9	0.5		0.5	7.8	0.1
Organics	0.3	0.2		27.0	0	0
Miscellaneous[c]	5.1	16.8		5.1	0	0
Chemical analysis (wt %)						
Ash	19.31	22.30				
Fe (Fe_2O_3)	0.91	1.12				
Al (Al_2O_3)	1.20	1.40				
Cu (CuO)	0.04	0.02				
Pb (PbO)	0.03	0.04				
Ni (NiO)	0.02	0.02				
Zn (ZnO)	0.06	0.06				
Visual analysis (wt %)						
Fe				0.68	8.98	9.99
Tin cans				5.28	77.80	88.93
Al				2.89	10.97	0.20
Cu				0.17	0.50	0
Size (inches)						
Percent larger than 2.5 in.	8.2	12.5		6.8		0
Percent less than 2.5 in.	91.8	87.5		93.2		100.0
Percent less than 1.5 in.	90.7	83.3		87.3		96.9
Percent less than 0.75 in.	75.6	61.1		63.7		59.9
Percent less than 0.375 in.	44.2	38.9		37.2		11.4
Percent less than 0.187 in.	24.4	27.8		14.0		1.0
Percent less than 0.094 in.	16.3	19.4		5.3		0.2
Particle size						
Geometric mean diameter inch	0.38	0.44		0.51		0.65
Geometric standard deviation	2.93	3.45		2.58		1.67

a/ Values shown are higher heating values and represent complete combustion of all components, including metals. Therefore, the values shown for those streams comprised mostly of metal (S4-S8), are not representative of heat that could be recovered in the utility boiler combustion process.

b/ Because the ferrous metal (and other dense components) are such a small part of some streams (e.g., S1), especially on a volume basis, considerable inaccuracies may occur in the composition analysis due to the relatively small sample volumes.

c/ Miscellaneous category is comprised of small or otherwise unidentifiable material.

Table 9h. SUMMARY OF PROCESSING PLANT MATERIAL FLOWS DURING 3-WEEK PERIOD WHEN REFUSE SAMPLES WERE NOT TAKEN

Week of 1974		Weekly totals - Quantity tons				
		Stream				
		S1	S2	S3	S5	S8
Month	Day	Raw refuse to mill	Cyclone separator bottoms	Storage bin discharge	Magnetic belt rejects	Ferrous metal by-product
10	28	292.9	245.4	287.9	21.3	15.0
11	4	Plant not operating				
11	11	464.7	393.8	313.7	38.2	25.1

Table 9i. AVERAGE CHARACTERISTICS OF STREAMS OVER DURATION OF SAMPLING

	S1 Mill discharge	S2 Cyclone discharge	S3 Storage bin discharge	S4 ADS heavies	S5 Magnetic belt rejects	S6 Nuggetizer feed	S7 Magnetic drum rejects	S8 Ferrous metal by-products
Heating value (Btu/lb)	5,008.3	5,178.0	4,862.2	2,575.6	2,712.8	-	2,937.9	2,238.2
Bulk density (lb/ft^3)	7.2	5.9	8.1	38.6	35.5	38.8	59.7	60.9
Moisture (wt %)	22.17	23.10	28.85	4.84	14.99	0.31	0.89	0.21
Composition (wt %)								
Paper	57.1	58.9	63.3	1.5	6.8	0.05	0.14	0
Plastic	6.3	5.4	6.5	0.9	3.8	0.05	0.5	0.02
Wood	3.2	2.6	2.4	2.8	8.5	0	0.4	0
Glass	2.8	1.6	1.0	6.6	18.5	0	0	0
Magnetic metal	3.8	0.2	0.1	69.4	19.2	99.8	87.1	99.5
Other metal	0.5	0.6	0.6	3.8	4.8	0.02	11.3	0.08
Organics	2.3	2.9	0.6	7.5	20.4	0	0.1	0
Miscellaneous	24.1	26.2	25.4	7.9	19.0	0.2	0.7	0.3
Chemical analysis (wt %)								
Ash	22.66	19.16	19.19					
Fe (Fe_2O_3)	2.33	0.87	11.14					
Al (Al_2O_3)	1.42	1.47	1.53					
Cu (CuO)	0.07	0.07	0.05					
Pb (PbO)	0.05	0.06	0.05					
Ni (NiO)	0.02	0.02	0.02					
Zn (ZnO)	0.10	0.07	0.09					
Visual analysis (wt %)								
Fe				9.35	3.03	12.08	12.78	12.69
Tin cans				50.01	10.55	85.18	69.09	83.81
Al				2.30	5.24	0.05	13.72	0.17
Cu				0.30	1.11	0.001	0.59	0.02
Size (inches)								
Percent larger than 2.5 in.	2.3	2.5		1.6	2.6	1.0		0
Percent less than 2.5 in.	97.7	97.5		98.4	97.4	99.0		100.0
Percent less than 1.5 in.	94.2	94.0		91.0	93.7	80.6		98.8
Percent less than 0.75 in.	71.3	73.5		25.1	66.7	11.0		54.8
Percent less than 0.375 in.	45.3	49.0		9.4	35.6	1.0		8.4
Percent less than 0.187 in.	26.9	31.9		3.0	12.9	0.4		0.7
Percent less than 0.094 in.	16.5	21.2		1.4	5.2	0.2		0.2
Particle size								
Geometric mean diameter (inches)	0.38	0.34		0.87	0.49	1.11		0.69
Geometric standard deviation	2.77	2.92		1.82	2.31	1.46		1.59

2. All analysis for the week of 25 November 1974 was performed on a weekly composite sample. This data is recorded directly in Table 9g and there is no appendix table for this week.

The ADS heavies (Stream S4) and the various metal streams (Streams S4, S6, S7, S8) contained too high a metal content to make chemical analysis practical. Therefore, these samples were analyzed visually for metal content. The magnetic portion was separated into tin cans and ferrous metal. Tin cans are magnetic but contain metals other than ferrous.

The screen size distribution is reported in detail. However, to make comparisons easier, the geometric mean diameter and the geometric standard deviation were calculated and reported in Appendix Tables A-3v and A-3w. These two parameters are a standard method adopted by the American Society of Agriculture Engineers, Standard ASAE S319, for expressing the fineness of ground materials. This method assumes a straight line logarithmic distribution of particle size. The geometric mean diameter is the size at which half the particles are larger than, and half the particles are smaller than, the mean. The geometric standard deviation is the dispersion about the mean. A value close to one means a small dispersion, while a large value indicates that particles are widely distributed over a large size range.

An analysis of the geometric mean diameter data shows that the refuse fuel (S2) has a slightly smaller mean diameter than the mill discharge (S1). The ADS heavies (S4) contain the larger particles in the material being fed to the ADS system. Also, as would be expected, the nuggetizer feed (S6) has a larger mean diameter than the ferrous metal product (S8). An analysis of the geometric standard deviation data shows that the metal streams have a smaller dispersion about the mean than the milled raw refuse or the refuse fuel.

Plant material flow results given in Tables 9a through 9h, in conjunction with calculated weighted average heating values and percent magnetic metal, were utilized to compute weekly mass and energy balances as well as ferrous metal recovery efficiencies. Weighted averages, instead of the straight arithmetic averages reported in Tables 9a through 9h, were used to take into account the daily tonnage variations. This was done so that the energy balance and ferrous metal recovery computations would be as accurate as possible. Weighted averages are shown in Appendix Tables A-4a and A-4b. Results of the mass and energy balances on a percentage basis are tabulated in Table 10 and plotted in Figure 8.

Figure 8 reflects the fact that the refuse fuel is higher in heating value (Btu/lb) than the raw refuse, and therefore the refuse fuel represents a

Table 10. WEEKLY SUMMARY OF PLANT MATERIAL AND ENERGY BALANCE

	No.	Week of 1974 Month	Week of 1974 Day	S1 Mill discharge	S2 Cyclone discharge	S5 Magnetic belt rejects	S7 Magnetic drum rejects	S8 Ferrous metal	Error in balance
Weight, expressed as % of S1	1	9	23	100	77.54	7.54	0.08	5.04	9.80
	2	9	30	100	77.42	8.95	0.08	6.07	7.48
	3	10	7	100	79.61	8.03	0.12	6.43	5.81
	4	10	14	100	75.42	7.81	0.13	4.93	11.71
	5	10	21	100	80.50	8.73	0.15	4.79	5.83
	6	10	28	100	83.78	7.27	b/	5.12	3.83
	8	11	11	100	84.74	8.22	b/	5.40	1.64
	9	11	18	100	84.40	7.84	0.11	5.16	2.49
	10	11	25	100	75.14	7.58	0.13	4.95	12.20
	Average				79.84	8.00	0.11	5.32	6.75
Energy, expressed as % of S1 a/	1	9	23	100	82.95	4.24	0.05	2.45	10.31
	2	9	30	100	81.52	5.27	0.05	2.91	10.25
	3	10	7	100	81.21	3.44	c/	2.71	12.64
	4	10	14	100	78.98	4.26	c/	2.40	14.36
	5	10	21	100	85.76	5.77	c/	2.14	6.33
	9	11	18	100	83.31	3.22	0.07	2.18	11.22
	10	11	25	100	82.23	5.18	0.07	2.18	10.34
	Average				82.28	4.48	0.06	2.42	10.78

a/ Based on data presented in Appendix A (Table A-4a).

b/ Magnetic drum rejects not weighed. Calculated weight loss therefore includes magnetic drum rejects.

c/ Heating valve of magnetic drum rejects was not determined. Calculated energy loss therefore includes magnetic drum rejects.

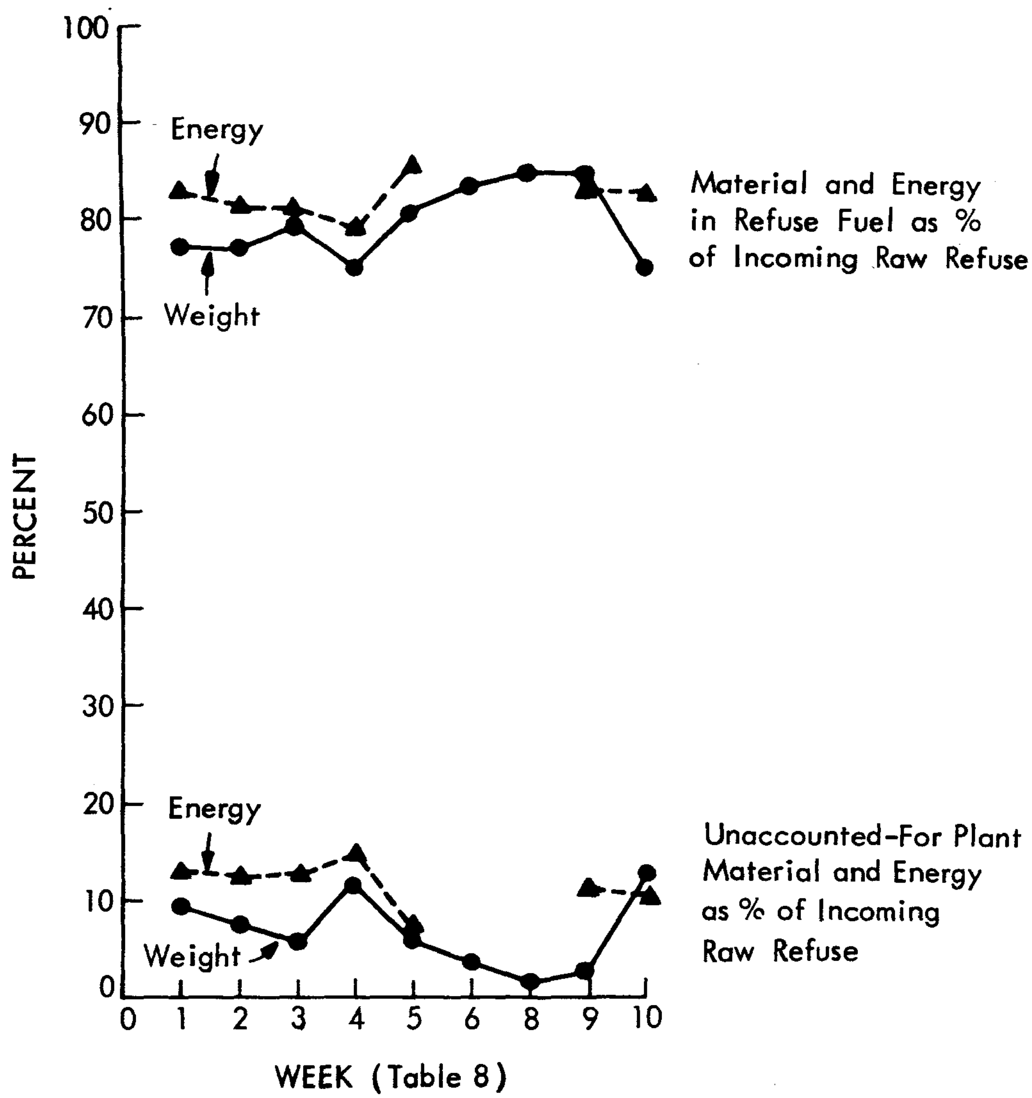


Figure 8. Daily variations in material and energy recovery.

higher percent recovery from the raw refuse on an energy basis than on a weight basis; i.e., the heavy fraction from the ADS is mainly dense non-combustible materials.

The curves in Figure 8 and the data in Table 10 show that there was always considerable error in mass and, consequently, energy balances. That is, the amount of plant product (S2, S5, S7, and S8) never equaled the amount of incoming raw refuse (S1). Energy balances are calculated by multiplying the weight of material at the various input and output points by the corresponding higher heating values of the materials as determined by sample analysis. Errors in the mass balance therefore result in energy balance errors. There are four possible sources of these errors:

1. Particulate and moisture lost through the hammermill dust collection system (S1 weights were determined by weighing raw refuse, prior to shredding).

2. Particulate matter and moisture carried away by the ADS air.

3. Spillage from equipment.

4. Possible scale errors in weighing trucks.

Emission test data have shown that the maximum particulates and moisture losses from the hammermill and ADS system could only account for about 1.5% of the apparent weight loss. Observation of equipment spillage indicates that this would not likely account for much of the loss. Therefore, scale errors would seem the most likely reason for the material imbalance errors.

It is important to note that of all the various categories of trucks weighed, the semitrucks (tractor-trailer units) used for refuse fuel shipments are too long to fit on the plant truck scale. These trucks are weighed by weighing separately each of the three axles (two for the tractor, one for the trailer). The three weights are summed and a correction factor applied to yield total weight. At this point we assume that much of the material loss could be attributed to errors in weighing these trucks. In future tests we plan to investigate this by weighing some of the refuse fuel trucks on a full-length truck scale.

Data from Tables 9a through 9h and Appendix Table A-4b were also used to compute ferrous metal recovery efficiency as shown in Table 11. This tabulation shows considerable variability in the recovery of ferrous metal from week to week and indicates that a considerable amount of Fe metal is being lost in the magnetic belt reject stream. It may be possible to

Table 11. WEEKLY SUMMARY OF PLANT FERROUS METAL RECOVERY a/

Week of 1974		Tons of magnetic metal					
Month	Day	S2 Cyclone separator discharge	S5 Magnetic belt rejects	S7 Magnetic drums rejects	S8 Ferrous metal stream	Total	Ferrous metal recovered (%)
9	23	3.56	37.95	0.93	76.25	118.69	64.2
9	30	2.39	41.99	1.04	92.67	138.09	67.7
10	7	7.19	13.32	0.91 b/	57.87	79.29	73.0
10	14	0	12.69	0.90 b/	38.18	51.77	73.7
10	21	2.5	8.75	1.01 b/	36.27	48.53	74.7
11	18	0	4.01	1.04	54.79	59.84	91.6
11	25 c/	0	6.00	0.53	22.88	29.41	77.8

a/ Based on data presented in Appendix A (Table A-4b).

b/ Assumes 86.3% magnetic material.

c/ Weekly composite.

improve magnetic belt efficiency by adjusting belt spacing. However, it has been necessary to purposely set the belt spacing for lower recovery in order to avoid overloading the nuggetizer.

In characterizing the streams, as tabulated in Tables 9a through 9h, the refuse fuel stream samples were also used to determine proximate and ultimate analysis. Weekly summaries of these analyses results were computed, as shown in Table 12, based on data from the appendix. Table 12 includes similar data, for comparison purposes, on Orient 6 coal used at the Union Electric power plant. This comparison shows that the refuse fuel is lower or higher than the coal on a weight basis as follows:

Lower	Higher
Heating value	Moisture
Volatile matter	Ash
Fixed carbon	Oxygen
Carbon	
Hydrogen	
Sulfur	
Nitrogen	

The largest difference is sulfur. The refuse fuel contained only slightly more than one-tenth the sulfur content of Orient 6 coal during the test period shown in Table 12. The heating value of refuse fuel is 45% of the coal heating value.

Data on moisture and heating values of the refuse fuel, from Table 12, have also been plotted in Figure 9 and show an expected, but important, relationship of increasing refuse fuel heating value with decreasing moisture content. Statistical analysis of the data showed 85% correlation between heating value and moisture. The best fit curve equation is a linear function, indicating that heating value is relatively constant on a dry matter basis. As stated before, all sample results including heating values are reported on a sample as received basis. Comparison of refuse fuel heating value to the heating values of other fuels will depend in part upon the moisture content of the refuse fuel.

STATISTICAL EVALUATION OF PROCESS STREAM SAMPLES

It was realized that the sampling methodology for characterizing the process streams might involve considerable error and not yield representative results. Therefore, a statistical evaluation of certain data was performed. The methods used to perform these statistical evaluations and the results are discussed in the follwoing paragraphs.

Table 12. WEEKLY SUMMARY OF PROXIMATE AND ULTIMATE ANALYSIS OF REFUSE FUEL PRODUCED

Date 1974 Week of Month	Day	Heating Value (Btu/lb)	Moisture	Ash	Volatile matter	Fixed carbon	Carbon	Hydrogen	Oxygen (by difference)	Sulfur	Nitrogen
		Received moisture basis - weekly average									
			Percent by weight								
		Stream S3 - Storage bin discharge									
9	23	4,879.8	27.76	19.06	26.10	7.17	27.74	3.79	1.47	0.20	0.61
9	30	4,844.5	26.94	19.32	27.71	6.73	26.35	3.72	3.63	0.15	0.55
		Stream S2 - Cyclone discharge									
9	23	4,920.2	27.86	18.90	26.93	6.48	27.07	4.39	1.87	0.23	0.59
9	30	4,887.1	26.30	19.87	27.71	7.84	26.58	3.76	3.82	0.19	0.53
10	7	5,557.1	18.70	21.94	29.60	15.97	22.88	4.05	11.92	0.17	0.63
10	14	4,838.1	28.98	22.19	24.62	9.64	26.62	3.59	3.51	0.14	0.54
10	21	5,312.4	20.60	23.90	28.81	15.67	29.58	3.99	10.17	0.14	0.60
11	18	5,189.5	21.84	17.46	34.81	9.11	30.17	4.62	8.45	0.17	0.51
11	25	5,541.7	17.40	22.30	36.39	9.54	30.65	6.72	7.81	0.17	0.59
7 week avg. of Stream S2		5,178.0	23.10	20.94	29.84	10.61	27.65	4.45	6.79	0.17	0.57
Avg of 21 Orient 6 coal samples 10-31-74 through 11-7-74		11,579.4	12.49	7.61	32.88	46.78	66.08	5.29	5.78	1.57	1.45

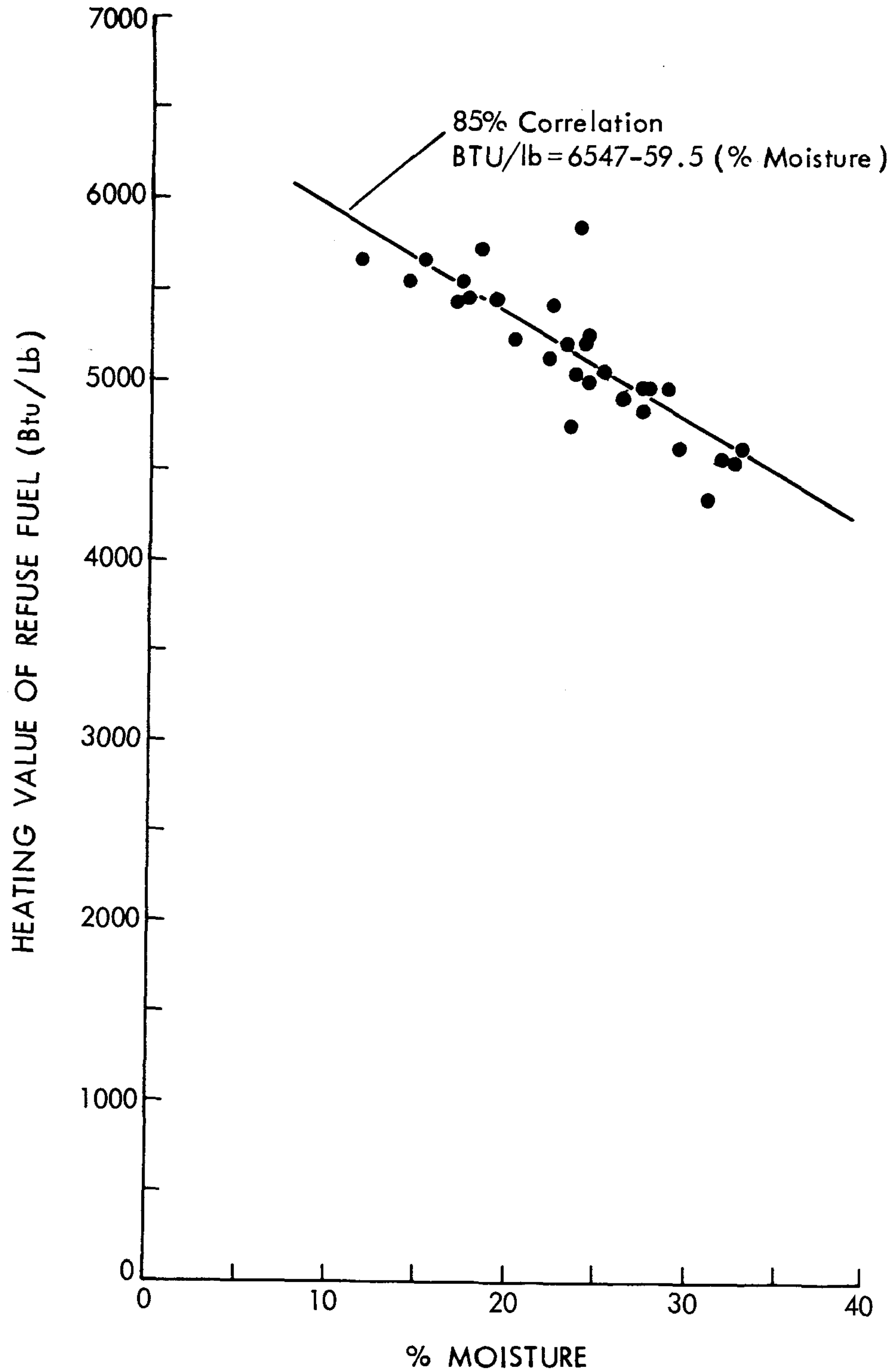


Figure 9. Heating value of refuse fuel versus moisture content for daily samples.

Statistical Difference Between Refuse Fuel Entering and Leaving the Storage Bin

The daily sample analysis results on Streams S2 and S3, taken during the 10-day period 23 September through 4 October 1974, were subjected to statistical analysis.

At 95% statistical confidence coefficient, there was no significant difference between S2 and S3 for any of the sample spectrums except bulk density. Logically, it would not be surprising to find that bulk density is higher in the storage bin discharge, due to the bin packing factor. Weight of material in the bin causes material compaction at the lower bin elevations. Since the bin was designed to discharge the material at the bin bottom, this discharge material is always more compressed and has a higher bulk density (lb/ft^3), than the material entering the bin.

Sample Variability

Two tests were performed to determine sample variance. First, eight subsamples evenly spaced over a 2-hr period were taken of the milled raw refuse (S1) and the cyclone discharge (S2). Second, eight subsamples evenly spaced over a 1-hr period were taken of the refuse fuel entering the storage bin (S2) and leaving the storage bin (S3). Each individual subsample was analyzed. The individual results are shown in Appendix Table A-5.

The sample results were subjected to statistical analysis. It was determined that there was no significant difference in sample variability between samples taken over a 1-hr interval and those taken over a 2-hr interval. Short-term time trends that may be present do not effect the variability or dispersion of the sample data.

Daily samples of the various plant refuse streams were composed of four subsamples taken at 2-hr intervals which were composited to form one daily sample that was inspected and analyzed. Daily sample results are therefore the mean of four subsamples. The precision of such a mean can be calculated from the pooled sample variance of the test data listed in Table A-5. Table 13 shows the variability for each analysis spectrum category based on 95% confidence coefficient for a sample size of four, which constitutes the number of subsamples in each daily composite sample. This then is an estimate of the precision of the daily results reported during the test period. In general, the data in Table 13 indicate that results obtained by the normal sampling method (i.e., sample size of four) could be expected, with 95% confidence, to be within ± 10 to 15% of the actual mean value for most analysis spectra (e.g., heating value, moisture, etc.).

Table 13. SAMPLE VARIABILITY OF MILLED REFUSE

Spectrum	Variability about the mean (±)[a] (at 95% confidence coefficient and sample size = 4)
Moisture (%)	3.89
Heating value (Btu/lb)	482
Ash (%)	3.66
Bulk density	1.08
Metal content by chemical analysis (%)	
Fe (Fe_2O_3)	0.68
Al (Al_2O_3)	0.55
Cu (CuO)	0.037
Pb (PbO)	0.040
Ni (NiO)	0.0091
Zn (ZnO	0.037
Proximate and ultimate analysis (%)	
Volatile matter	3.12
Fixed carbon	4.22
Carbon	1.99
Hydrogen	0.36
Oxygen (by difference)	2.39
Sulfur	0.083
Nitrogen	0.072
Composition by visual analysis (%)	
Paper	9.4
Plastic	6.73
Wood	2.75
Glass	0.90
Magnetic metal	b/
Other metal	b/
Organics	b/
Miscellaneous (Tr = trace)	10.09

Table 13. (Concluded)

Spectrum	Variability about the mean (±)[a] (at 95% confidence coefficient and sample size = 4)
Square screen size (in.) (%)	
Larger than 2.5 in.	No variance
Less than 2.5 in.	No variance
Less than 1.5 in.	8.26
Less than 0.75 in.	12.04
Less than 0.375 in.	10.66
Less than 0.187 in.	8.08
Less than 0.094 in.	6.00

a/ Variability based on sample data reported in Appendix A (Table A-5).

b/ Variance not calculated because of large number of trace or zero responses.

ENVIRONMENTAL EVALUATIONS

During the weeks of 18 November 1974 and 20 January 1975, environmental tests were conducted at the processing plant. The purpose of these tests was to:

1. Characterize air pollutant emissions from the discharge of the Air Density Separator (ADS) cyclone as to mass emission rate and particle size.

2. Characterize air pollutant emissions from the discharge of the hammermill (HM) cyclone as to mass emission rate and particle size.

3. Determine the quantity and character of runoff resulting from area washdown activities.

4. Determine sound levels at various locations in the processing plant.

Sampling and analysis of refuse streams was also carried out during each day of the November environmental tests. These results are contained in the preceding section.

TEST PROCEDURES FOR AIR EMISSION SAMPLING

Visual observation of the effluent from the ADS cyclone had indicated that it contained some large particles (pieces of paper, etc.) and was perhaps one of the more significant sources of debris that occurs in and around the plant. However, some windblown debris also undoubtedly occurs from the semi-enclosed conveyors and spillage from loading of packer trucks, etc.

Since it was obvious that the ADS cyclone discharge contained these large particles, it was considered impractical to sample the effluent using EPA Method 5 sampling trains because the small probe tips that are required would very likely be plugged by the large particles. The same would have been true for the cascade impactors that are usually used to determine particle size distribution of particulate matter in effluent streams. Therefore, it was necessary to utilize high-volume sampling techniques with their larger probes (~ 1-in. diameter). Both a high-volume mass train and high-volume cascade impactor, equipped with a pre-cyclone, were provided by EPA for this work.

ADS Cyclone Test Procedures

Sampling of the ADS cyclone discharge was carried out in the 42-in. diameter horizontal duct at the inlet to the ADS fan as shown in Figure 10. Two 4-in. diameter sampling ports had been installed in the top and side of this duct. The nearest flow disturbance, relative to the sampling ports, was five duct diameters upstream (a 90-degree elbow) and two diameters downstream (air flow control vanes and fan).

Particulate sampling of the emissions from the ADS cyclone was carried out with a high-volume (~ 15 scfm) sampler. Sampling was conducted using a 0.91-in. diameter probe tip and sampling for 2 min at 14 points along each of the two duct traverses. Configuration of the mass sampling equipment is shown in Figure 11. Isokinetic sampling was carried out, but it was necessary to determine the proper sampling rate based on a preliminary velocity traverse.

Particle size distribution of the ADS cyclone discharge was determined using the Andersen Hi-Volume cascade impactor and precyclone provided by EPA as depicted in Figure 12. A 1.125-in. diameter probe tip was used and the sampling was conducted for 30 min at a single point near the center of the duct.

Hammermill Cyclone Test Procedure

Sampling of the hammermill cyclone discharge was carried out in a 12-in. diameter vertical duct extension equipped with two sampling ports 90 degrees apart. The end of this duct extension was two duct diameters downstream of the sampling ports and there were in excess of 10 duct diameters upstream of the ports before any flow disturbance.

Particulate sampling of emissions from the HM cyclone was carried out using the same equipment as for sampling of the ADS system (see Figure 11). The only differences were the selection of the 1.125-in. diameter probe tip and use of the probe heater, heating jacket for the filter holder, and moisture trap ahead of the orifice, in order to minimize problems due to high moisture content of the effluent stream. Sampling was conducted for 5 min at four points along each of the two duct traverses. Again, sampling rate at each point was based on a preliminary velocity traverse.

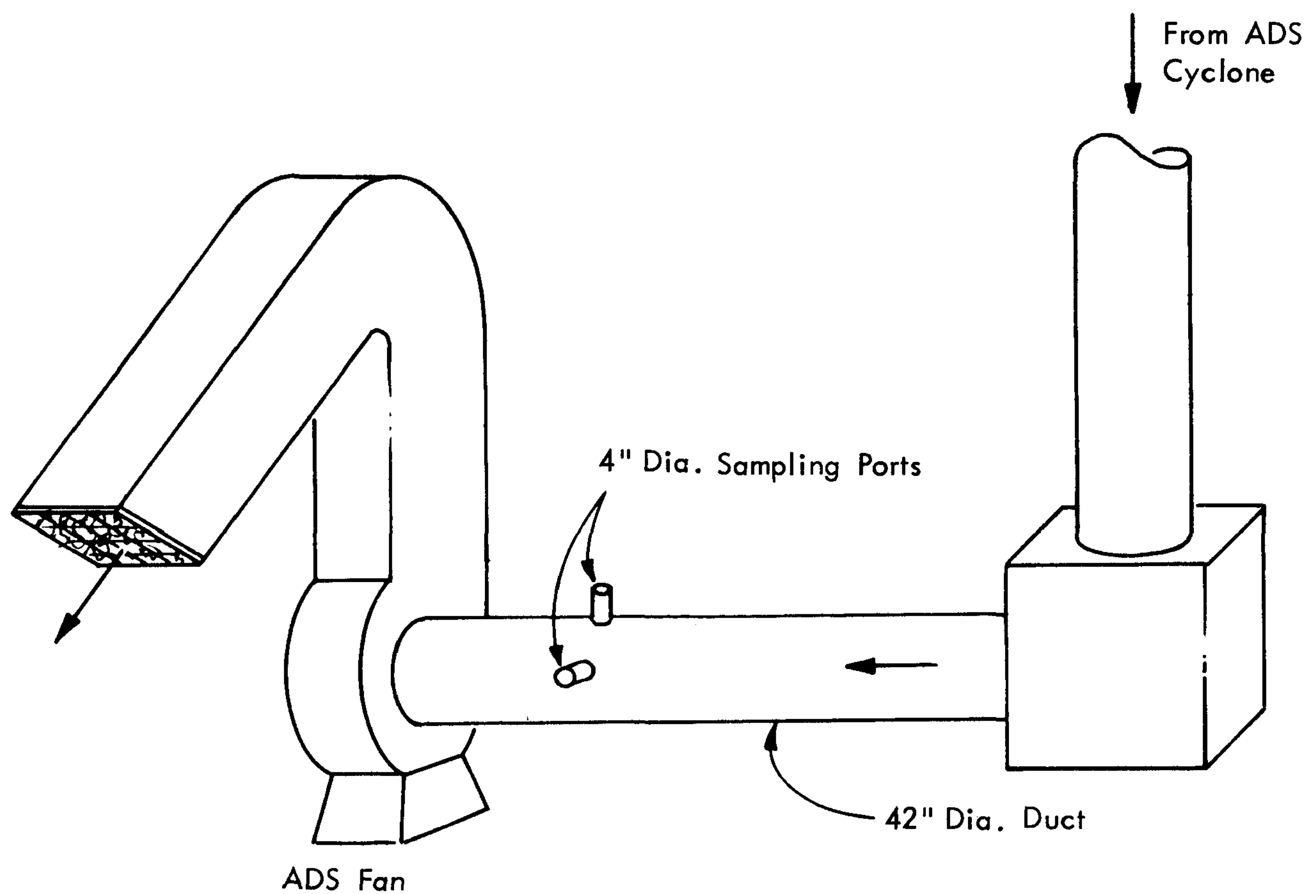
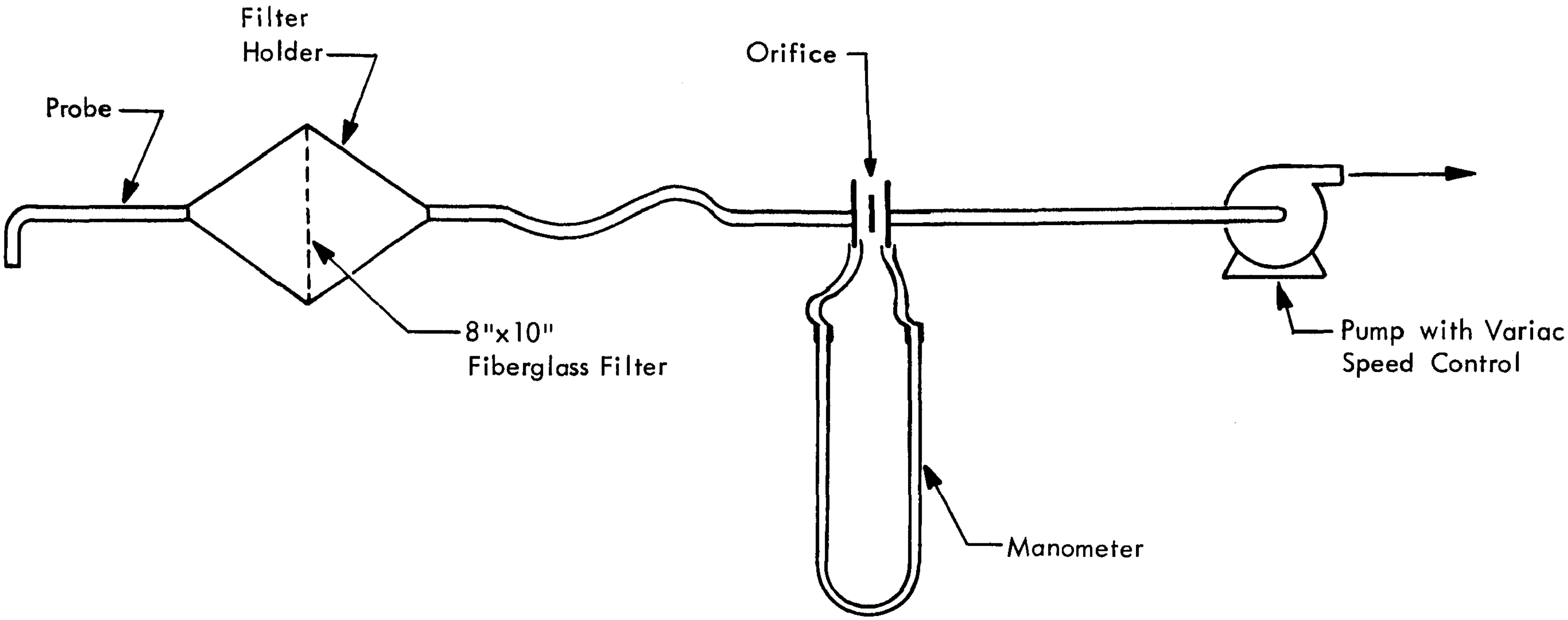


Figure 10. Diagram of ADS cyclone discharge sampling locations.

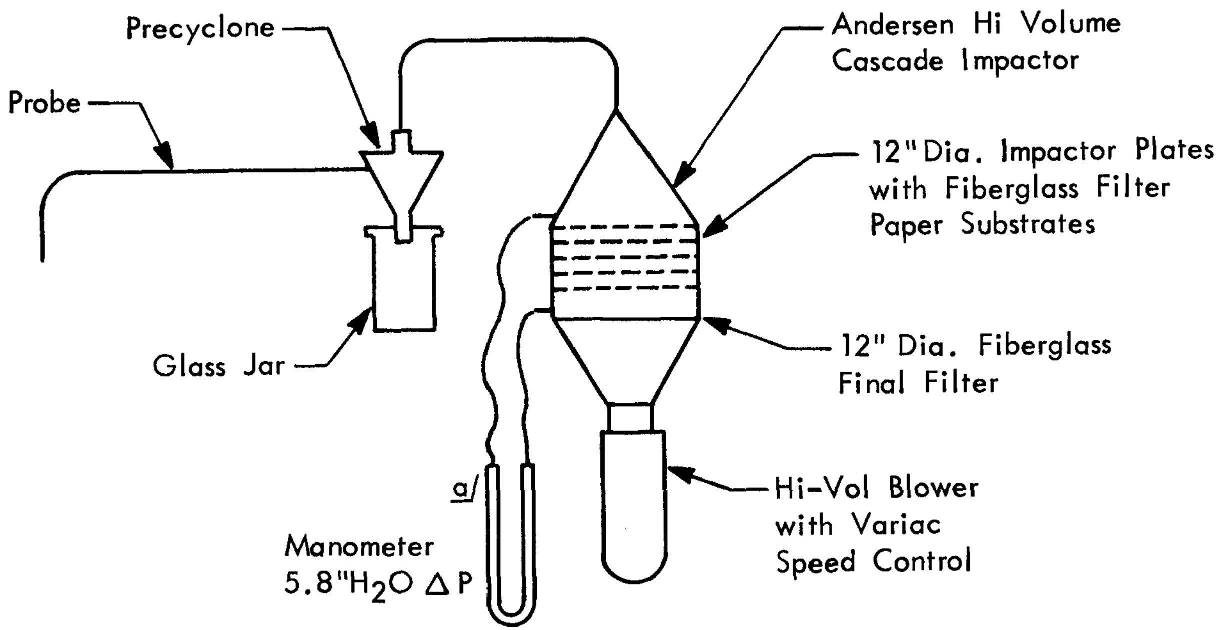


Note:

A preliminary velocity traverse was made of gas flow in duct in order to determine proper sampling rate at each sample point. Average sampling rate was about 15 cfm

During tests at Hammermill Cyclone, heated probe and filter holder were used, along with ice cooled condenser preceeding the orifice.

Figure 11. Diagram of particulate mass sampling equipment.



a/ Constant flow at 20 cfm maintained by adjusting blower speed to keep manometer reading constant at 5.8" $H_2O \Delta P$

Figure 12. Diagram of particle size sampling equipment.

Particle size distribution tests on the HM cyclone discharge were done using the same high-volume cascade impactor used for sampling the ADS system (Figure 12). The 1.125-in. diameter probe tip was used and the sampling was conducted for 1 hr at a single point near the center of the duct. However, because of the high moisture content of this stream, the heated probe and heating jacket for the impactor were used.

RESULTS OF AIR EMISSION TESTS

During the week of 18 November 1974, the processing plant was operated at the 300 tons/8-hr day rate and the mass emission and particle size tests were carried out. A total of five mass emission tests were conducted on the ADS cyclone discharge and two tests on the HM cyclone discharge. Results of these tests are summarized in Table 14 and a complete listing of the test data is contained in Table 15.

ADS Cyclone

Table 14 shows that the emissions from the ADS cyclone ranged from 19.9 lb/hr up to 68.2 lb/hr with an average of 50 lb/hr. At a normal processing rate of 40 tons/hr, this represents an emission factor of 1.25 lb/ton of raw refuse. This is a significant quantity of emissions and verifies the need for controlling or reducing the emissions in future plants of this type.

Two particle size distribution tests were also conducted on the ADS cyclone discharge and HM cyclone discharge as summarized in Table 16 and depicted in Figures 13 and 14. The effective cutoff for the impactor stages are noted in Table 16 and in considering these values it was assumed that the cutoff diameter for the precyclone was $\sim 10\,\mu$. However, the cutoff diameter for the impactor stages strictly applies only to spherical particles of density 1.0, which undoubtedly is not the case for the particles in these effluent streams. In this regard, visual inspection of the material caught on the mass train filter and in the precyclone showed much of it to be of a fibrous linty nature, similar in appearance to material collected in a household vacuum cleaner. Small pieces of paper and plastic (~ 1 in. x 1 in.) were also observed.

Bearing in mind the considerations discussed above, it is significant to note that the data in Table 16 indicate that most of the particulate matter (> 80%) was caught in the precyclone.

Table 14. RESULTS OF EMISSION TESTS AT PROCESSING PLANT

	ADS cyclone discharge				
	Test No. 1 11-19-74	Test No. 2 11-20-74	Test No. 3 11-20-74	Test No. 4 11-20-74	Test No. 5 11-20-74
Gas flow (air) (scfm)	25,560	23,310	30,000	30,910	30,670
Particulate concentration (grains/dscf)	0.089	0.280	0.169	0.243	0.263
Particulate emissions (lb/hr)	19.9	55.3	43.0	63.6	68.2

	Hammermill cyclone discharge	
	Test No. 6 11-21-74	Test No. 7 11-21-74
Gas flow (air) (scfm)	1,890	1,850
Particulate concentration (grains/dscf)	0.0082	0.0012
Particulate emissions (lb/hr)	0.127	0.018

Table 15. MASS EMISSION TEST DATA

Run No.	ADS cyclone discharge 1	2	3	4	5	HM cyclone discharge 6	7
Date	19-11-74	20-11-74	20-11-74	20-11-74	20-11-74	21-11-74	21-11-74
Probe tip dia (in.)	0.91	0.91	0.91	0.91	0.91	1.125	1.125
Net time of run (min)	56.50	56.18	56.28	55.94	56.22	40.0	40.0
Barometric pressure (in. Hg)	29.44	29.39	29.71	29.71	29.71	29.76	29.78
Avg orifice vacuum (in. Hg)	1.43	1.16	1.26	1.55	1.44	0.91	0.95
Orifice pressure absolute (in. Hg)	28.01	28.23	28.45	28.16	28.27	28.85	28.83
Avg orifice temperature (°F)	63.9	55.2	57.6	53.8	53.1	47.1	53.3
Volume condensate (ml)	0	0	0	0	0	178	223
Percent moisture by volume	2.1	1.3	1.1	1.3	1.4	3.9	5.0
Moisture content after condenser	2.1	1.3	1.1	1.3	1.4	2.7	3.5
Volume gas sampled, std cond. (scf)	726	622	824	843	841	701	669
Volume gas sampled, dry std cond. (dscf)	711	614	815	832	829	674	636
Molecular wt dry stack gas (lb/lb mole)	29.0	29.0	29.0	29.0	29.0	29.0	29.0
Molecular wt wet stack gas (lb/lb mole)	28.77	28.86	28.88	28.86	28.85	28.57	28.45
Molecular wt stack gas at orifice (lb/lb mole)	28.77	28.86	28.88	28.86	28.85	28.70	28.62
Pitot tube coefficient	0.85	0.85	0.826	0.826	0.826	0.826	0.826
Avg stack velocity head (in. H_2O)	0.749	0.616	0.975	1.034	1.018	0.586	0.574
Avg sq root stack velocity head	0.855	0.748	0.985	1.015	1.007	0.763	0.755
Avg stack temperature (°F)	60.0	53.1	55	53.5	53	83.9	91.8
Avg sq root stack temperature	22.804	22.651	22.694	22.661	22.650	23.321	23.489
Static pressure stack (in. Hg)	-0.61	-0.61	-0.61	-0.61	-0.61	-0.03	-0.03
Stack pressure absolute (in. Hg)	28.83	28.78	29.10	29.10	29.10	29.73	29.75
Stack dia (ft)	3.4167	3.4167	3.4167	3.4167	2.4167	0.979	0.979
Stack area (ft^2)	9.168	9.168	9.168	9.168	9.168	0.753	0.753
Avg stack gas velocity (ft/min)	2,950	2,560	3,270	2,360	2,330	2,590	2,580
Avg stack gas velocity, std cond. (ft/min)	2,900	2,540	3,270	3,370	3,350	2,510	2,460
Stack gas flow rate, stack cond. (acfm)	27,050	23,470	29,980	30,800	30,530	1,950	1,940
Stack gas flow rate, std cond. (scfm)	26,560	23,310	30,000	30,910	30,670	1,890	1,850
Stack gas glow rate, dry std cond. (dscfm)	26,000	23,010	29,670	30,510	30,240	1,820	1,760
Particulate weight (mg)	4,124.7	11,172.8	8,928.0	13,125.3	14,144.8	357.0	49.4
Particulate concentration, dry std cond. (gr/dscf)	0.0893	0.2802	0.1687	0.2429	0.2628	0.0082	0.0012
Particulate concentration, dry std cond. (mg/ncm)	204	641	386	556	601	18.67	2.74
Particulate emission rate, dry std cond. (lb/hr)	19.93	55.32	42.95	63.60	68.18	0.1274	0.0181
Particulate emission rate, dry std cond. (kg/hr)	9.0	25.1	19.5	28.8	30.9	0.0578	0.0082
Percent isokinetic	98.5	96.9	99.5	99.4	99.2	101.2	98.5

Table 16. PARTICLE SIZE DISTRIBUTIONS OF ADS AND HAMMERMILL DISCHARGES[a/]

	Effective cutoff[b/] diameters-microns	ADS cyclone discharge (wt %)		Hammermill cyclone discharge (wt %)	
		Test No. 8	Test No. 9	Test No. 10	Test No. 11
Precyclone	10	96.82	80.87	88.59	90.94
Stage 1	7.0	2.09	17.26	2.64	1.67
Stage 2	3.3	0.28	0.60	0.76	0.99
Stage 3	2.0	0.22	0.47	1.49	0.91
Stage 4	1.1	0.07	0.19	1.37	1.04
Final filter		0.52	0.61	5.15	4.45

a/ Hi-Volume Anderson Cascade Impactor with precyclone.

b/ Cutoff diameters are for special particles of density 1.0, which undoubtedly is not the case for the particles in these effluent streams.

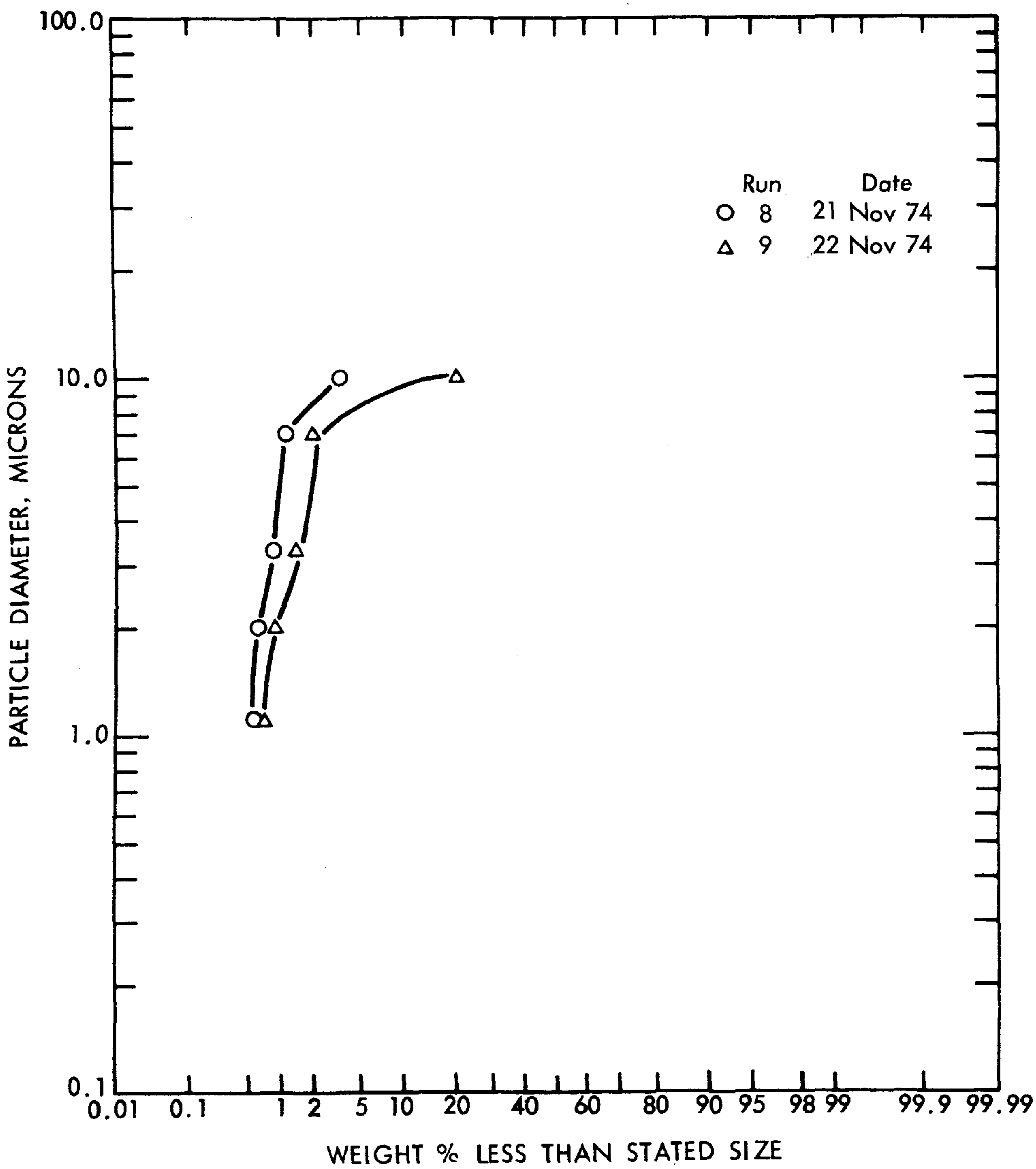


Figure 13. Particle size distribution for ADS cyclone discharge.

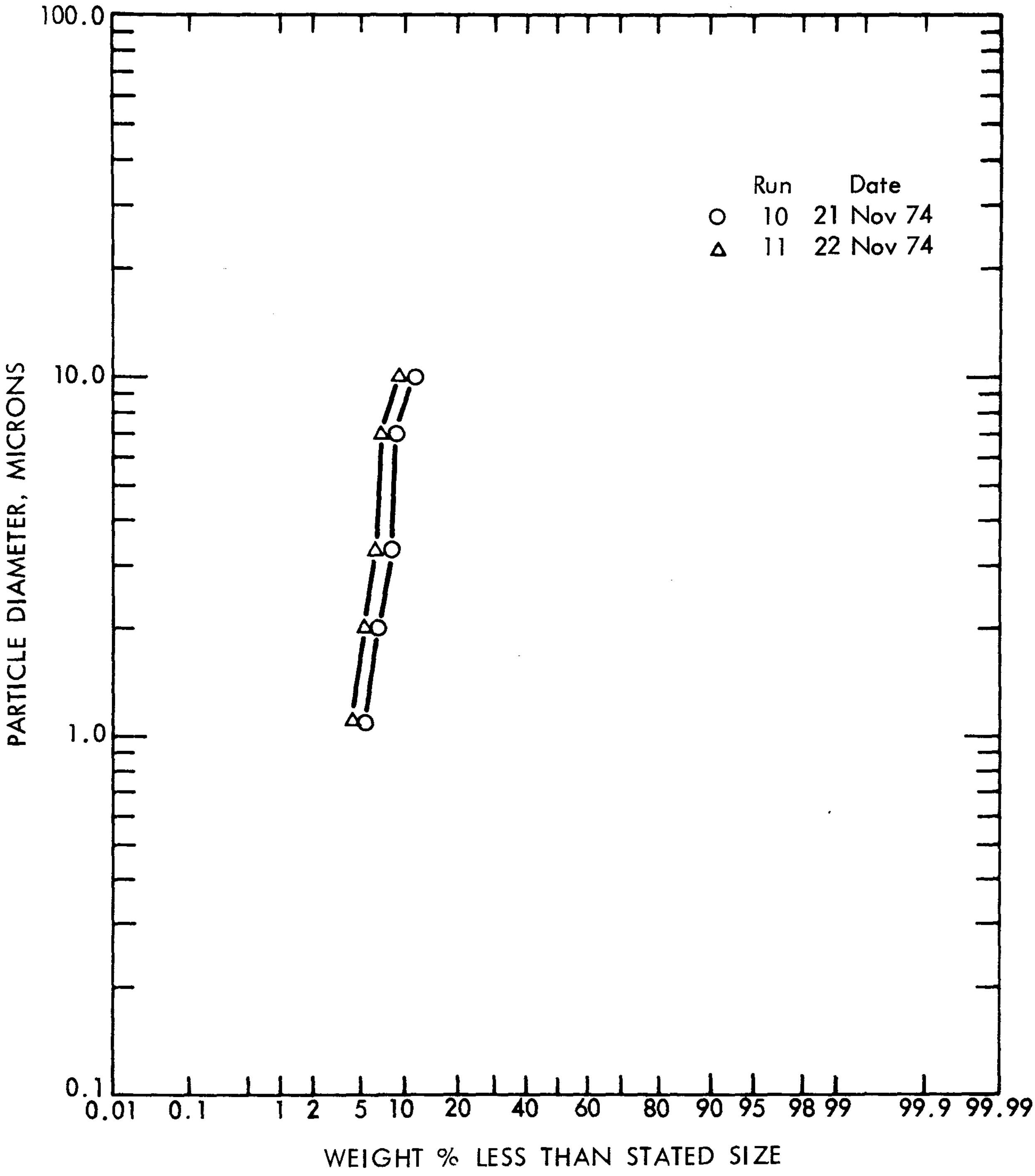


Figure 14. Particle size distribution for hammermill cyclone discharge.

Because of the results of the particle size tests on the effluent from the ADS cyclone and visual observation of the large particles in this stream, it was thought worthwhile to try to quantify the emission of these particles for comparison with the overall average emission rate of 50 lb/hr. Therefore, a net arrangement was constructed of nylon mesh with openings of about 1/4 in. x 1/4 in. During 4 days in December 1974 and Janaury 1975, this net was placed over the outlet of the ADS fan for approximately 1/2 hr each day in an attempt to capture and weigh all of the larger particles. These tests (Table 17) showed that the emission rate of large particles (> 1/4 in.) ranged from 4.3 to 8.0 lb/hr with an average of 5.6 lb/hr. The composition of this effluent was also scrutinized. Much of it was found to be pieces of paper and plastic, as well as miscellaneous fibrous materials.

HM Cyclone

Measured emissions from the HM cyclone are included in Table 14 and the two tests showed values of 0.018 lb/hr and 0.127 lb/hr. As expected, the emissions from the HM cyclone are much lower than those from the ADS cyclone and are not a significant source of particulate emissions. The emission test data for the HM cyclone (Table 15) show that the effluent gas temperature was about 25°F above ambient and that it contained a relatively high moisture content (~ 4% moisture by volume). This result verifies the expectation that the HM causes a temperature increase and removes some moisture from the refuse stream.

Particle size distribution tests were also conducted on the discharge from the HM cyclone. Results of these tests are included in Table 16 and are plotted in Figure 14. As was the case for the ADS cyclone effluent, the particle size distribution tests on the HM cyclone effluent showed that most of the particulate matter (> 88%) was caught in the precyclone.

RUNOFF FROM WASHDOWN ACTIVITIES

Washdown of the asphalted processing area of the plant (not including the floor of the raw refuse receiving building) is periodically carried out by plant personnel. This cleanup effort removes dust and settled particles, much of which occurs due to blowoff from conveyor belts and ADS cyclone emissions. It was therefore of interest to determine the quantity and character of runoff from this washdown activity.

During the week of environmental tests (18-22 November 1974) two washdowns took place, one on 20 November 1974, and another 2 days later on 22 November 1974. The test procedure used during these periods was to determine the quantity of water being used over the length of the washdown period

Table 17. TEST DATA ON PARTICLES CAPTURED BY NET PLACED OVER ADS FAN DISCHARGE

	Monday 12-30-74	Tuesday 12-31-74	Thursday 1-2-75	Monday 1-6-75
Test time (min:sec)	13:27	30:00	30:00	31:15
Emissions (lb/hr)	8.0	5.5	4.3	4.4
Fan air flow (acfm)	27,420	31,317	31,181	30,161
Sample Composition				
Density (lb/ft^3)[a]	1.8	2.1	2.3	1.6
Paper (%)	33.2	49.0	21.2	15.0
Plastic (%)	13.2	30.5	8.2	15.0
Wood (%)	0	0	0	0
Glass (%)	0	0	0	0
Magnetic metal (%)	0	0	0	0
Other metal (%)	0	0.3[c]	0	0
Organics (%)	0	0	0	0
Miscellaneous (%)[b]	53.6	20.2	70.6	70.0

a/ Uncompacted density--material very fluffy.

b/ Miscellaneous consists of the following: grass, paper fibers, threads, rug fibers, cloth fibers, small pieces of tissue, dust particles, feathers, and styrofoam.

c/ Aluminum foil.

(~ 1 hr) and to collect samples of the runoff at various points around the washdown area. These samples were composited in one container and a portion of this composite sample, as well as a sample of the raw water, was analyzed.

A tabulation of the data obtained for the two washdown periods is presented in Table 18. These data show that the washdown rate was about 35 gal/min and total runoff was about 2,000 gal. Comparison of analysis data for the raw water and the runoff indicates a large increase in TSS, as expected. There was also a significant increase in BOD and COD. However, the quantity of effluent (~ 2,000 gal.) seems relatively small, considering the fact that it occurs only one or two times per week.

TEST PROCEDURE FOR SOUND SURVEY

The following General-Radio test equipment was used for the sound survey:

Model 1558 DP Portable Octave Band Noise Analyzer
Model 1560 Pb One Inch Ceramic Microphone
Model 1562 A Calibrator

The noise analyzer with microphone was calibrated each day of the sound survey. Meter-response range was 44 to 150 decibels (dB). A zero meter response was listed as $<$ 44 dB. The portable analyzer was hand-held, and the microphone was placed 4.5 ft above grade at each measurement location.

Sound levels in decibels at slow meter response were measured at ten octave bands plus the A scale (dBA). The octave band measurements show the overall sound spectrum in terms of decibels versus frequency. This information will be useful for acoustical engineering, land-use zoning, and other activities related to the total sound spectrum produced. Octave bands used are as follows:

OCTAVE BANDS USED

	Frequency (Hz)		
Octave band No.	Band center	Lower cutoff	Upper cutoff
1	31.5	22.3	44.6
2	63	44.6	89.2
3	125	88.4	177
4	250	177	354
5	500	354	707
6	1,000	707	1,414
7	2,000	1,414	2,820
8	4,000	2,828	5,656
9	8,000	5,656	11,310
10	16,000	11,310	22,620

Table 18. TABULATION OF DATA ON WASHDOWN ACTIVITY

	Test No. 1		Test No. 2	
Date	11/20/74		11/22/74	
Time of washdown	1:50-2:40 p.m.		1:09-2:10 p.m.	
Raw water flow rate	35 GPM		35 GPM	
Total water used	1,745 gal.		2,111 gal.	
Volume of runoff collected	9.8 gal.		12.9 gal.	
Water analysis	Raw water	Composite runoff sample	Raw water	Composite runoff sample
Total suspended solids (ppm)	8.00	6,024.00	8.00	9,292.00
Total dissolved solids (ppm)	248.00	444.00	252.00	564.00
Biochemical oxygen demand (ppm)	ND[a/]	374.00	ND[a/]	765.00
Chemical oxygen demand (ppm)	52.90	2,137.30	33.40	1,532.00
pH	9.7	6.5	9.5	6.3
Total alkalinity (ppm)	62.00	80.00	32.00	38.00
Total organic carbon (ppm)	4.50	1,760.00	6.50	1,150.00

a/ None detected.

The A scale sound levels will be useful to those interested in O.S.H.A. applications. (O.S.H.A. regulations are defined in terms of dBA measurements.)

Measurements were made (a) when the plant was conducting normal operations, and (b) when the plant was not operating, to identify the levels of usual background noise. Any sound measurements of operating equipment will be the combination of the sound produced by the equipment plus the background sound. For the City of St. Louis Refuse Processing Plant, the background sound sources consist of the following:

LOCATION OF BACKGROUND SOURCES

Background source	Direction from plant
Interstate Highway 55	West
Mississippi River	East
City Incinerator	North
City Truck Maintenance Garage	Southwest

Table 19 lists the measurement locations. Sixteen locations were used to monitor noise levels in the following three general areas:

1. Employee work areas (Locations 1 through 8).

2. Light sound level equipment areas (Locations 9 through 11).

3. Sound levels along processing plant perimeter (Locations 12 through 16).

Figure 15 is a plot plan showing the measurement locations.

SOUND SURVEY RESULTS

Tables 20 and 21 list the sound-measurement results. The background sound is relatively low, being less than 60 dB above 250 Hz center band frequency. The major background is low-frequency sound from adjacent Interstate Highway 55. The major sound from the processing plant is in the lower frequencies; the hammermill, nuggetizer, ADS fan exhaust, front-end loader, and raw-refuse trucks are the principal contributors.

Table 19. SOUND SURVEY MEASUREMENT LOCATIONS

No.	Description	
1	Control Room	- Inside operators control room. Approximately center of room.
2	Shop	- Inside maintenance shop and storage room located next to hammermill. Approximately center of room.
3	Packer Control	- 2 ft west of packer control panel east-west center line. Location where operator would stand to operate controls.
4	Receiving Building	- 3 ft south of raw refuse receiving building north wall on building north-south center line.
4.1		Front-end loader operating at maximum load. No refuse trucks dumping.
4.2		Refuse trucks dumping. Front-end loader at engine idle.
5	Front-End Loader	- Inside operator's cab of front-end loader used inside receiving building to push raw refuse onto the raw refuse receiving belt conveyor. Cab doors closed.
6	ADS Heavies Discharge	- 3 ft east of edge of ADS heavies belt conveyor tail pulley.
7	Mag Belt Discharge	- 5 ft northwest from edge of nuggetizer frame. Location just outside door to drivers compartment in magnetic belt reject truck. Location when truck is positioned to fill front 1/3 of truck body.
8	Fe Metal Discharge	- 3 ft south of edge of ferrous metal belt conveyor. Location just outside door to drivers compartment of ferrous metal truck. Located when truck is positioned to fill front 1/3 of truck body.
9	Hammermill	- 5 ft east of edge of hammermill frame on mill east-west centerline. Location on top of concrete base for hammermill.
10	Nuggetizer	- 5 ft east from edge of nuggetizer frame on nuggetizer east-west centerline.
11	ADS Fan Exhaust	- 40 ft south of edge of fan exhaust duct on duct north-south centerline.

There is a truck driveway on the east, south, and west sides of the processing area. The following locations are along the outside edge of this driveway.

12	E. Drive	- ℄ mill - 65 ft east of edge of hammermill frame on mill east-west centerline.
13	E. Drive	- ℄ Stg. Bin - 60 ft east of edge of storage bin on bin east-west centerline.
14	W. Drive	- ℄ ADS - 75 ft west of edge of ADS air separation chamber on chamber east-west centerline.
15	W. Drive	- ℄ Stg. Bin - 70 ft west of edge of storage bin on bin east-west centerline.
16	S. Drive	- ℄ Stg. Bin - 40 ft south of edge of storage bin on bin north-south centerline.

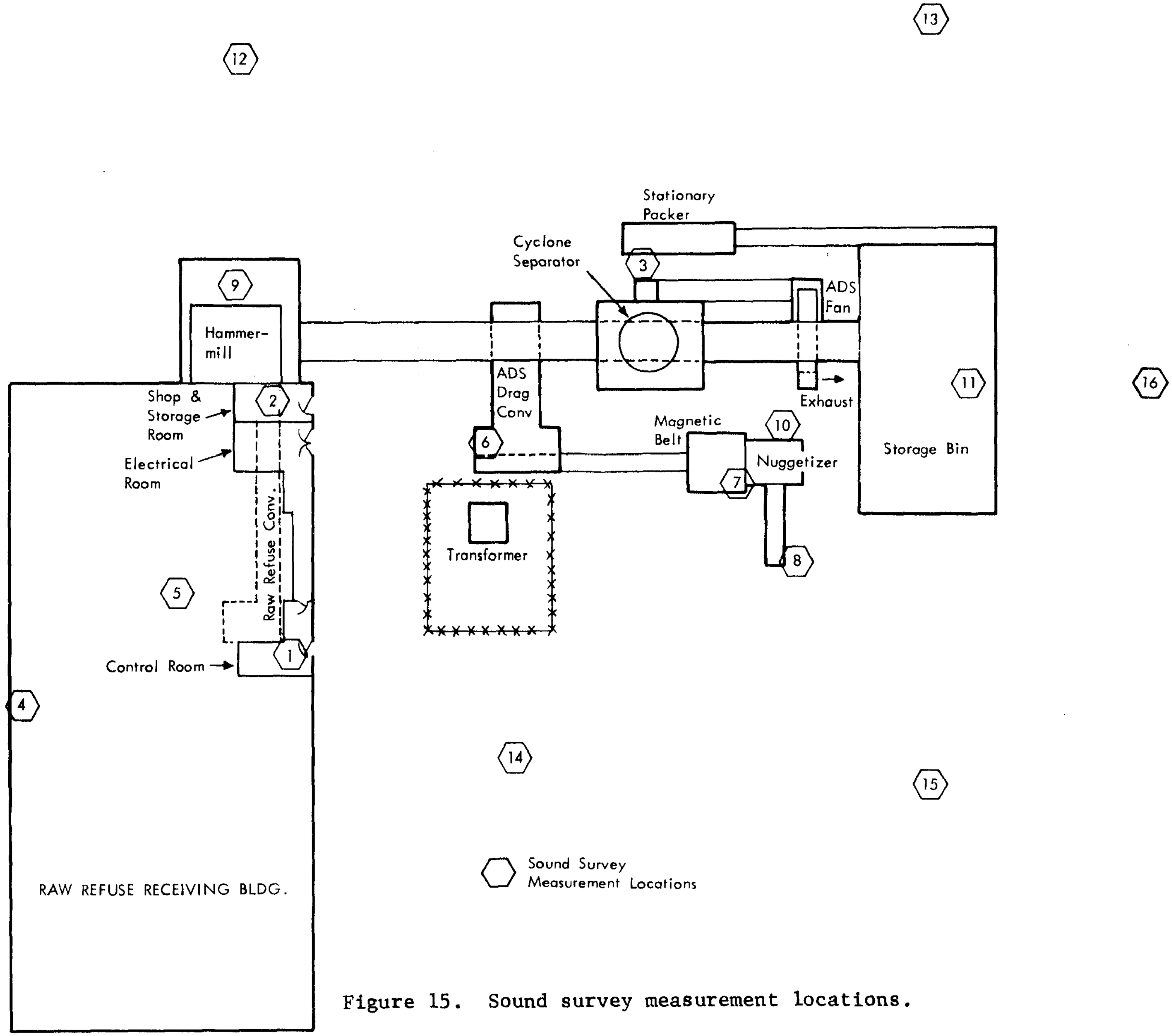


Figure 15. Sound survey measurement locations.

Table 20. SOUND SURVEY - CITY OF ST. LOUIS REFUSE PROCESSING PLANT

Plant in operation — 20 January 1974

Measurement location		Decibels (dB) at center band frequency - Hz											
No.	Description	Hz	31.5	63	125	250	500	1K	2K	4K	8K	16K	dBA
1	Control room		82	82	76	64	65	60	58	56	< 44	< 44	68
2	Shop		83	89	89	80	78	76	73	69	52	50	83
3	Packer control		91	96	88	86	83	81	78	75	70	58	86
4.1	Receiving bldg.		92	106	94	88	88	89	88	84	72	56	94
4.2	Receiving bldg.		100	110	100	96	90	94	90	86	80	74	100
5	Front end loader		106	100	93	92	87	82	78	78	78	66	89
6	ADS heavies disch.		93	96	92	88	86	86	86	88	84	72	94
7	Mag. belt disch.		91	92	92	93	96	100	102	103	98	88	108
8	Fe metal disch.		88	88	86	87	87	88	87	86	82	70	94
9	Hammermill		96	99	98	92	89	88	88	86	80	68	95
10	Nuggetizer		94	94	91	90	93	95	96	93	89	79	101
11	ADS fan exhaust		100	97	93	97	93	89	86	82	75	68	95
12	E. Drive - ℄ Mill		90	92	84	78	76	72	69	65	56	45	80
13	E. Drive - ℄ Stg. bin		85	85	80	76	72	71	59	56	57	46	76
14	W. Drive - ℄ ADS		84	90	84	78	74	78	78	74	69	56	84
15	W. Drive - ℄ Stg. bin		90	84	83	80	77	79	79	78	72	58	85
16	S. Drive - ℄ Stg. bin		85	85	80	82	75	76	76	72	64	50	82

Table 21. SOUND SURVEY - CITY OF ST. LOUIS REFUSE PROCESSING PLANT

Background sound - plant not in operation — 21 January 1974

Measurement location		Decibels (dB) at center band frequency - Hz											
No.	Description	Hz	3.15	63	125	250	500	1K	2K	4K	8K	16K	dBA
1	Control room		51	53	50	< 44	< 44	< 44	< 44	All readings at			< 44
2	Shop		60	58	63	55	50	45	< 44	4K, 8K and 16K			53
3	Packer control		62	64	58	56	53	50	< 44	Hz frequency			54
4	Receiving bldg.		62	60	62	57	54	52	46	are less than			56
5	Front end loader[a]		64	62	56	49	46	< 44	< 44	44 dB at all			47
6	ADS heavies disch.		65	64	67	69	56	54	50	locations.			61
7	Mag. belt disch.		64	66	63	61	53	53	48				59
8	Fe metal disch.		66	66	64	61	55	54	48				59
9	Hammermill		60	71	61	58	51	49	< 44				56
10	Nuggetizer		63	65	66	65	56	54	< 44				59
11	ADS fan exhaust		66	62	62	55	51	49	< 44				55
12	E. Drive - ℄ Mill		62	65	54	55	50	50	< 44				52
13	E. Drive - ℄ Stg. Bin		60	66	64	56	50	52	45				57
14	W. Drive - ℄ ADS		62	64	66	60	54	52	47				59
15	W. Drive - ℄ Stg. Bin		62	66	65	62	54	54	47				56
16	S. Drive - ℄ Stg. Bin		63	63	63	62	52	54	45				58

a/ Motor off - loader inside building.

Location 7 had the highest sound level in the upper frequencies. This location was closest to the working mechanism of the nuggetizer, and also underneath the metal-nuggetizer feed chute. This feed chute receives the magnetic metal from the magnetic separator belt, and its sound production is primarily due to the metal particles striking the metal chute. Both the nuggetizer and the magnetic belt are acting together to produce higher sound levels in the 1,000 to 8,000 Hz center band frequencies.

Location 4.1 is with the front-end loader working at maximum load. Location 5 shows that, with the operator's cab doors closed, the cab is reducing the engine sound except for center band frequencies 31.5 and 250 Hz. Fortunately, these frequencies do not have a full effect on the A scale, and the dBA is below the O.S.H.A. limit of 90 dBA.

Location 4.2 is inside the receiving building at the same physical point as 4.1. These measurements are highest when the raw-refuse trucks discharge refuse onto the building floor. These refuse trucks are not dump trucks with a tilting truck box. Instead, the trucks utilize a mechanism which rapidly shakes the cargo compartment to discharge the raw refuse. Measurements were taken during the shaking action. However, this action lasts for only a few seconds per truck.

The current[1/] O.S.H.A. regulations specify a maximum of 90 dBA for continuous 8-hr exposure, with shorter allowable time limits at levels above 90 dBA. No operator must spend a full work day at any location above 90 dBA. Locations above 90 dBA are shown in Table 22.

The time that an individual employee may spend in these locations when the equipment is operating is estimated to be less than the allowable time exposure. Also, at locations 4.1 and 4.2 the front-end loader is at maximum load less than 100% of the time.

1/ O.S.H.A. regulations as of 27 June 1974.

Table 22. LOCATION OF SOUND LEVELS ABOVE 90 dBA AND ALLOWABLE EXPOSURE

Locations	Description	dBA	O.S.H.A. allowable time exposure - hours[1/]
4.1	Receiving building	94	4
4.2	Receiving building	100	2
6	ADS heavies discharge	94	4
7	Magnetic belt rejects	108	1/2
8	Fe metal discharge	94	4
9	Hammermill	95	4
10	Nuggetizer	101	1-1/2
11	ADS fan exhaust	95	4

APPENDIX

TABULTIONS OF DATA ON EQUIPMENT AND ANALYSIS OF REFUSE SAMPLES

Table A-1. MAJOR ITEMS OF EQUIPMENT - REFUSE PROCESSING PLANT

Equipment description Belt conveyors	Physical parameters Length	Width	Angle of incline (degrees)	Ft/Min	Belt type	Troughing idlers Degrees	Nominal spacing
Raw refuse receiving[a]	24 ft 0 in.	8 ft 1 in.	0	5.7	Smooth	None	
Raw refuse to Hammermill	92 ft 0 in.	5 ft 0 in.	20	285	Smooth	35	5 ft 0 in.
Milled refuse to ADS[b]	75 ft 9 in.	4 ft 6 in.	18	235	Smooth	35	5 ft 0 in.
Refuse fuel to storage bin[b]	98 ft 3 in.	4 ft 6 in.	18	230	Smooth	35	5 ft 0 in.
Storage bin feeding cross belt	27 ft 0 in.	5 ft 0 in.	0	215	Smooth	20	3 ft 0 in.
Storage bin discharge	73 ft 0 in.	4 ft 0 in.	0	215	Smooth	35	3 ft 4 in.
Load out to packer	100 ft 0 in.	4 ft 0 in.	15	216	Smooth	35	4 ft 6 in.
ADS heavies	51 ft 0 in.	2 ft 6 in.	17	200	Rough top	20	5 ft 0 in.
Ferrous metal	39 ft 0 in.	2 ft 6 in.	15	60	Rough top	20	5 ft 0 in.
Magnetic belt (Indiana General-Model 54-A)	6 ft 4 in.	2 ft 6 in.	14	350	Metal bar	None	

a/ Raw refuse receiving conveyor variable speed 0 to 23 ft/min maximum (5.7 ft/min normal).
b/ Both conveyors driven by one 10 HP motor.

Vibrating conveyors	Length	Width	Angle of incline (degrees)	Stroke	RPM	Model
Hammermill feeder	12 ft 9 in.	7 ft 0 in.	0	1 ft	454	Stephens Adamson natural frequency conveyor
Hammermill discharge	16 ft 0 in.	7 ft 7 in.	0	1 ft	460	Stephens Adamson natural frequency conveyor
ADS feeder[a]	9 ft 9 in.	8 ft 0 in.	0	--	902	FMC straight line vibrator No. 62810

a/ Feeder has round hole flat metal perforated screen 2 ft 0 in. large to remove fine particles from feed to ADS.

Other conveyors	Speed	Model
ADS drag conveyor	42 ft/min	Rader Pneumatic's 7 ft 6 in. wide feed from 8 ft x 12 ft hopper.
ADS drag conveyor scalping roll	82 rpm	7 ft 6 in. wide by 18 in. diameter.

Other equipment	Shaft speed (rpm)	Model
Hammermill	894	Gruendler 60 ft x 84 ft with 3 in. square grate
ADS fan	1,570	New York blower size 44 Design 48,000 cfm, 134 BHP at 13.5 in. WGSP and 1,449 rpm
Nuggetizer	419	Eidal mill model 100B
Magnetic drum	42	Sterns magnetic drum with permanent magnetic; 22 in. wide, 26 in. diameter

Bins	Material height	Length	Width	Capacity (ft^3)
Storage bin	35 ft 0 in.	60 ft 4 in.	14 ft 2 in. top 19 ft 0 in. bottom	35,020
Packer bin	19 ft 9 in.	11 ft 0 in.	6 ft 0 in.	1,304

Table A-2. MAJOR MOTORS - REFUSE PROCESSING PLANT

Equipment served	HP	RPM	Amperage: Name plate	Amperage: Acutal	Amperage: % of Name plate
3 Phase 4,160 V motors					
Hammermill	1,250	894	155	50-300	32-194
3 Phase 460 V motors					
Raw refuse receiving belt conveyor	5	1,750	9	0.5	6
Raw refuse belt conveyor to Hammermill	15	1,755	19.5	10.0	51
Hammermill feeder vibrating conveyor	20	1,200	27	11	41
Hammermill dust collection fan	7.5	1,740	10	6.5	65
Hammermill discharge vibrating conveyor	25	1,200	33	14	42
Milled refuse belt conveyor	10	1,755	13.5	8.5	63
ADS drag conveyor	15	1,750	19.2	10.8	56
ADS drag conveyor scalper roll	3	1,740	4.5	1.5	33
ADS feeder vibrating conveyor	10	1,750	12.9	6.2	48
ADS feed rotary airlock	25	1,750	34	11	32
ADS cyclone discharge rotary airlock	25	1,760	30.5	13	43
ADS fan	200	1,780	230	145-170	63-74
Storage bin feeding cross belt conveyor	5	1,730	7	3.3	47
Storage bin discharge screw conveyor	150	1,780	16.5	50-120	30-73
Storage bin discharge belt conveyor	10	1,755	13.5	6.0	44
Load out belt conveyor to packer	7.5	1,740	10	5.0	50
Packer hydraulic unit	60	1,750	69	18	26
ADS heavies belt conveyor	3	1,755	4.2	2.5	60
Magnetic separator belt	5	1,745	6.8	4.2	62
Nuggetizer	100	1,780	117	32-100	27-86
Magnetic drum	1	1,740	1.9	1.7	89
Nuggetizer dust collection fan	7.5	1,750	10.3	5.9	57
Ferrous metal belt conveyor	3	1,755	4.6	2.6	57
Air compressor	3	1,755	4.6	4.0	87
Storage bin cross belt carriage drive	1/2	1,750	1	not used	
3 Phase 208 V motor					
Fire protection line air compressor	1-1/2	1,740	5.5	4.8	87
Direct current 100 V motor					
Storage bin discharge screw conveyor Carriage drive (variable speed, max 1,750 RPM)	1/2	1,750	5	4.2	84
Power supplies - 3 phase 460 V	kw				
Magnetic belt power supply	10	--	15	8	53

Table A-3a. MOISTURE ANALYSIS OF MILLED REFUSE STREAMS - PERCENT BY WEIGHT

Daily samples Date 1974 Month	Day	S1 Mill discharge	S2 Cyclone discharge	S3 Storage bin discharge	S4 ADS heavies	S5 Magnetic belt rejects	S6 Nuggetizer feed	S7 Magnetic drum rejects	S8 Ferrous metal
9	23	20.60	27.10	28.80	8.00	32.80	0.10	10.60	0.10
9	24	31.00	26.30	31.10	7.40	12.20	0.60	0.40	0.60
9	25	31.90	32.80	31.60	6.70	26.10	0.40	0.30	0.20
9	26	27.50	27.80	24.90	4.67	12.60	0.30	0.16	0.26
9	27	28.80	25.30	22.40	1.10	14.10	0.07	2.28	0.12
Week avg		27.96	27.86	27.76	5.57	19.56	0.29	2.75	0.26
9	30	32.30	28.80	25.20	0.32	12.00	0.14	0.11	0.14
10	1	32.00	31.00	33.00	7.00	17.90	0.30	0.20	0.10
10	2	23.90	29.40	25.40	4.80	17.00	0.40	0.50	0.10
10	3	18.00	24.50	27.00	1.30	14.70	0.40	0.51	0.20
10	4	27.20	17.80	24.10	7.10	7.59	0.40	0.40	0.07
Week avg		26.68	26.30	26.94	4.10	13.84	0.33	0.34	0.12
10	7	15.60	17.00			8.30			0.07
10	8	18.70	20.10			13.10			0.10
10	9	19.50	23.90			16.70			0.04
10	10	17.60	18.20			12.00			0.10
10	11	15.30	14.30			9.92			0.14
Week avg		17.34	18.70			12.00			0.09
10	15	29.20	31.80			23.20			0.13
10	16	27.60	32.30			14.50			0.16
10	17	26.50	24.10			15.40			0.16
10	18	19.90	27.70			14.00			0.12
Week avg		25.80	28.98			16.78			0.14
10	21	23.90	23.20			7.80			0.10
10	22	23.70	23.10			13.30			0.20
10	23	17.50	22.50			15.50			3.00
10	24	10.10	15.10			17.40			0.15
10	25	19.60	19.10			11.10			0.10
Week avg		18.96	20.60			13.02			0.71
11	18	25.50	27.40			15.20		0.31	0.06
11	19	19.20	22.10			16.70		0.29	0.13
11	20	20.50	24.40			14.00		0.26	0.13
11	21	18.30	23.60			15.50		0.19	0.07
11	22	7.70	11.70			12.80		0.02	0.08
Week avg		18.24	21.84			14.84		0.21	0.09

Table A-3b. HEATING VALUE OF MILLED REFUSE STREAMS BTU/LB (RECEIVED MOISTURE BASIS)

Daily samples Date 1974 Month	Day	S1 Mill discharge	S2 Cyclone discharge	S3 Storage bin discharge	S4 ADS heavies	S5 Magnetic belt rejects	S7 Magnetic drum rejects	S8 Ferrous metal
9	23	5,057.9	4,981.8	4,865.6	2,641.3	2,274.7	2,589.0	2,207.8
9	24	4,144.3	4,926.9	4,741.0	2,522.4	2,648.1	3,273.9	2,225.6
9	25	4,447.7	4,638.2	4,379.8	2,528.4	2,556.9	3,022.9	2,224.5
9	26	4,716.3	4,981.6	5,085.5	2,373.7	3,171.8	3,346.6	2,262.1
9	27	4,628.4	5,072.4	5,326.9	2,768.9	2,142.4	2,784.0	2,233.3
Week avg		4,598.9	4,920.2	4,879.8	2,566.9	2,558.8	3,003.3	2,230.7
9	30	3,973.7	4,982.9	5,061.8	2,498.0	2,912.8	2,967.7	2,215.1
10	1	4,638.9	4,340.7	4,500.3	2,491.5	2,662.5	2,913.2	2,229.8
10	2	5,059.7	4,628.6	5,260.3	2,531.4	2,973.9	3,220.0	2,214.8
10	3	4,838.7	5,022.6	4,619.2	2,847.5	2,964.2	3,078.5	2,235.2
10	4	4,723.5	5,460.9	4,781.0	2,552.9	2,239.1	3,207.1	2,219.5
Week avg		4,646.9	4,887.1	4,844.5	2,584.3	2,750.5	3,077.3	2,223.0
10	7	5,092.0	5,414.3			2,301.7		2,619.2
10	8	5,195.6	5,225.5			2,196.0		2,180.0
10	9	5,654.7	5,852.5			2,637.3		2,187.5
10	10	5,822.4	5,734.8			1,845.4		2,232.8
10	11	5,339.7	5,558.2			2,976.2		2,154.8
Week avg		5,420.9	5,557.1			2,391.3		2,274.9
10	15	4,470.3	4,587.4			3,409.2		2,245.2
10	16	4,616.6	4,563.8			2,282.0		2,250.1
10	17	4,250.3	5,209.3			1,717.4		2,231.2
10	18	5,111.5	4,991.7			2,623.9		2,213.3
Week avg		4,612.2	4,838.1			2,508.1		2,235.0
10	21	4,628.4	4,746.3			3,807.9		2,199.2
10	22	4,588.0	5,266.3			2,861.1		2,204.6
10	23	5,556.7	5,420.4			3,637.7		2,184.4
10	24	5,612.5	5,671.6			3,282.5		2,369.4
10	25	4,410.0	5,457.0			2,333.6		2,202.8
Week avg		4,959.1	5,312.4			3,174.6		2,232.1
11	18	4,291.2	4,835.2			2,289.6	2,863.9	2,205.2
11	19	4,872.2	5,132.1			2,570.6	3,075.1	2,202.6
11	20	5,480.7	5,266.3			1,676.9	2,718.9	2,216.0
11	21	5,109.8	5,039.7			2,124.3	2,712.8	2,223.4
11	22	6,329.9	5,674.2			2,315.2	2,611.5	2,332.1
Week avg		5,216.8	5,189.5			2,195.3	2,796.4	2,235.9

Table A-3c. ASH ANALYSIS OF MILLED REFUSE STREAMS
PERCENT BY WEIGHT (RECEIVED MOISTURE BASIS)

Daily samples Date 1974 Month	Day	Stream S1 Mill discharge	S2 Cyclone discharge	S3 Storage bin discharge
9	23	33.44	21.14	18.96
9	24	26.55	20.43	17.67
9	25	21.12	15.88	18.19
9	26	27.18	17.54	20.14
9	27	21.57	19.51	20.32
Week avg		25.97	18.90	19.06
9	30	25.12	19.92	20.85
10	1	20.94	22.76	18.59
10	2	19.48	16.01	18.93
10	3	29.00	21.80	18.90
10	4	19.99	18.87	19.35
Week avg		22.91	19.87	19.32
10	7	23.75	23.41	
10	8	23.49	20.70	
10	9	16.57	18.96	
10	10	22.35	19.23	
10	11	23.53	20.90	
Week avg		21.94	20.64	
10	15	20.36	16.40	
10	16	20.08	15.96	
10	17	26.73	17.61	
10	18	21.64	15.04	
Week avg		22.19	16.25	
10	21	24.45	21.93	
10	22	26.69	17.29	
10	23	20.30	15.55	
10	24	30.03	20.23	
10	25	18.01	18.30	
Week avg		23.90	18.70	
11	18	24.56	17.05	
11	19	24.85	18.56	
11	20	18.60	15.54	
11	21	24.76	19.25	
11	22	19.21	16.89	
Week avg		22.40	17.46	

Table A-3d. DAILY RESULTS - PROXIMATE AND ULTIMATE ANALYSIS OF REFUSE FUEL

Date 1974 Month	Day	Percent by weight (received moisture basis) Volatile matter	Fixed carbon	Carbon	Hydrogen	Oxygen (by difference)	Sulfur	Nitrogen
(Stream S3 - Storage bin discharge)								
9	23	26.94	4.85	28.64	3.66	0	0.21	0.63
9	24	25.35	4.46	26.71	3.64	0	0.18	0.61
9	25	25.66	2.93	24.25	3.26	0.27	0.16	0.66
9	26	25.02	11.23	29.84	4.24	1.40	0.21	0.57
9	27	27.53	12.37	29.27	4.13	5.70	0.24	0.57
Week avg		26.10	7.17	27.74	3.79	1.47	0.20	0.61
9	30	27.12	7.98	26.46	3.99	3.89	0.17	0.59
10	1	27.76	0.00	23.64	3.22	0.00	0.15	0.51
10	2	28.28	8.44	28.04	4.07	3.99	0.10	0.52
10	3	26.59	7.80	26.76	3.66	3.30	0.15	0.52
10	4	28.82	9.43	26.83	3.65	6.96	0.20	0.61
Week avg		27.71	6.73	26.35	3.72	3.63	0.15	0.55
(Stream S2 - Cyclone discharge)								
9	23	28.77	3.23	26.81	3.68	0.69	0.20	0.63
9	24	28.73	5.16	27.19	3.54	2.37	0.18	0.62
9	25	23.51	5.77	25.94	3.63	0	0.15	0.60
9	26	25.65	8.93	27.83	3.62	2.42	0.22	0.51
9	27	26.98	9.31	27.58	3.82	3.89	0.40	0.61
Week avg		26.93	6.48	27.07	3.66	1.87	0.23	0.59
9	30	27.03	3.75	26.34	3.66	0.00	0.18	0.60
10	1	29.21	0.00	21.98	3.24	0.00	0.21	0.45
10	2	24.35	9.49	26.45	3.85	2.94	0.11	0.49
10	3	29.35	5.86	27.47	3.77	3.28	0.16	0.53
10	4	28.59	20.11	30.64	4.30	12.86	0.30	0.60
Week avg		27.71	7.84	26.58	3.76	3.82	0.19	0.53
10	7	32.63	12.86	29.93	4.08	10.52	0.23	0.72
10	8	28.59	14.55	29.30	4.09	9.04	0.11	0.56
10	9	27.94	11.01	27.32	3.85	7.52	0.14	0.60
10	10	27.87	19.81	30.37	4.31	12.23	0.20	0.61
10	11	30.95	21.60	27.48	3.93	20.28	0.16	0.66
Week avg		29.60	15.97	22.88	4.05	11.92	0.17	0.63
10	15	24.77	5.34	25.53	3.51	0.44	0.16	0.47
10	16	23.70	6.18	26.29	3.34	0	0.16	0.49
10	17	26.76	13.04	27.32	3.87	8.08	0.10	0.62
10	18	23.24	14.00	27.35	3.64	5.52	0.13	0.59
Week avg		24.62	9.64	26.62	3.59	3.51	0.14	0.54
10	21	31.75	5.30	26.33	3.65	6.40	0.12	0.55
10	22	26.50	15.35	29.19	3.75	8.21	0.15	0.55
10	23	25.70	18.82	29.92	3.96	9.94	0.08	0.60
10	24	32.33	19.52	30.84	4.11	16.06	0.17	0.66
10	25	27.77	19.38	31.62	4.48	10.23	0.18	0.65
Week avg		28.81	15.67	29.58	3.99	10.17	0.14	0.60
11	18	27.42	8.24	28.66	4.00	2.39	0.15	0.46
11	19	33.64	8.49	30.86	4.74	5.75	0.19	0.59
11	20	32.90	8.72	29.93	4.51	6.58	0.17	0.44
11	21	30.08	9.04	28.84	3.74	5.85	0.14	0.55
11	22	50.03	11.05	32.56	6.13	21.70	0.18	0.52
Week avg		34.81	9.11	30.17	4.62	8.45	0.17	0.51

Table A-3e. ANALYSIS OF MILLED REFUSE STREAMS
FERROUS BY CHEMICAL ANALYSIS (Fe_2O_3)
ALUMINUM BY CHEMICAL ANALYSIS (Al_2O_3)
PERCENT BY WEIGHT (RECEIVED MOISTURE BASIS)

Daily samples Date 1974 Month	Day	Ferrous (Fe_2O_3) Stream S1 Mill discharge	S2 Cyclone discharge	S3 Storage bin discharge	Aluminum (Al_2O_3) Stream S1 Mill discharge	S2 Cyclone discharge	S3 Storage bin discharge
9	23	10.30	0.85	0.77	1.69	1.41	1.76
9	24	5.84	1.42	0.65	1.37	1.43	1.36
9	25	3.74	0.77	0.66	1.50	1.16	1.20
9	26	5.33	1.75	1.14	1.29	0.90	1.07
9	27	4.40	1.37	2.42	2.04	1.79	1.68
Week avg		5.92	1.23	1.13	1.58	1.34	1.41
9	30	4.82	1.00	1.11	1.72	1.55	2.32
10	1	6.62	2.75	1.45	2.66	2.71	1.63
10	2	2.50	0.67	1.36	1.42	1.17	1.37
10	3	8.27	0.91	0.92	1.71	1.61	1.37
10	4	1.08	0.78	0.90	1.63	1.47	1.57
Week avg		4.66	1.22	1.15	1.83	1.70	1.65
Weekly composite week of (1974)							
10-7		1.60	0.88		1.41	1.78	
10-15		0.73	0.59		1.53	1.21	
10-21		0.49	0.52		1.36	1.42	
11-18		2.03	0.53		1.05	1.46	

Table A-3f. ANALYSIS OF MILLED REFUSE STREAMS
COPPER BY CHEMICAL ANALYSIS (CuO)
LEAD BY CHEMICAL ANALYSIS (PbO)
PERCENT BY WEIGHT (RECEIVED MOISTURE BASIS)

Daily samples		Copper (CuO) Stream			Lead (PbO) Stream		
Date 1974 Month	Day	S1 Mill discharge	S2 Cyclone discharge	S3 Storage bin discharge	S1 Mill discharge	S2 Cyclone discharge	S3 Storage bin discharge
9	23	0.17	0.03	0.04	0.06	0.07	0.05
9	24	0.03	0.07	0.02	0.03	0.05	0.03
9	25	0.46	1.67	0.15	0.14	0.04	0.01
9	26	0.07	0.03	0.04	0.04	0.02	0.05
9	27	0.68	0.04	0.04	0.05	0.02	0.04
Week avg		0.28	0.37	0.06	0.06	0.04	0.04
9	30	0.03	0.06	0.08	0.06	0.05	0.06
10	1	0.07	0.04	0.05	0.06	0.07	0.04
10	2	0.03	0.02	0.01	0.03	0.03	0.04
10	3	0.04	0.02	0.01	0.05	0.05	0.06
10	4	0.04	0.03	0.03	0.07	0.24	0.05
Week avg		0.04	0.03	0.04	0.05	0.09	0.05
Weekly composite week of (1974)							
10-7		0.05	0.02		0.10	0.09	
10-15		0.03	0.02		0.04	0.04	
10-21		0.01	0.01		0.04	0.07	
11-18		0.02	0.01		0.03	0.05	

Table A-3g. ANALYSIS OF MILLED REFUSE STREAMS
NICKEL BY CHEMICAL ANALYSIS (NiO)
ZINC BY CHEMICAL ANALYSIS (ZnO)
PERCENT BY WEIGHT (RECEIVED MOISTURE BASIS)

Daily samples		Nickel (NiO) Stream			Zinc (ZnO) Stream		
Date 1974		S1	S2	S3	S1	S2	S3
Month	Day	Mill discharge	Cyclone discharge	Storage bin discharge	Mill discharge	Cyclone discharge	Storage bin discharge
9	23	0.02	0.01	0.01	0.13	0.14	0.06
9	24	0.02	0.01	0.01	0.04	0.05	0.16
9	25	0.01	0.01	0.01	0.60	0.05	0.06
9	26	0.01	0.01	0.02	0.11	0.07	0.08
9	27	0.07	0.03	0.03	0.46	0.06	0.08
Week avg		0.03	0.01	0.02	0.27	0.07	0.09
9	30	0.03	0.02	0.02	0.24	0.09	0.08
10	1	0.04	0.03	0.02	0.09	0.08	0.08
10	2	0.15	0.01	0.01	0.08	0.05	0.08
10	3	0.05	0.17	0.01	0.25	0.11	0.07
10	4	0.02	0.07	0.02	0.10	0.29	0.08
Week avg		0.06	0.06	0.02	0.15	0.12	0.08
Weekly composite week of (1974)							
10-7		0.02	0.02		0.09	0.09	
10-15		0.02	0.02		0.05	0.05	
10-21		0.01	0.02		0.05	0.06	
11-18		0.01	0.02		0.04	0.07	

Table A-3h. ANALYSIS OF MILLED REFUSE STREAMS
FERROUS METAL BY VISUAL ANALYSIS
PERCENT BY WEIGHT (RECEIVED MOISTURE BASIS)

Daily samples Date 1974 Month	Day	Stream S1 ADS heavies	S5 Magnetic belt rejects	S6 Nuggetizer feed	S7 Magnetic drum rejects	S8 Ferrous metal
9	23	21.53	3.43	16.98	17.88	18.08
9	24	10.19	9.04	4.17	11.95	13.22
9	25	8.02	4.21	11.16	14.96	18.56
9	26	10.39	1.01	9.90	22.86	11.17
9	27	3.96	2.92	8.49	10.26	14.18
Week avg		10.82	4.12	10.14	15.58	15.04
9	30	5.98	3.87	11.08	13.59	15.78
10	1	8.93	5.01	20.54	17.07	13.99
10	2	9.23	2.08	8.67	14.93	12.49
10	3	7.50	2.39	17.03	9.95	13.77
10	4	7.71	1.76	12.75	12.35	16.69
Week avg		7.87	3.02	14.01	13.58	14.60
10	7		6.88			12.99
10	8		8.69			11.89
10	9		1.08			10.00
10	10		2.56			16.78
10	11		2.52			9.99
Week avg			4.35			12.33
10	15		0.02			11.98
10	16		2.85			9.98
10	17		1.61			8.99
10	18		2.15			10.99
Week avg			1.66			10.49
10	21		18.81			12.99
10	22		0.87			12.23
10	23		2.79			11.07
10	24		1.67			18.67
10	25		2.67			13.29
Week avg			5.36			13.66
11	18		2.37		8.97	10.99
11	19		1.08		15.36	11.98
11	20		0.77		11.97	7.99
11	21		2.28		14.07	15.99
11	22		3.49		14.10	13.79
Week avg			2.00		12.89	12.15

Table A-3i. ANALYSIS OF MILLED REFUSE STREAMS
TIN CANS BY VISUAL ANALYSIS
PERCENT BY WEIGHT (RECEIVED MOISTURE BASIS)

Daily samples Date 1974 Month	Day	Stream S4 ADS heavies	S5 Magnetic belt rejects	S6 Nuggetizer feed	S7 Magnetic drum rejects	S8 Ferrous metal
9	23	37.90	7.39	71.73	52.75	80.02
9	24	42.60	12.73	94.33	62.75	85.38
9	25	51.04	12.93	87.25	67.80	80.54
9	26	51.86	5.99	88.47	59.01	87.45
9	27	75.16	12.80	90.54	54.04	84.70
Week avg		51.71	10.37	88.46	59.27	83.62
9	30	45.85	30.45	86.88	67.13	83.18
10	1	48.08	23.97	78.07	62.38	85.01
10	2	53.50	14.86	87.05	65.17	86.81
10	3	51.13	9.13	81.67	70.64	85.33
10	4	42.92	16.73	85.76	66.23	82.64
Week avg		48.30	19.03	83.89	66.31	84.59
10	7		10.91			86.04
10	8		7.65			85.91
10	9		7.41			87.96
10	10		11.34			82.92
10	11		16.94			86.88
Week avg			10.85			87.94
10	15		3.67			85.89
10	16		16.87			88.86
10	17		1.10			89.86
10	18		16.50			86.90
Week avg			9.54			87.88
10	21		12.08			85.91
10	22		12.48			87.13
10	23		7.69			84.97
10	24		5.95			80.77
10	25		10.67			86.41
Week avg			11.91			85.04
11	18		5.60		73.77	86.95
11	19		5.58		65.61	0.20
11	20		4.30		75.40	90.88
11	21		7.01		73.76	83.44
11	22		11.86		76.28	81.73
Week avg			6.87		72.96	68.64

Table A-3j. ANALYSIS OF MILLED REFUSE STREAMS
ALUMINUM BY VISUAL ANALYSIS
PERCENT BY WEIGHT (RECEIVED MOISTURE BASIS)

Daily samples Date 1974 Month	Day	S4 ADS heavies	S5 Magnetic belt rejects	S6 Nuggetizer feed	S7 Magnetic drum rejects	S8 Ferrous metal
9	23	1.84	2.49	0	13.41	0.10
9	24	2.78	2.81	0	20.92	0.05
9	25	3.36	2.36	0	15.95	0.10
9	26	2.57	4.63	0	17.27	0.10
9	27	0.99	2.75	0	14.46	0.04
Week avg		2.31	3.01	0	16.40	0.08
9	30	1.99	6.86	0	13.90	0.10
10	1	2.51	2.46	0	14.97	0.05
10	2	1.71	3.57	0	17.31	0.08
10	3	1.78	3.50	0	15.92	0.004
10	4	3.44	4.53	0.02	17.33	0.10
Week avg		2.29	4.18	0.004	15.90	0.07
10	7		1.47			0.06
10	8		2.09			0.06
10	9		1.50			0.10
10	10		1.30			0.09
10	11		3.51			0.10
Week avg			1.97			0.08
10	15		1.69			0.10
10	16		1.72			0.10
10	17		2.79			0.10
10	18		3.87			0
Week avg			2.52			0.08
10	21		2.67			0.10
10	22		3.38			0.10
10	23		2.28			0.10
10	24		3.96			0.001
10	25		5.78			0.10
Week avg			3.61			0.08
11	18		4.49		13.96	0.20
11	19		6.16		16.85	0
11	20		3.44		9.67	0.08
11	21		1.69		9.58	0.10
11	22		4.53		7.90	2.60
Week avg			4.06		11.59	0.60

Table A-3k. ANALYSIS OF MILLED REFUSE STREAMS
COPPER BY VISUAL ANALYSIS
PERCENT BY WEIGHT (RECEIVED MOISTURE BASIS)

Daily samples Date 1974 Month	Day	S4 ADS heavies	S5 Magnetic belt rejects	S6 Nuggetizer feed	S7 Magnetic drum rejects	S8 Ferrous metal
9	23	0.46	0.20	0	2.68	0
9	24	0.19	1.23	0	0.20	0
9	25	0	0.30	0	0.50	0
9	26	0.10	0.29	0.01	0.20	0
9	27	0.04	0.09	0	0.58	0.01
Week avg		0.16	0.42	0.002	0.83	0.002
9	30	0.40	0.79	0	1.00	0.30
10	1	1.49	0.08	0	0.70	0
10	2	0.10	1.08	0	0.40	0.005
10	3	0.05	0.60	0	0.30	0
10	4	0.09	0.46	0	0.90	0
Week avg		0.43	0.60	0	0.66	0.06
10	7		0.92			0
10	8		0.09			0
10	9		8.41			0
10	10		1.08			0.15
10	11		1.08			0
Week avg			2.32			0.03
10	15		0.69			0
10	16		0.57			0
10	17		0.17			0
10	18		1.98			0
Week avg			0.85			0
10	21		0.18			0
10	22		1.13			0
10	23		0.51			0
10	24		0.08			0
10	25		1.33			0.03
Week avg			3.23			0.006
11	18		0.25		0.40	0
11	19		0.25		0.30	0
11	20		0.17		0.30	0
11	21		0.08		0.40	0
11	22		0.17		0.40	0.20
Week avg			0.18		0.36	0.04

Table A-31. BULK DENSITY OF MILLED REFUSE STREAMS
LB/FT^3 (RECEIVED MOISTURE BASIS)

Daily samples Date 1974 Month	Day	S1 Mill discharge	S2 Cyclone discharge	S3 Storage bin discharge	S4 ADS heavies	S5 Magnetic belt rejects	S6 Nuggetizer feed	S7 Magnetic drum rejects	S8 Ferrous metal
9	23	7.3	5.9	7.7	38.4	37.6	38.7	57.3	58.1
9	24	6.9	6.5	7.3	40.0	37.4	41.0	55.2	60.2
9	25	8.1	6.9	6.8	36.3	35.2	37.4	55.6	58.9
9	26	8.5	6.1	7.7	38.4	41.6	38.3	55.6	57.3
9	27	6.5	6.5	7.7	42.3	39.4	38.2	58.9	58.5
Week avg		7.5	6.4	7.4	39.1	38.2	38.7	56.5	58.6
9	30	8.9	8.5	8.5	39.9	36.7	35.5	59.3	61.8
10	1	7.6	6.9	8.9	39.5	34.7	37.9	56.9	59.3
10	2	8.4	6.4	8.9	37.9	32.7	36.3	56.0	55.8
10	3	8.5	6.8	8.5	37.4	37.1	41.5	57.1	58.9
10	4	8.5	6.4	9.3	35.5	44.8	42.7	56.8	59.7
Week avg		8.4	7.0	8.8	38.0	37.2	38.8	57.2	59.1
10	7	8.1	6.4			37.1			59.0
10	8	7.3	5.6			39.1			61.4
10	9	5.2	5.6			29.4			62.1
10	10	7.3	5.6			37.1			62.9
10	11	7.0	4.8			37.1			64.7
Week avg		7.0	5.6			36.0			62.0
10	15	8.9	7.7			21.8			59.3
10	16	7.7	6.4			33.1			58.2
10	17	9.7	5.8			33.5			63.9
10	18	8.5	6.8			36.6			63.9
Week avg		8.7	6.7			31.2			61.3
10	21	7.7	5.6			27.4			68.1
10	22	6.8	5.2			38.7			62.5
10	23	5.6	4.4			27.0			59.5
10	24	6.8	5.2			25.8			62.5
10	25	6.4	5.6			39.1			62.5
Week avg		6.7	5.9			31.6			63.0
11	18	7.7	5.2			42.7		58.5	61.7
11	19	6.9	4.8			33.9		58.5	57.7
11	20	5.6	4.8			40.3		65.3	60.9
11	21	6.4	4.8			39.1		66.1	60.5
11	22	4.0	4.0			40.3		66.1	63.7
Week avg		6.1	4.7			39.3		62.9	60.9

Table A-3m. ANALYSIS OF MILLED REFUSE STREAMS
PAPER BY VISUAL ANALYSIS
PERCENT BY WEIGHT (RECEIVED MOISTURE BASIS)

Daily samples Date 1974 Month	Day	S1 Mill discharge	S2 Cyclone discharge	S3 Storage bin discharge	S4 ADS heavies	S5 Magnetic belt rejects	S6 Nuggetizer feed	S7 Magnetic drum rejects	S8 Ferrous metal
9	23	47.0	64.6	59.3	1.7	2.5	0	0	0
9	24	54.9	55.2	57.9	0.6	8.3	trace	0	0
9	25	43.7	39.7	50.5	0.5	4.2	0	0	0
9	26	52.6	69.9	68.8	0.4	4.0	0	0	0
9	27	61.6	69.9	73.5	2.0	5.6	0	0.4	0
Week avg		52.0	58.9	62.0	1.0	4.9	trace	0.1	0
9	30	62.0	53.9	69.0	3.0	0.8	0.6	trace	0
10	1	64.9	65.6	64.5	1.6	6.1	trace	trace	0
10	2	63.4	55.3	63.5	0.5	3.6	0	0	0
10	3	73.7	56.6	65.0	3.4	9.6	0.1	0	0
10	4	72.0	66.3	61.3	1.0	3.0	trace	trace	0
Week avg		67.4	59.5	64.6	2.0	4.6	0.1	trace	0
10	7	47.5	42.4			9.6			trace
10	8	46.8	65.9			9.3			0
10	9	68.2	70.6			9.4			0
10	10	20.7	60.8			3.2			trace
10	11	66.4	48.3			1.5			0
Week avg		49.9	57.6			6.6			trace
10	15	38.9	52.5			9.7			0
10	16	53.4	45.6			9.0			0
10	17	50.9	67.2			22.0			0
10	18	63.4	48.8			9.4			0
Week avg		51.6	53.5			12.5			0
10	21	63.4	56.2			5.4			0
10	22	41.7	52.6			10.8			0
10	23	23.6	63.3			5.2			0
10	24	52.8	55.7			10.3			0
10	25	59.0	61.4			7.8			0
Week avg		48.1	57.8			7.9			0
11	18	58.3	70.1			1.3		0	0
11	19	54.5	71.8			6.6		0	0
11	20	27.5	68.5			1.7		0	0
11	21	73.3	46.7			4.7		0	trace
11	22	65.8	68.8			5.7		0	0
Week avg		55.9	65.2			4.0		0	trace

Table A-3n. ANALYSIS OF MILLED REFUSE STREAMS
PLASTIC BY VISUAL ANALYSIS
PERCENT BY WEIGHT (RECEIVED MOISTURE BASIS)

Daily samples Date 1974 Month	Day	S1 Mill discharge	S2 Cyclone discharge	S3 Storage bin discharge	S4 ADS heavies	S5 Magnetic belt rejects	S6 Nuggetizer feed	S7 Magnetic drum rejects	S8 Ferrous metal
9	23	7.8	2.4	1.8	0	1.0	0.2	0	0
9	24	6.4	4.2	4.0	0.7	4.9	0.1	0.7	0
9	25	12.5	4.8	16.5	1.5	1.1	0	0.5	0
9	26	9.5	5.1	9.9	1.0	5.1	0	0.2	0
9	27	3.7	3.0	1.9	0	7.1	0	0.7	0
Week avg		8.0	3.9	6.8	0.6	3.8	0.1	0.4	0
9	30	3.9	7.5	3.8	0.5	1.5	trace	trace	0
10	1	2.2	3.4	7.7	3.5	0.9	0	0	0
10	2	2.1	4.5	11.7	0	4.0	0	0	0
10	3	7.0	3.5	2.8	2.2	1.8	0	0.6	0
10	4	5.8	10.6	4.5	trace	3.4	trace	0.6	0
Week avg		4.2	5.9	6.1	1.2	2.3	trace	0.2	0
10	7	5.4	12.1			9.0			0
10	8	13.8	3.1			1.2			0
10	9	1.2	2.4			8.0			0
10	10	9.9	5.0			10.8			0.2
10	11	6.5	5.7			3.3			0
Week avg		7.4	5.7			6.5			0.04
10	15	3.6	5.7			2.7			0
10	16	1.2	4.9			7.4			0
10	17	2.1	8.1			1.2			0
10	18	2.3	3.3			1.0			0
Week avg		2.3	5.5			3.2			0
10	21	1.2	4.2			0.6			0.3
10	22	11.5	5.5			0			0
10	23	10.6	3.1			9.0			0
10	24	5.7	3.7			12.6			0
10	25	4.2	3.7			0.4			0
Week avg		6.6	4.0			4.5			0.1
11	18	6.1	8.7			3.3		0	0
11	19	6.0	4.8			13.7		0	0
11	20	8.2	6.0			1.0		3.3	0
11	21	2.2	10.3			0.6		0.2	trace
11	22	2.3	6.0			0.3		0.1	0
Week avg		5.0	7.2			3.8		0.7	trace

Table A-3o. ANALYSIS OF MILLED REFUSE STREAMS
WOOD BY VISUAL ANALYSIS
PERCENT BY WEIGHT (RECEIVED MOISTURE BASIS)

Daily samples Date 1974 Month	Day	S1 Mill discharge	S2 Cyclone discharge	S3 Storage bin discharge	S4 ADS heavies	S5 Magnetic belt rejects	S6 Nuggetizer feed	S7 Magnetic drum rejects	S8 Ferrous metal
9	23	0.9	0.9	3.4	2.6	2.4	0	0	0
9	24	0.9	1.6	3.5	0.3	6.9	0	0.1	0
9	25	3.0	5.3	1.4	6.0	5.0	0	4.6	0
9	26	trace	1.9	1.8	4.3	2.1	0	0	0
9	27	2.6	0.6	0.4	0	5.0	0	0.1	0
Week avg		1.5	2.1	2.1	2.6	4.3	0	1.0	0
9	30	2.9	1.1	3.1	5.8	2.9	0	trace	0
10	1	3.2	0	0.3	5.0	16.1	0	0	0
10	2	1.7	1.3	1.4	2.3	14.0	0	1.2	0
10	3	4.6	2.9	4.3	0.4	5.5	0	0.4	0
10	4	1.3	2.8	3.8	1.0	17.3	0	0	0
Week avg		2.7	2.0	2.6	2.9	11.2	0	0.3	0
10	7	0.9	1.1			1.3			0
10	8	2.7	1.8			15.1			0
10	9	1.4	2.4			3.5			0
10	10	2.7	4.1			16.2			0
10	11	2.7	7.2			5.0			0
Week avg		2.1	3.3			8.2			0
10	15	15.1	7.5			3.2			0
10	16	3.8	1.2			6.4			0
10	17	0.8	3.0			23.0			0
10	18	2.0	2.1			24.9			0
Week avg		5.4	3.4			14.4			0
10	21	3.0	trace			3.0			0
10	22	2.2	2.1			4.5			0
10	23	3.2	2.3			6.1			0
10	24	0	1.4			2.4			0
10	25	2.6	9.5			8.2			0
Week avg		2.2	3.1			4.8			0
11	18	0	0			0.2		0.6	0
11	19	0.9	0			2.0		0	0
11	20	22.4	1.8			4.0		0	0
11	21	2.2	6.7			20.2		0	0
11	22	3.3	1.8			5.7		1.3	0
Week avg		5.8	2.1			6.4		0.4	0

Table A-3p. ANALYSIS OF MILLED REFUSE STREAMS
GLASS BY VISUAL ANALYSIS
PERCENT BY WEIGHT (RECEIVED MOISTURE BASIS)

Daily samples Date 1974		Stream							
Month	Day	S1 Mill discharge	S2 Cyclone discharge	S3 Storage bin discharge	S4 ADS heavies	S5 Magnetic belt rejects	S6 Nuggetizer feed	S7 Magnetic drum rejects	S8 Ferrous metal
9	23	1.7	1.1	1.0	5.1	18.2	0	0	0
9	24	1.2	1.3	trace	5.8	7.0	0	0	0
9	25	0.9	0.8	0.8	3.0	24.1	0	0	0
9	26	1.8	0.9	0.7	0.9	21.1	0	0	0
9	27	0.8	3.3	1.0	5.6	17.8	0	0	0
Week avg		1.3	1.5	0.7	4.1	17.6	0	0	0
9	30	5.1	0.4	0.3	19.4	5.5	0	0	0
10	1	3.2	0	0.3	5.0	16.1	0	0	0
10	2	4.2	0.6	1.8	3.4	4.3	0	0	0
10	3	3.3	4.0	1.9	15.6	29.5	0	0	0
10	4	trace	0.6	1.7	1.9	17.3	0	0	0
Week avg		3.2	1.1	1.2	9.0	14.5	0	0	0
10	7	11.8	1.6			19.5			0
10	8	3.8	2.9			22.2			0
10	9	0.4	1.6			18.4			0
10	10	2.0	0.9			15.6			0
10	11	3.0	5.3			16.6			0
Week avg		4.2	2.5			18.5			0
10	15	0.5	2.5			3.0			0
10	16	2.7	0			13.1			0
10	17	2.5	1.0			17.1			0
10	18	6.0	1.2			15.9			0
Week avg		2.9	1.2			12.3			0
10	21	1.2	5.0			19.1			0
10	22	9.8	0.8			13.5			0
10	23	3.2	0			14.5			0
10	24	0	0			8.7			0
10	25	4.1	1.2			20.0			0
Week avg		3.7	1.4			15.2			0
11	18	1.7	0			36.9		0	0
11	19	6.9	1.0			18.4		0	0
11	20	0	1.2			23.7		0	0
11	21	0.4	0.5			11.4		0	0
11	22	0	0			26.2		0	0
Week avg		1.8	0.5			23.3		0	0

Table A-3q. ANALYSIS OF MILLED REFUSE STREAMS
MAGNETIC METAL BY VISUAL ANALYSIS
PERCENT BY WEIGHT (RECEIVED MOISTURE BASIS)

Daily Samples Date 1974 Month	Day	S1 Mill discharge	S2 Cyclone discharge	S3 Storage bin discharge	S4 ADS heavies	S5 Magnetic belt rejects	S6 Nuggetizer feed	S7 Magnetic drum rejects	S8 Ferrous metal
9	23	a/	0	0	71.2	20.3	98.7	85.0	99.8
9	24	a/	0.8	0	73.7	40.2	99.7	79.4	99.9
9	25	a/	0	0	74.7	38.4	99.9	74.2	99.9
9	26	1.4	0	1.2	83.1	36.9	99.6	80.3	97.0
9	27	1.8	0.3	0	81.5	25.0	100	82.7	99.7
Week avg		1.6	0.2	0.2	76.8	32.2	99.6	80.3	99.3
9	30	2.9	1.3	0	24.7	40.1	99.4	91.9	99.9
10	1	1.5	0	0.2	77.3	55.4	100	87.6	96.2
10	2	1.5	0	0	69.7	4.6	100	82.7	99.4
10	3	2.1	0	trace	54.5	16.7	99.9	80.9	98.6
10	4	2.4	0	trace	84.5	24.4	100	89.2	99.9
Week avg		2.2	0.3	0.04	62.1	28.2	99.9	86.5	98.8
10	7	6.6	4.0			38.0			100
10	8	2.1	0			11.2			99.9
10	9	1.8	0			0			99.1
10	10	6.3	0			7.0			99.7
10	11	2.7	0			23.4			99.9
Week avg		3.9	0.8			15.9			99.7
10	15	3.5	0			14.9			99.7
10	16	3.3	0			43.5			99.8
10	17	17.5	0			0			99.8
10	18	4.1	0			27.6			99.6
Week avg		7.1	0			21.5			99.7
10	21	1.6	0			26.8			99.7
10	22	1.0	0			10.1			99.1
10	23	2.5	0			6.6			99.5
10	24	5.0	0			0			90.8
10	25	5.8	2.0			21.6			99.9
Week avg		3.2	0.4			13.0			99.6
11	18	2.5	0			2.3		87.5	100
11	19	5.3	0			13.5		85.7	100
11	20	3.0	0			0		89.8	99.8
11	21	5.4	0			3.7		94.4	99.8
11	22	9.9	0			0.1		91.6	99.4
Week avg		5.2	0			3.9		89.8	99.8

a/ Changed inspection method to pick up metal in S1 average for 2 days only.

Table A-3r. ANALYSIS OF MILLED REFUSE STREAMS
NONMAGNETIC METAL BY VISUAL ANALYSIS
PERCENT BY WEIGHT (RECEIVED MOISTURE BASIS)

Daily samples Date 1974 Month	Day	S1 Mill discharge	S2 Cyclone discharge	S3 Storage bin discharge	S4 ADS heavies	S5 Magnetic belt rejects	S6 Nuggetizer feed	S7 Magnetic drum rejects	S8 Ferrous -metal
9	23	a/	0	0	2.5	3.0	0	14.3	0
9	24	a/	0.5	0	6.3	2.7	0	18.8	0
9	25	a/	0	0	3.9	6.0	0	15.8	0.1
9	26	0.9	0	0	3.4	1.2	0.2	19.0	0
9	27	0.3	trace	4.6	0	3.0	0	10.1	0
Week avg		0.6	0.1	0.9	3.2	3.2	0.04	15.6	0.02
9	30	0.4	2.4	0.8	8.2	9.4	0	7.9	0.1
10	1	0.2	0	0.5	2.8	2.9	0	12.4	0
10	2	0.9	0	0	5.6	24.2	0	15.0	0.1
10	3	0.3	0	0	2.0	0	0	18.1	0
10	4	trace	0.2	0	3.4	14.6	0	10.2	0.1
Week avg		0.4	0.5	0.3	4.4	10.2	0	12.7	0.1
10	7	0.7	0			0			0
10	8	0.1	0			3.8			0.1
10	9	0.4	0			18.7			0.1
10	10	0	0			2.8			0
10	11	0.1	5.7			12.3			0.1
Week avg		0.3	1.1			7.5			0.1
10	15	trace	0.9			7.9			0.1
10	16	0.2	1.6			0.5			0.1
10	17	0.4	0			0			trace
10	18	0.2	0			0			0.1
Week avg		0.2	0.6			2.1			0.1
10	21	0.3	0			3.8			0
10	22	0	0			1.5			0
10	23	0.2	0			14.7			0.2
10	24	1.0	3.7			1.3			0
10	25	0.4	0			11.4			0
Week avg		0.4	0.7			6.5			0.04
11	18	0.3	0			0		11.7	0
11	19	0.3	0			4.2		14.3	0
11	20	0	1.8			6.1		6.7	0.2
11	21	1.1	0			3.5		5.4	trace
11	22	0.4	0			3.5		7.0	0.5
Week avg		0.4	0.4			3.5		9.0	0.1

a/ Changed inspection method to pick up metal in S1. Average for 2 days only.

Table A-3s. ANALYSIS OF MILLED REFUSE STREAMS
ORGANICS BY VISUAL ANALYSIS
PERCENT BY WEIGHT (RECEIVED MOISTURE BASIS)

Daily samples Date 1974 Month	Day	S1 Mill discharge	S2 Cyclone discharge	S3 Storage bin discharge	S4 ADS heavies	S6 Magnetic belt rejects	S6 Nuggetizer feed	S7 Magnetic drum rejects	S8 Ferrous metal
9	23	1.4	0.2	0	4.8	6.0	0	00	0
9	24	3.8	5.5	0.8	1.6	8.1	0	0	0
9	25	0.3	12.0	0.6	2.6	7.8	0	0	0
9	26	7.0	0.5	0.9	5.0	12.8	0	0	0
9	27	0	0.6	0	6.3	22.8	0	0.5	0
Week avg		2.5	3.8	0.5	4.1	11.5	0	0.1	0
9	30	0	4.0	0	18.5	26.8	0	0	0
10	1	0	1.4	0	5.8	4.1	0	0	0
10	2	4.2	2.3	0	13.1	20.1	0	1.1	0
10	3	4.4	0	2.3	10.0	16.3	0	0	0
10	4	0	1.5	0.9	7.0	13.7	0	0	0
Week avg		1.7	1.8	0.6	10.9	16.2	0	0.2	0
10	7	1.5	0			12.5			0
10	8	2.4	2.1			25.2			0
10	9	4.6	trace			14.8			0
10	10	7.3	0.7			18.5			0
10	11	0	3.0			7.3			0
Week avg		3.2	1.2			16.7			0
10	15	0.8	2.0			10.0			0
10	16	5.0	21.5			14.4			0
10	17	4.6	3.0			14.3			0
10	18	2.0	0			9.5			0
Week avg		3.1	6.6			12.2			0
10	21	2.5	2.1			28.0			0
10	22	10.9	9.3			34.4			0
10	23	4.9	4.7			19.4			0
10	24	0	1.4			40.0			0
10	25	3.1	1.6			14.4			0
Week avg		4.3	3.8			27.2			0
11	18	0	1.2			29.0		0	0
11	19	0	2.4			29.7		0	0
11	20	2.0	1.8			35.8		0	0
11	21	0.4	5.6			31.0		0	0
11	22	4.2	1.8			33.7		0	0
Week avg		1.3	2.6			31.8		0	0

Table A-3t. ANALYSIS OF MILLED REFUSE STREAMS
MISCELLANEOUS MATERIAL BY VISUAL ANALYSIS
(NOT OTHERWISE CLASSIFIED AS PAPER, PLASTIC,
WOOD, GLASS, METAL OR ORGANICS)
PERCENT BY WEIGHT (RECEIVED MOISTURE BASIS)

Daily samples Date 1974		Stream							
Month	Day	S1 Mill discharge	S2 Cyclone discharge	S3 Storage bin discharge	S4 ADS heavies	S5 Magnetic belt rejects	S6 Nuggetizer feed	S7 Magnetic drum rejects	S8 Ferrous metal
9	23	41.2	30.8	34.3	12.1	46.6	1.1	0.7	0.2
9	24	32.8	30.9	33.8	11.0	21.9	0.2	1.0	0.1
9	25	39.4	37.4	30.2	7.8	13.4	0.1	4.9	0
9	26	26.8	21.7	16.7	1.9	16.8	0.2	0	3.0
9	27	29.2	27.3	18.6	4.6	13.7	0	6.0	0.3
Week avg		33.9	29.6	26.7	7.5	22.5	0.3	2.5	0.7
9	30	22.0	29.4	23.0	19.9	14.0	0	0.2	0
10	1	26.6	29.0	24.5	4.0	10.6	0	0	3.8
10	2	22.0	36.0	21.6	5.4	25.1	trace	0	0.5
10	3	4.6	33.0	23.7	11.4	20.6	0	0	1.4
10	4	18.0	18.0	27.8	0.9	18.7	0	trace	0
Week avg		18.6	29.1	24.1	8.3	17.8	trace	0.04	1.1
10	7	25.6	38.8			10.1			0
10	8	28.3	24.2			12.0			0
10	9	22.0	23.0			22.2			Trace
10	10	51.1	28.5			25.9			0.1
10	11	18.6	24.8			30.6			0
Week avg		29.1	27.9			20.2			0.02
10	15	32.0	28.9			47.9			0.2
10	16	30.4	25.2			10.2			0.1
10	17	21.2	17.7			22.4			0.2
10	18	20.1	44.6			11.7			0.3
Week avg		26.1	29.1			23.1			0.2
10	21	26.8	32.5			13.3			0
10	22	22.9	29.7			25.2			0.9
10	23	51.8	26.6			24.5			0.3
10	24	35.5	34.1			24.7			0.2
10	25	20.8	20.6			16.2			0.1
Week avg		31.6	28.7			20.8			0.3
11	18	31.1	20.0			27.0		0.2	0
11	19	26.1	20.0			11.9		0	0
11	20	36.9	18.9			27.7		0.2	0
11	21	15.0	30.2			24.9		0	0
11	22	14.1	21.6			24.8		Trace	0.1
Week avg		24.6	22.1			23.3		0.1	0.02

Table A-3u. ANALYSIS OF MILLED REFUSE STREAMS
SQUARE SCREEN SIZE
PERCENT BY WEIGHT (RECEIVED MOISTURE BASIS)

(LARGER THAN 2.5 IN.)

Daily samples Date 1974 Month	Day	Stream S1 Mill discharge	S2 Cyclone discharge	S4 ADS heavies	S5 Magnetic belt rejects	S6 Nuggetizer feed	Ferrous metal
9	23	0	0	0	0	7.4	0
9	24	0	0	0	0	0	0
9	25	10.9	8.7	15.9	0	0	0
9	26	0	6.3	0	0	0	0
9	27	26.0	0	0	8.1	0	0
Week avg		7.4	3.0	3.2	1.6	1.5	0
9	30	0	0	0	0	2.3	0.7
10	1	0	0	0	0	0	0
10	2	0	0	0	3.1	0	0
10	3	0	0	0	0	0	0
10	4	0	0	0	0	0	0
Week avg		0	0	0	0.6	0.5	0.1
10	7	0	0		11.0		0
10	8	0	1.0		0		0
10	9	0	0		0		0
10	10	2.9	0		0		0
10	11	0	0		0		0
Week avg		0.6	0.2		2.2		0
10	15	0	0		0		0
10	16	0	0		0		0
10	17	0	0		0		0
10	18	0	0		0		0
Week avg		0	0		0		0
10	21	0	0		5.4		0
10	22	0	0		0		0
10	23	0	0		24.2		0
10	24	0	0		0		0
10	25	0	0		0		0
Week avg		0	0		5.9		0
11	18	0	0		4.7		0
11	19	0	2.6		0		0
11	20	0	1.3		0		0
11	21	0	0		0		0
11	22	0	5.8		0		0
Week avg		0	1.9		0.9		0

Table A-3u. (Continued)

(SMALLER THAN 2.5 IN.)

Daily samples Date 1974 Month	Day	S1 Mill discharge	S2 Cyclone discharge	S4 ADS heavies	S5 Magnetic belt rejects	S6 Nuggetizer feed	S8 Ferrous metal
		Stream					
9	23	100	100	100	100	92.6	100
9	24	100	100	100	100	100	100
9	25	89.1	91.3	84.1	100	100	100
9	26	100	93.7	100	100	100	100
9	27	74.0	100	100	91.9	100	100
Week avg		92.6	97.0	96.8	98.4	98.5	100
9	30	100	100	100	100	97.7	99.3
10	1	100	100	100	100	100	100
10	2	100	100	100	96.9	100	100
10	3	100	100	100	100	100	100
10	4	100	100	100	100	100	100
Week avg		100	100	100	99.4	99.5	99.9
10	7	100	100		89.0		100
10	8	100	99.0		100		100
10	9	100	100		100		100
10	10	97.1	100		100		100
10	11	100	100		100		100
Week avg		99.4	99.8		97.8		100
10	15	100	100		100		100
10	16	100	100		100		100
10	17	100	100		100		100
10	18	100	100		100		100
Week avg		100	100		100		100
10	21	100	100		94.6		100
10	22	100	100		100		100
10	23	100	100		75.8		100
10	24	100	100		100		100
10	25	100	100		100		100
Week avg		100	100		94.1		100
11	18	100	100		95.3		100
11	19	100	97.4		100		100
11	20	100	98.7		100		100
11	21	100	100		100		100
11	22	100	94.2		100		100
Week avg		100	98.1		99.1		100

Table A-3u. (Continued)

(SMALLER THAN 1.5 IN.)

Daily samples Date 1974 Month	Day	S1 Mill discharge	S2 Cyclone discharge	S4 ADS heavies	S5 Magnetic belt rejects	S6 Nuggetizer feed	S8 Ferrous metal
		Stream					
9	23	100	97.1	100	88.9	74.5	100
9	24	89.2	100	87.7	100	100	97.7
9	25	61.0	83.5	72.7	100	91.8	100
9	26	89.9	86.3	82.2	89.9	71.2	100
9	27	71.9	93.2	87.2	91.9	56.7	100
Week avg		82.4	92.0	86.0	94.1	78.8	99.5
9	30	100	100	92.7	100	94.3	99.3
10	1	95.4	99.2	98.0	86.4	69.9	100.0
10	2	100	100	94.7	88.8	67.6	100.0
10	3	97.3	99.1	100	84.8	85.1	99.2
10	4	92.4	95.3	94.6	93.2	94.4	100.0
Week avg		97.0	98.7	96.0	90.6	82.3	99.7
10	7	100	99.0		89.0		98.4
10	8	96.7	99.0		100		100
10	9	96.4	95.7		100		96.2
10	10	92.1	100		100		100
10	11	96.9	89.7		100		100
Week avg		96.4	96.7		97.8		98.9
10	15	96.1	100		99.0		100
10	16	98.9	100		98.6		100
10	17	97.2	97.2		99.6		100
10	18	100	96.7		94.6		100
Week avg		98.1	98.5		98.0		100
10	21	99.1	93.5		94.5		100
10	22	100	96.6		100		97.0
10	23	93.2	98.7		75.8		100
10	24	96.0	97.5		99.1		100.0
10	25	98.8	96.5		97.5		100.0
Week avg		97.4	96.6		93.4		99.4
11	18	98.0	93.7		93.8		100.0
11	19	97.6	93.6		97.5		98.0
11	20	95.5	92.6		97.8		95.4
11	21	98.8	93.4		93.1		97.5
11	22	96.1	91.2		92.2		95.6
Week avg		97.2	92.4		94.9		97.3

Table A-3u. (Continued)

(SMALLER THAN 0.75 IN.)

Daily samples Date 1974 Month	Day	S1 Mill discharge	S2 Cyclone discharge	S4 ADS heavies	S5 Magnetic belt rejects	S6 Nuggetizer feed	S8 Ferrous metal
9	23	77.9	71.4	14.8	59.9	1.9	85.6
9	24	71.4	82.3	20.7	71.3	11.8	46.9
9	25	37.0	60.2	16.4	60.0	18.4	58.6
9	26	63.1	68.4	17.4	65.4	2.5	65.5
9	27	46.5	73.5	28.1	67.9	8.3	59.6
Week avg		59.2	71.2	19.5	64.9	8.6	63.2
9	30	77.2	86.5	17.4	55.6	12.3	61.0
10	1	65.9	84.7	26.7	47.8	11.1	60.4
10	2	84.7	81.4	39.0	59.7	10.7	47.7
10	3	61.3	84.5	21.7	50.0	26.0	53.2
10	4	71.4	79.1	48.6	77.3	6.9	50.5
Week avg		72.1	83.2	30.7	58.1	13.4	54.6
10	7	57.5	74.7		65.4		56.4
10	8	84.6	82.8		71.9		63.2
10	9	83.3	83.9		80.0		39.6
10	10	50.0	78.3		77.1		45.0
10	11	82.6	70.5		62.2		49.0
Week avg		71.6	78.0		71.3		50.8
10	15	83.1	86.9		82.9		46.0
10	16	87.6	81.2		95.0		50.1
10	17	72.6	78.9		75.2		39.0
10	18	68.7	80.4		66.4		64.0
Week avg		78.0	81.9		79.9		49.8
10	21	76.8	68.5		41.3		53.7
10	22	60.2	69.5		66.1		60.4
10	23	75.7	84.8		62.1		63.2
10	24	67.3	69.1		72.4		58.5
10	25	84.1	74.7		64.2		49.8
Week avg		72.8	73.3		61.2		57.1
11	18	84.0	75.2		59.6		50.0
11	19	61.7	55.1		86.2		45.2
11	20	65.8	67.0		66.4		55.9
11	21	82.7	64.1		65.7		42.2
11	22	55.9	66.6		60.0		49.2
Week avg		70.0	65.6		67.7		48.5

Table A-3u. (Continued)

(SMALLER THAN 0.375 IN.)

Daily samples Date 1974 Month	Day	Stream S1 Mill discharge	S2 Cyclone discharge	S4 ADS heavies	S5 Magnetic belt rejects	S6 Nuggetizer feed	S8 Ferrous metal
9	23	53.3	50.0	5.5	29.9	0.7	14.4
9	24	50.5	58.3	7.0	34.3	0.9	4.5
9	25	22.4	38.8	4.6	26.8	0.8	5.7
9	26	39.9	45.3	4.7	49.2	0.5	9.4
9	27	27.6	45.4	11.0	38.3	0.4	13.0
Week avg		38.7	47.6	6.6	35.7	0.7	9.4
9	30	52.2	64.7	17.1	22.5	2.2	9.9
10	1	46.6	62.1	11.5	21.6	1.3	6.4
10	2	52.5	55.8	11.3	36.0	0.6	6.6
10	3	30.6	62.7	6.6	22.6	1.6	7.7
10	4	43.8	47.7	14.7	43.3	1.0	7.9
Week avg		45.1	58.6	12.2	29.2	1.3	7.1
10	7	35.9	50.5	52.2	52.2		13.1
10	8	51.6	60.0	40.1	40.1		18.8
10	9	51.2	58.1	45.1	45.1		2.9
10	10	35.0	51.8	42.6	42.6		4.3
10	11	55.1	46.1	28.6	28.6		5.1
Week avg		45.8	53.3	41.7	41.7		8.8
10	15	58.4	66.3		45.7		10.7
10	16	61.8	54.7		50.4		2.1
10	17	50.0	55.0		39.0		6.8
10	18	46.5	54.3		18.3		11.4
Week avg		54.2	57.6		38.4		7.8
10	21	55.3	43.5		29.4		11.2
10	22	37.3	44.1		40.3		12.6
10	23	47.3	55.7		29.1		4.3
10	24	39.6	45.7		34.4		6.4
10	25	56.1	47.1		35.7		4.9
Week avg		47.1	47.2		32.0		7.9
11	18	53.2	49.3		33.3		7.3
11	19	39.6	34.6		48.5		11.0
11	20	38.2	37.7		35.1		5.8
11	21	49.4	38.0		28.2		2.0
11	22	31.2	39.1		29.5		3.0
Week avg		42.3	39.7		34.4		5.8

Table A-3u. (Continued)

(SMALLER THAN 0.187 IN.)

Daily samples Date 1974 Month	Day	Stream S1 Mill discharge	S2 Cyclone discharge	S4 ADS heavies	S5 Magnetic belt rejects	S6 Nuggetizer feed	S8 Ferrous metal
9	23	35.3	34.3	1.9	10.0	0.6	0.9
9	24	33.5	40.6	1.9	12.1	0.3	0.3
9	25	12.5	23.3	2.1	6.9	0.4	1.1
9	26	23.8	29.5	1.1	17.1	0.3	0.9
9	27	15.7	28.8	3.5	14.2	0.3	1.9
Week avg		24.2	31.3	2.1	12.1	0.4	1.0
9	30	31.6	47.4	5.4	7.9	0.5	0.7
10	1	28.4	40.3	2.8	7.6	0.3	0.4
10	2	32.3	36.0	3.2	14.8	0.3	0.6
10	3	11.7	40.0	3.4	7.6	0.4	0.3
10	4	14.3	27.9	4.9	13.1	0.3	0.3
Week avg		23.7	38.3	3.9	10.2	0.4	0.5
10	7	22.2	34.3		23.6		0.9
10	8	33.0	39.0		13.9		1.5
10	9	29.8	33.3		17.8		0.3
10	10	26.4	34.9		16.1		0.4
10	11	29.7	29.5		9.5		0.7
Week avg		28.2	34.2		16.2		0.8
10	15	37.7	44.6		21.5		0.6
10	16	37.1	34.4		14.9		0.3
10	17	29.2	35.8		12.7		0.3
10	18	28.3	32.6		5.4		0.8
Week avg		33.1	36.9		13.6		0.5
10	21	37.5	27.2		8.0		0.9
10	22	21.7	28.8		14.3		0.8
10	23	32.4	35.4		13.4		0.4
10	24	25.7	30.9		12.9		1.1
10	25	34.1	31.0		12.4		0.3
Week avg		30.3	30.7		12.2		0.8
11	18	30.8	30.8		13.4		0.7
11	19	23.6	21.8		16.8		1.0
11	20	22.3	21.9		11.4		0.5
11	21	26.4	23.9		8.0		0.2
11	22	18.2	21.7		10.0		0.2
Week avg		24.3	24.0		11.9		0.5

Table A-3u. (Concluded)

(SMALLER THAN 0.094 IN.)

Daily samples Date 1974 Month	Day	Stream: S1 Mill discharge	S2 Cyclone discharge	S4 ADS heavies	S5 Magnetic belt rejects	S6 Nuggetizer feed	S8 Ferrous metal
9	23	24.6	22.2	1.3	4.8	0.2	0.4
9	24	23.4	24.1	1.0	5.4	0.1	0.2
9	25	8.3	14.6	1.2	1.1	0.2	0.1
9	26	15.5	21.1	0.6	6.6	0.1	0.1
9	27	11.4	18.2	1.5	6.9	0.1	0.4
Week avg		16.6	20.0	1.1	5.0	0.1	0.2
9	30	18.4	29.5	2.0	2.3	0.2	0.1
10	1	18.2	25.0	1.0	3.6	0.1	0.2
10	2	19.6	22.1	1.5	6.1	0.2	0.2
10	3	0.9	27.3	2.1	3.5	0.2	0.1
10	4	1.0	18.6	2.0	4.3	0.2	0.2
Week avg		11.6	24.5	1.7	4.0	0.2	0.2
10	7	14.4	23.2		12.0		0.3
10	8	20.9	26.7		4.9		0.1
10	9	17.9	21.5		7.3		0.2
10	10	18.6	25.3		5.4		0.2
10	11	18.7	20.5		5.1		0.1
Week avg		18.1	23.4		6.9		0.2
10	15	23.4	27.2		9.6		0.2
10	16	22.5	20.3		5.2		0.2
10	17	17.0	22.9		4.4		0.2
10	18	17.2	21.7		2.7		0.2
Week avg		20.0	23.0		5.5		0.2
10	21	24.1	19.6		3.5		0.1
10	22	15.7	20.3		5.4		0.2
10	23	23.0	25.3		7.3		0.1
10	24	18.8	22.2		5.7		0.1
10	25	23.2	21.8		4.6		0.1
Week avg		21.0	21.8		5.3		0.1
11	18	19.6	22.2		5.7		0.1
11	19	16.0	14.1		6.2		0.3
11	20	18.1	15.8		3.8		0.2
11	21	18.4	16.3		3.0		0.1
11	22	13.0	13.0		3.4		0.1
Week avg		17.0	16.3		4.5		0.2

Table A-3v. ANALYSIS OF MILLED REFUSE STREAMS
PARTICLE SIZE - GEOMETRIC MEAN DIAMETER - INCH
PERCENT BY WEIGHT (RECEIVED MOISTURE BASIS)

Daily samples Date 1974 Month	Day	Stream S1 Mill discharge	S2 Cyclone discharge	S4 ADS heavies	S5 Magnetic belt rejects	S6 Nuggetizer feed	S8 Ferrous metal
9	23	0.28	0.31	0.90	0.55	1.24	0.53
9	24	0.33	0.26	0.92	0.45	0.97	0.75
9	25	0.80	0.47	1.12	0.55	0.97	0.67
9	26	0.42	0.38	1.00	0.43	1.23	0.63
9	27	0.68	0.35	0.84	0.47	1.29	0.63
Week avg		0.50	0.35	0.96	0.49	1.14	0.64
9	30	0.31	0.22	0.83	0.58	1.00	0.65
10	1	0.36	0.25	0.80	0.66	1.16	0.66
10	2	0.29	0.27	0.75	0.51	1.19	0.72
10	3	0.52	0.24	0.84	0.65	0.95	0.70
10	4	0.45	0.33	0.67	0.42	1.03	0.71
Week avg		0.39	0.26	0.78	0.56	1.07	0.69
10	7	0.43	0.30		0.41		0.66
10	8	0.29	0.25		0.43		0.59
10	9	0.31	0.28		0.37		0.81
10	10	0.46	0.28		0.40		0.75
10	11	0.30	0.36		0.51		0.73
Week avg		0.36	0.29		0.42		0.71
10	15	0.27	0.22		0.35		0.71
10	16	0.25	0.28		0.34		0.74
10	17	0.34	0.28		0.43		0.77
10	18	0.35	0.29		0.58		0.63
Week avg		0.30	0.27		0.42		0.71
10	21	0.28	0.37		0.67		0.67
10	22	0.42	0.35		0.44		0.65
10	23	0.32	0.27		0.61		0.66
10	24	0.38	0.34		0.45		0.67
10	25	0.27	0.32		0.48		0.72
Week avg		0.33	0.33		0.53		0.68
11	18	0.29	0.32		0.51		0.71
11	19	0.40	0.47		0.36		0.72
11	20	0.40	0.41		0.48		0.71
11	21	0.31	0.41		0.53		0.79
11	22	0.48	0.43		0.54		0.76
Week avg		0.38	0.41		0.49		0.74

Table A-3w. ANALYSIS OF MILLED REFUSE STREAMS
PARTICLE SIZE - GEOMETRIC STANDARD DEVIATION

Daily samples Date 1974 Month	Day	Stream S1 Mill discharge	S2 Cyclone discharge	S4 ADS heavies	S5 Magnetic belt rejects	S6 Nuggetizer feed	S8 Ferrous metal
9	23	2.80	2.95	1.59	2.35	1.47	1.49
9	24	3.16	2.71	1.74	2.14	1.31	1.55
9	25	2.99	3.18	1.91	1.95	1.45	1.54
9	26	2.92	3.28	1.67	2.56	1.40	1.56
9	27	3.30	2.86	1.92	2.55	1.52	1.67
Week avg		3.03	3.00	1.77	2.31	1.43	1.56
9	30	2.66	2.69	2.02	2.01	1.45	1.60
10	1	2.91	2.67	1.77	2.26	1.54	1.53
10	2	2.55	2.68	1.85	2.57	1.52	1.56
10	3	2.11	2.71	1.72	2.29	1.57	1.57
10	4	2.23	2.72	1.95	2.23	1.33	1.57
Week avg		2.49	2.69	1.86	2.27	1.48	1.57
10	7	2.72	2.86		3.02		1.68
10	8	2.68	2.78		2.17		1.70
10	9	2.62	2.70		2.20		1.54
10	10	3.18	2.82		2.16		1.52
10	11	2.63	3.05		2.14		1.54
Week avg		2.77	2.84		2.34		1.60
10	15	2.77	2.62		2.29		1.63
10	16	2.56	2.64		1.92		1.48
10	17	2.75	2.82		2.10		1.56
10	18	2.74	2.76		1.95		1.59
Week avg		2.70	2.71		2.06		1.56
10	21	2.84	2.94		2.23		1.63
10	22	2.72	2.90		2.25		1.67
10	23	2.98	2.71		3.00		1.49
10	24	2.86	2.95		2.17		1.55
10	25	2.67	2.87		2.24		1.52
Week avg		2.81	2.87		2.38		1.57
11	18	2.60	2.93		2.45		1.57
11	19	2.79	2.88		2.14		1.67
11	20	2.82	2.82		2.17		1.60
11	21	2.55	2.86		2.13		1.50
11	22	2.68	2.85		2.26		1.55
Week avg		2.69	2.87		2.23		1.58

Table A-4a. WEEKLY SUMMARY WEIGHTED AVERAGE HEATING VALUE (Btu/lb)
TOTAL HEAT ENERGY (Btu x 10^6)

No.	Week of 1974 Month	Week of 1974 Day		S1 Mill discharge	S2 Cyclone discharge	S3 Cyclone bin discharge	S4 ADS heavies	S5 Mag. belt rejects	S7 Mag. drum rejects	S8 Mag. metal
1	9	23	Weighted Avg Heating Value	4,593.3	4,913.6	4,853.2	2,557.7	2,580.3	2,983.4	2,233.3
			Total Heat Energy	14,046	11,651	11,267=	990	545	7.16	344
2	9	30	Weighted Avg Heating Value	4,645.4	4,891.6	4,812.9	2,580.4	2,733.1	3,104.5	2,223.9
			Total Heat Energy	14,346	11,695	11,195	1,204	755	7.45	417
3	10	7	Weighted Avg Heating Value	5,425.5	5,534.6			2,326.7		2,287.0
			Total Heat Energy	9,802	7,960			337		2,663
4	10	14	Weighted Avg Heating Value	4,601.2	4,818.0			2,514.0		2,237.7
			Total Heat Energy	7,152	5,640			305		171
5	10	21	Weighted Avg Heating Value	5,016.7	5,344.6			3,317.8		2,238.3
			Total Heat Energy	7,790	6,681			449		167
8	11	18	Weighted Avg Heating Value	5,278.8	5,210.4			2,165.4	3,232.4	2,232.2
			Total Heat Energy	11,242	9,366			362	7.76	245
9	11	25	Weekly Composite Heating Value	5,063.5	5,541.7			3,461.0	2,774.7	2,235.7
			Total Heat Energy	4,684	3,856			243	3.33	102

Table A-4b. WEEKLY SUMMARY WEIGHTED AVERAGE PERCENT OF MAGNETIC METAL

Week of 1974 Mo.	Day	S2 Cyclone discharge	S5 Magnetic belt rejects	S7 Magnetic drum rejectes	S8 Magnetic metal stream
9	23	0.3	32.6	78.8	98.9
9	30	0.2	30.1	85.9	98.8
10	7	1.0	18.1	86.3[a]	99.6
10	15	0	20.9	86.3[a]	99.7
10	21	0.4	12.9	86.3[a]	97.5
11	18	0	4.8	88.9	99.8
11	25	0	17.1	91.5	99.9

a/ Average of weeks 9-23, 30; 11-18, 25.

Table A-5a. SAMPLE VARIABILITY OF MILLED REFUSE--RESULTS BY WEIGHT (RECEIVED MOISTURE BASIS)

Spectrum	Date 1974 Month	Date 1974 Day	Time for eight sub-samples (hr)	Stream	Mean	Individual subsamples 1	2	3	4	5	6	7	8
Moisture (%)	10	1	2	S1	31.23	33.10	11.10	33.50	33.10	36.80	37.50	33.20	31.50
				S2	30.63	30.10	22.90	35.90	33.80	25.50	34.20	33.10	29.50
	9	26	1	S2	27.63	27.10	30.50	27.00	29.70	32.20	24.20	24.20	26.10
				S3	29.36	30.20	30.10	30.00	28.80	28.00	30.40	28.00	29.40
Heating valve (Btu/lb)	10	1	2	S1	4,680.9	4,319.7	7,381.9	3,630.3	4,582.7	3,756.2	4,111.0	4,520.3	5,144.8
				S2	4,391.8	4,455.2	4,849.0	3,904.3	4,500.9	4,463.0	4,372.2	4,148.2	4,441.9
	9	26	1	S2	4,791.0	4,199.8	4,919.1	4,997.3	4,786.1	4,647.6	5,164.9	4,399.0	5,214.5
				S3	4,908.4	4,937.1	5,111.2	5,225.5	4,904.4	4,689.7	4,723.1	4,968.1	4,708.0
Ash (%)	10	1	2	S1	19.17	18.16	24.81	25.93	18.40	16.80	16.62	18.27	14.37
				S2	19.91	19.49	23.94	21.32	16.14	24.42	16.13	18.48	19.39
	9	26	1	S2	19.84	19.84	16.69	20.71	18.50	17.25	18.72	28.98	18.04
				S3	18.47	18.91	17.98	11.31	20.19	22.31	20.79	16.21	20.04
Metal content by chemical analysis (%)													
Fe (Fe_2O_3)	10	1	2	S1	1.17	0.81	1.24	2.23	1.01	1.01	1.00	0.91	1.17
				S2	0.78	0.68	1.21	1.21	0.59	0.79	0.55	0.47	0.74
	9	26	1	S2	1.56	2.34	2.09	1.45	1.01	0.94	1.06	2.06	1.54
				S3	1.71	2.69	2.64	1.03	1.67	1.42	1.46	0.82	1.97
Al (Al_2O_3)	10	1	2	S1	1.36	1.10	1.57	1.63	1.06	1.23	1.21	1.40	1.55
				S2	1.38	1.22	1.56	2.21	1.04	1.53	1.10	1.08	1.30
	9	26	1	S2	1.76	1.41	1.57	1.70	1.63	1.63	1.55	2.64	1.93
				S3	1.99	2.83	2.20	1.25	1.87	2.81	1.94	1.23	1.79
CU (CuO)	10	1	2	S1	0.06	0.01	0.05	0.14	0.02	0.03	0.03	0.01	0.15
				S2	0.03	0.01	0.02	0.04	0.05	0.04	0.01	0.01	0.02
	9	26	1	S2	0.06	0.05	0.03	0.14	0.03	0.06	0.03	0.11	0.04
				S3	0.04	0.06	0.06	0.04	0.03	0.05	0.04	0.02	0.04
Pb (PbO)	10	1	2	S1	0.06	0.09	0.01	0.10	0.03	0.07	0.07	0.05	0.03
				S2	0.08	0.21	0.07	0.06	0.04	0.05	0.05	0.04	0.10
	9	26	1	S2	0.04	0.06	0.01	0.09	0.03	0.05	0.01	0.07	0.02
				S3	0.04	0.04	0.03	0.01	0.04	0.04	0.03	0.04	0.05
Ni (NiO)	10	1	2	S1	0.02	0.01	0.03	0.05	0.02	0.03	0.03	0.01	0.01
				S2	0.02	0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.02
	9	26	1	S2	0.01	0.01	0.02	0.01	0.01	0.01	0.02	0.02	0.01
				S3	0.02	0.01	0.02	0.01	0.02	0.03	0.02	0.02	0.03
Zn (ZnO)	10	1	2	S1	0.10	0.10	0.20	0.11	0.05	0.04	0.04	0.09	0.14
				S2	0.08	0.18	0.08	0.10	0.05	0.04	0.05	0.06	0.06
	9	26	1	S2	0.09	0.08	0.10	0.07	0.12	0.07	0.09	0.08	0.07
				S3	0.07	0.07	0.06	0.06	0.06	0.07	0.08	0.08	0.10

Table A-5a. (Continued)

Spectrum	Date 1974 Month	Date 1974 Day	Time for eight sub-samples (hr)	Stream	Mean	Individual subsamples 1	2	3	4	5	6	7	8
Proximate and ultimate analysis (%)													
Volatile matter	10	1	2	S2	27.22	27.75	32.03	27.90	23.17	31.61	23.19	26.31	25.80
	9	26	1	S2	27.54	27.24	24.12	26.51	25.65	24.65	29.65	34.38	27.08
				S3	25.58	26.37	24.36	20.20	27.06	29.09	26.79	24.18	26.55
Fixed carbon	10	1	2	S2	2.43	1.62	3.48	0.00	4.51	0.00	3.97	1.31	4.51
	9	26	1	S2	5.95	6.07	7.50	6.07	5.27	4.07	9.10	0.00	9.50
				S3	5.86	3.43	6.52	17.49	3.45	0.45	0.86	11.44	3.25
Carbon	10	1	2	S2	23.57	23.40	26.51	20.26	23.69	24.50	23.59	22.04	24.60
	9	26	1	S2	26.16	28.22	27.40	26.43	25.28	24.75	26.08	24.11	27.03
				S3	25.91	26.20	26.86	27.94	25.49	25.08	24.34	26.21	25.16
Hydrogen	10	1	2	S2	3.38	3.40	3.96	2.82	3.26	3.58	3.37	3.12	3.55
	9	26	1	S2	3.76	3.89	3.84	4.32	3.56	3.55	3.10	3.92	3.92
				S3	3.73	3.53	3.94	4.10	3.70	3.52	3.64	3.82	3.62
Oxygen (by dif-ference)	10	1	2	S2	1.52	1.85	4.35	0.00	0.07	2.47	0.00	1.87	1.54
	9	26	1	S2	2.05	0.42	0.00	1.15	1.18	0.00	8.76	0.00	4.92
				S3	1.37	0.00	0.00	4.93	0.56	0.19	0.00	4.90	0.40
Sulfur	10	1	2	S2	0.16	0.13	0.22	0.30	0.14	0.10	0.11	0.13	0.13
	9	26	1	S2	0.23	0.20	0.13	0.22	0.42	0.14	0.21	0.33	0.21
				S3	0.15	0.19	0.19	0.11	0.13	0.12	0.23	0.12	0.10
Nitrogen	10	1	2	S2	0.48	0.59	0.46	0.51	0.53	0.43	0.42	0.45	0.48
	9	26	1	S2	0.53	0.57	0.64	0.46	0.48	0.49	0.58	0.56	0.49
				S3	0.59	0.53	0.61	0.62	0.63	0.62	0.58	0.58	0.53

Table A-5a. (Continued)

Spectrum	Date 1974 Month	Date 1974 Day	Time for eight sub-samples (hr)	Stream	Mean	Individual subsamples 1	2	3	4	5	6	7	8
Bulk density (lb/ft^3)	10	1	2	S1	9.1	7.3	8.1	12.1	8.5	9.8	8.1	10.3	8.9
				S2	7.1	6.5	6.5	8.8	6.8	6.8	6.9	6.5	7.7
	9	26	1	S2	6.8	6.5	7.1	6.5	6.1	7.3	6.5	8.5	6.0
				S3	7.6	6.9	7.3	6.5	7.3	8.5	8.5	7.3	8.5
Composition by visual analysis (%)													
Paper	10	1	2	S1	56.5	53.0	44.7	52.3	64.3	58.2	48.5	59.9	71.4
				S2	67.1	65.6	66.6	41.4	64.3	85.8	81.3	61.4	70.1
	9	26	1	S2	62.8	66.5	67.0	66.8	55.9	62.3	60.5	53.3	70.3
				S3	64.1	81.3	67.9	57.6	57.4	63.4	61.1	58.6	65.4
Plastic	10	1	2	S1	7.2	2.4	4.1	4.6	0.6	9.9	33.0	1.3	1.6
				S2	4.5	5.6	9.0	12.4	2.8	1.7	0.7	2.5	1.6
	9	26	1	S2	8.6	11.0	3.9	13.7	5.9	11.4	15.9	3.3	3.5
				S3	5.9	12.1	13.7	2.9	2.6	1.7	5.4	2.7	6.4
Wood	10	1	2	S1	4.6	15.3	3.2	2.0	7.0	2.7	1.0	2.0	3.4
				S2	2.2	1.6	2.5	0.0	0.5	1.4	2.5	4.2	4.9
	9	26	1	S2	3.3	2.6	2.0	0.8	4.9	3.8	1.6	3.3	7.4
				S3	2.6	4.0	1.0	2.9	3.3	1.9	2.2	2.0	3.8
Glass	10	1	2	S1	1.1	0.8	0.0	1.0	1.5	3.3	0.8	1.1	Trace
				S2	0.9	1.2	Trace	0.0	Trace	1.9	0.0	2.2	1.6
	9	26	1	S2	0.4	1.1	0.8	0.8	Trace	Trace	0.0	0.6	Trace
				S3	1.3	1.2	1.4	Trace	0.5	3.0	2.5	1.5	0.5
Fe metal	10	1	2	S1	2.8	3.8	3.7	1.7	1.8	0.7	2.0	2.1	6.5
				S2	2.1	0.0	0.0	0.0	0.0	0.0	0.0	15.4	1.4
	9	26	1	S2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				S3	0.7	0.0	0.0	5.4	0.4	0.0	0.3	0.0	0.0
Other metal	10	1	2	S1	1.1	1.6	2.8	0.0	0.1	0.0	0.0	4.6	0.0
				S2	0.1	0.0	0.4	0.0	0.7	0.0	0.0	0.0	0.0
	9	26	1	S2	Trace	Trace	0.0	0.0	0.0	0.0	0.3	0.0	0.0
				S3	0.1	Trace	0.0	0.0	0.0	0.2	0.0	0.9	0.0
Organics	10	1	2	S1	1.7	2.4	1.0	3.1	2.7	3.6	0.0	0.5	0.0
				S2	1.9	7.4	Trace	1.9	0.9	Trace	0.0	3.9	1.2
	9	26	1	S2	0.7	0.0	0.0	1.0	0.0	2.5	2.2	0.0	0.0
				S3	0.1	0.0	0.0	0.0	1.1	0.0	0.0	0.0	0.0
Miscellaneous	10	1	2	S1	25.1	20.7	40.5	35.3	22.0	21.6	14.7	28.5	17.1
				S2	21.2	18.6	21.5	44.3	30.8	9.2	15.5	10.4	19.2
	9	26	1	S2	23.9	17.9	25.3	16.9	33.3	20.0	19.5	39.5	18.8
				S3	24.8	1.4	16.0	31.2	34.1	29.6	28.0	34.3	23.9

Table A-5a. (Concluded)

Spectrum	Date 1974 Month	Day	Time for eight sub-samples (hr)	Stream	Mean	Individual subsamples 1	2	3	4	5	6	7	8
Square screen size (in.)													
Larger than 2.5	10	1	2	S1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				S2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	9	26	1	S2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Less than 2.5	10	1	2	S1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
				S2	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	9	26	1	S2	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Less than 1.5	10	1	2	S1	97.0	98.2	87.7	99.3	96.6	97.2	97.2	100.0	100.0
				S2	98.6	100.0	98.2	100.0	97.7	99.1	100.0	99.0	94.4
	9	26	1	S2	92.3	96.0	95.5	96.9	94.8	59.6	99.2	100.0	96.4
Less than 0.75	10	1	2	S1	70.5	52.4	46.1	87.5	73.7	77.4	77.4	87.0	62.6
				S2	82.0	81.3	79.6	81.2	80.8	86.9	83.6	78.6	84.1
	9	26	1	S2	75.8	75.2	84.9	73.5	79.4	49.8	81.7	88.5	73.2
Less than 0.375	10	1	2	S1	48.5	37.9	21.9	62.5	48.3	54.7	54.7	64.7	43.3
				S2	58.5	57.1	56.6	61.6	56.1	60.9	59.6	55.3	60.7
	9	26	1	S2	51.0	48.5	57.5	45.9	57.3	33.2	51.6	65.6	48.2
Less than 0.187	10	1	2	S1	30.8	25.3	14.2	39.6	30.5	34.0	34.0	42.4	26.3
				S2	39.4	39.6	39.8	42.0	37.7	43.5	38.5	35.9	38.3
	9	26	1	S2	33.1	31.7	38.0	22.4	39.7	21.1	33.3	45.8	33.0
Less than 0.094	10	1	2	S1	18.7	17.5	10.5	23.6	17.8	19.8	19.8	24.5	16.4
				S2	25.8	28.6	28.3	26.8	23.8	27.8	25.0	24.3	21.5
	9	26	1	S2	21.6	20.8	25.7	9.2	26.5	13.0	22.2	32.3	23.2
Particle size													
Geometric mean diameter (in.)	10	1	2	S1	0.351	0.426	0.601	0.243	0.332	0.297	0.297	0.233	0.379
				S2	0.257	0.253	0.260	0.245	0.272	0.233	0.253	0.278	0.265
	9	26	1	S2	0.331	0.320	0.261	0.379	0.268	0.601	0.288	0.212	0.316
Geometric standard deviation	10	1	2	S1	2.73	2.95	2.65	2.58	2.78	2.77	2.77	2.58	2.78
				S2	2.78	2.82	2.90	2.77	2.80	2.70	2.68	2.80	2.75
	9	26	1	S2	2.85	2.86	2.80	2.47	2.96	3.38	2.70	2.67	2.95

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

1. REPORT NO. EPA-650/2-75-044	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE St. Louis Refuse Processing Plant Equipment, Facility, and Environmental Evaluations		5. REPORT DATE May 1975 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) L. J. Shannon, D. E. Fiscus, and P. G. Gorman		8. PERFORMING ORGANIZATION REPORT NO.
9. PERFORMING ORGANIZATION NAME AND ADDRESS Midwest Research Institute 425 Volker Boulevard Kansas City, Missouri 64110		10. PROGRAM ELEMENT NO. 1AB013; ROAP 21AQQ-010 11. CONTRACT/GRANT NO. 68-02-1324, Task 4
12. SPONSORING AGENCY NAME AND ADDRESS EPA, Office of Research and Development and Office of Solid Waste Management Programs Washington, DC 20460		13. TYPE OF REPORT AND PERIOD COVERED Final Task; 9/74 - 1/75 14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT The report describes partial results of the following tests and evaluations at the St. Louis refuse processing plant from 9/74 to 1/75: plant mass and energy balances; equipment and plant performance evaluations; an analysis of plant operating costs; particulate emission tests on the hammermill and air classification system dust collection cyclones; a pollution evaluation of plant washdown water; and a plant sound survey. The plant operated satisfactorily during the evaluation period, with about 80% of the incoming refuse converted to refuse fuel, on both a mass and energy basis. No major equipment breakdowns occurred. Plant operating and maintenance costs ranged from $2.58 to $14.80/ton of refuse produced, with costs varying primarily as a function of tonnage. Particulate emissions from the hammermill cyclone discharge were less than 0.01 gr/dscf; those from the air classifier cyclone discharge averaged 0.209 gr/dscf (about 1.25 lb/ton of refuse processed). Over 80% by weight of these particles had mean diameters greater than 10 micrometers. Washdown water samples showed significant increases in TSS, BOD, and COD; however, the small quantity of effluent (2000 gal., twice/week) can be handled easily by the average municipal waste treatment facility. At 8 of the 17 plant positions at which sound measurements were taken, sound levels were in excess of 90 dBA, the maximum OSHA level for continuous 8-hour exposure.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group	
Air Pollution	Washing	Air Pollution Control	13B	13H, 7A
Water Pollution		Stationary Sources		
Combustion		Wastes	21B	
Refuse		Municipal Waste	13A	
Evaluation		Particulates	14A	
Acoustic Measurement			20A, 14B	

18. DISTRIBUTION STATEMENT Unlimited	19. SECURITY CLASS *(This Report)* Unclassified	21. NO. OF PAGES 121
	20. SECURITY CLASS *(This page)* Unclassified	22. PRICE

EPA Form 2220-1 (9-73)