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GRID-CONNECTED INTEGRATED COMMUNITY ENERGY SYSTEM

Phase II, Stage 1, Final Report
Conceptual Design Pyrolysis and Waste Management Systems

March 8, 1978

Work Performed Under Contract No. EC-77-C-02-4210

University of Minnesota
Physical Plant
Minneapolis, Minnesota

U. S. DEPARTMENT OF ENERGY

Division of Buildings and Community Systems

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GRID-CONNECTED INTEGRATED
COMMUNITY ENERGY SYSTEM

PHASE II
STAGE 1 FINAL REPORT

CONCEPTUAL DESIGN
PYROLYSIS AND WASTE MANAGEMENT SYSTEMS

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Prepared For
The U. S. Department of Energy
Under Contract No. EC-77-C-02-4210

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CONCEPTUAL DESIGN
PYROLYSIS AND WASTE MANAGEMENT SYSTEMS

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REGIONAL QUANTITIES, INSTITUTIONAL CHARACTERISTICS AND
PROPERTIES OF HHC SOLID WASTE INPUT

Following initial definition of the 7-county metropolitan region for which the solid waste management system is to be planned, information is then necessary about the nature of the waste generated within this region. Estimates of the quantities generated, generation rates, and properties of the waste to be collected and disposed of are required in order to determine the appropriate size and capacity of the system. These estimates are designated and subsequently referred to as "system input". Institutional information is also necessary in designing the planned system, to be compatible with existing institutional operations and procedures, or to offer a minimum amount of problems to the participating institution in the region.

Initial considerations of health care institutions generating solid waste within the defined region are made on a comprehensive basis without any attempt to select out or include feasible candidate institutions, or institutional categories. As the study progresses, various criteria are used in select potential candidate institutional categories and institutions within the 7-county region as offering the most feasible solid waste system input to be successfully developed into a centralized program, however, it is hopeful such a system if developed could be maintained for the entire 7-county region, and remain comprehensive to the entire health care industry (also see Metropolitan Council letter, Appendix 1).

Basically three sources of information have been used to obtain data on solid waste from health care institutions in the 7-county region. The first was information that was available from literature sources reporting surveys from previous research investigations. This information, however, deals almost exclusively with large metropolitan general hospitals, and is usually based upon a single facility or institutional complex, although some studies present information on several hospitals in a given region, therefore limiting its applicability. The second source of information was that available by actual sample measurement, in which a survey team visited representative generation sites or institutions, to perform measurements, or to obtain survey samples for off-site testing. The third source was information that was obtained from the institution's operating personnel, or staff through letter questionnaire. This last form represents either data maintained on file at the institution or collected by internal staff on request.

In the cases of collecting information by personal survey, and by letter questionnaire, standardized forms were compiled and used for observation trials in order to obtain consistent information.

The methodology used in the estimation of regional quantities of HHC solid waste, and associated institutional characteristics has been organized and accomplished in three phases. These phases are identified as:

(a) Categorizing health care facilities in the TCMR; (b) Data collection; and (c) Analysis of data.

According to literature discussion some uncertainty exists concerning how broad a scope to apply in defining which categories of institutions should be included in planning a centralized solid waste management system. Little trouble was found in identifying the large metropolitan general hospital as a prime candidate, since solid waste generated for disposal is very characteristic, however, small nursing homes or supervised living facilities, also classified as health care institutions are examples of a borderline case since solid waste generated from these institutions may actually be non-distinguishable from ordinary municipal solid waste, and could be just as easily managed in that existing system. Therefore, the first phase was used to establish which health care institutional categories were to be used in estimating the planned system input.

As a starting point the Director for Licensed and Certified Health Care Facilities, 1976, published by the Minnesota Department of Health was used to obtain a listing of these facilities in the TCMR. Since this directory is applicable to the entire state, and subdivided according to county, the 7-county area was used to select-out initial TCMR listings.

Previous discussions with practicing professionals also indicate that solid waste generated from veterinary hospitals, possibly generated from the care of diseased animals should also be considered in a centralized management program, although not typically considered as part of the health care industry. Therefore a listing of veterinary hospitals and clinics was prepared from the Minneapolis/St. Paul telephone yellow-page directories published by the Northwestern Bell Company. Some selection was again necessary to limit the listings in scope to the TCMR. In addition to the yellow-page listings, the Membership Roster (1977) of the Minnesota Veterinary Medical Association was used as a cross-reference.

Additional categories of health care facilities were obtained from the Standard Industrial Classification (SIC) manual, and included categories such as medical clinics, offices of physicians, dental laboratories, and offices of dentists.

An initial orientation was accomplished to develop familiarization with the various facility categories identified, and to divide the composite listing into primary and secondary generating groups for study. The intent was to perform the greatest degree of study and analysis on the categories having the greatest degree of influence on the resultant system input, therefore producing the most accurate information where necessary.

Solid waste from health care facilities was initially defined for orientation into either general or special solid waste categories. General was summarized according to solid waste definitions as presented by the American Public Works Association, while the special category was summarized according to information derived from the Minnesota Department of Health. Tables 1 and 2, represent these two categories on solid waste. The selection of whether a particular institutional category was placed into the primary or secondary group was based first upon whether or not typical institutions in the category generated special waste in significant, continuous quantities, and second, the institutions total (general and special) solid waste quantities generated.

TABLE I

GENERAL SOLID WASTE

<u>Type of Waste</u>	<u>Principal Component</u>	<u>Approximate Composition (% Weight)</u>
Rubbish	Combustible waste: paper, cartons, rags, wood scraps, floor sweepings; domestic, commercial, industrial sources. Noncombustible waste: metals, tin cans, dirt, glass, crockery, minerals, ceramics.	Rubbish 100% (Garbage up to 20%)
Refuse	Rubbish and garbage, residential sources.	Rubbish 50% Garbage 50%
Garbage	Animal and vegetable wastes, restaurants, hotels, markets; institutional, commercial and club sources.	Garbage 100% (Rubbish up to 35%)
Ashes	Residue from combustion of fuel or waste, > 95 percent non-putrecible.	Varies with material combusted
Bulky Wastes	Furnishings, fixtures, appliances.	Varies
Street and Land-scaping	Sweepings, dirt, leaves, catch-basin dirt, contents of litter receptacles.	Varies
Construction and Demolition	Lumber, pipes, brick, masonry, and other materials from razed buildings.	Varies
Shop Wastes	Wood, metal, cloth, rubber, oils, glass.	Varies

TABLE 2

TYPICAL HEALTH CARE SPECIAL SOLID WASTE CATEGORIES

Infectious Waste:	including bandages, dressings, casts, catheters, tubing, and the like, which have been in contact with wounds, burns, or surgical incisions. Also included are all wastes which are generated from treatment of diagnosed or suspected communicably ill patients or isolation patients.
Needles and Syringes:	also includes other sharps causing potential physical hazard such as scalpels and knives.
Microbial Cultures:	including other laboratory apparatus discharged from laboratory analysis unless autoclaved.
Blood, Sputum, etc.:	including patient discharges and associated tissues, cups, and bags.
Human Tissue:	including amputated limbs, tissues and organs, placenta(s) and similar types of material.
Animal Tissue:	same as above.
Chemicals:	includes gaseous, liquid, and solid waste if containerized, or associated with solid material, and radioactives.
Other:	including any other waste materials considered to be a hazard to public health if managed in the normal municipal solid waste system without special procedures.

In the case of the hospital category, sufficient information was available directly from the literature sources to allow selection as a primary generator. However, the remaining institutional categories required selection based upon direct information collection. A telephone survey was therefore conducted by randomly selecting a small sample of approximately 10 percent of the institutions within each of the institutional categories other than hospitals, and requesting solid waste generation information from its operating staff. Estimates were obtained according to the previous general and special definitions described. Internal and external handling operations were requested if the information was readily available.

As previously indicated data collection was accomplished using literature sources, direct observations, and indirect letter questionnaires. All three sources were available in determining hospital estimates, while the latter two available to the remaining categories. One consultant study indicated however, that nursing homes could be considered as hospitals with limited services in estimating solid waste quantities and this method was therefore used as an additional estimating factor for this institutional category.

The division of institutional categories between primary and secondary generators was used to determine the manner used for data collection.

For the primaries, sample sizes were calculated for personal direct observation, using properties of normal distribution patterns. The frequency pattern for quantity of solid waste generated per patient-day for each institution within its category was first assumed normally distributed. Initial small samples (n) of approximately ten percent chosen randomly from each primary category were then measured by personal observations. Mean ($\hat{\mu}$) and standard deviation ($\hat{\sigma}$) estimators were then calculated for these sample sizes, and used in the following relationship to yield a new sample size ($\hat{n}$) of 68.3 percent confidence having the mean within 10% of the actual mean.

$$\hat{n} = \left(\frac{\hat{\sigma}}{0.10\hat{\mu}} \right)^2$$

Therefore, if the calculated sample size ($\hat{n}$) was greater than the initial 10 percent, the personal observations were then increased to the calculated number. A sample size ($\hat{n}$) less than the initial number indicated a sufficient size had been measured initially.

All measurements and observations were conducted according to the standardized forms pre-established for data collection in order to assure compatibility of information. Weight measurements were normally obtained by utilizing inspected and calibrated scales within the institutions, however for instances in which no scales were available, a portable hand-held, spring scale as purchased from Sears, Roebuck and Company, catalog number 29A14191 was used for the measurement. Volume measurements were limited to estimating the approximate container size used for internal handling of the solid waste.

The remaining institutions in each primary category, not personally observed, were then sent the standardized forms attached to a cover letter explaining the survey and soliciting their support. These letter questionnaires after being drafted were sent to a random trial sample of institutions, representing approximately ten percent of the total institutions remaining, excluding those personally observed. Information obtained from this initial trial, along with personal comments received from practicing professionals provided for some adjustments, to yield more effective questionnaires. A final draft was reproduced for the full survey. For all mailings, self-addressed, postage-paid envelopes were provided for the return mailing.

For the secondary generators, an initial selection was made to determine which health care institutional categories would be sampled. Again the criteria for selection was based upon general and special waste quantities generated from typical institutions in each category, determined by a random telephone survey.

A trial questionnaire and cover letter to be used for all the secondaries was drafted and tested for each institutional category. Based upon information obtained from this trial, an improved letter questionnaire was drafted, reproduced and sent to the remaining institutions.

The basic sequence of data collection for both primary and secondary generator is diagramed and presented in Figure 1.

FIGURE 1
DIAGRAM OF INFORMATION GATHERING

As previously indicated, the identification of institutional categories their division into primary and secondary groups, and the selection of secondary categories for survey were made based upon the quantities of general and special solid waste generated for disposal within the 7-county region. The remaining analysis of data was accomplished in order to determine first, the quantities of IHC solid waste generated in the 7-county region, and second some of the characteristics of the generating institutions.

Quantity estimates analyzed are indicated in Table 3, based upon the patient-day relationship.

TABLE 3

SOLID WASTE QUANTITY PARAMETERS ESTIMATED

<u>PARAMETER</u>	<u>DIMENSION</u>
Weight.....	Pounds Per Patient Day
Volume.....	Cubic Feet Per Patient Day
Density.....	Pounds Per Cubic Foot
Composition.....	Percentage Rubbish, Garbage, Special Solid Waste

In the case of primary generators, mean quantity estimates were determined from data collected by the personal observations. The additional data received from the letter questionnaires was then used to adjust this parameter. For the secondaries, the analysis was based upon the letter questionnaire alone.

The institutional characteristics analyzed have been organized into Table 4:

TABLE 4

INSTITUTIONAL CHARACTERISTICS ANALYZED

- Generation percentages, as to the kind of solid waste generated, i.e., special, general, garbage, rubbish.
- Type and quantity of special solid waste, and general solid waste.
- Handling method and containment of general and special solid waste.
- Disposal methods used.
- Professional opinions concerning centralized disposal concept and regional management programs.

In both cases of primary and secondary groups a summation of information has been conducted based upon the total responses received.

RESULTS OF SELECTING INSTITUTIONS FOR STUDY AND
DIVISION INTO PRIMARY AND SECONDARY SOURCES

The 1976 Director of Licensed Health Care Facilities, published by the Minnesota Department of Health was used to produce Table 5 for the TCMR.

Follow-up discussions with practicing health professionals, environmental planners, and pollution control agency representatives resulted in additional categories and TCMR numbers according to Table 6.

Based upon orientation survey results, Tables 7 and 8 were compiled to represent the division of institutional categories into primary and secondary groups for study. Medical clinics, offices of physicians and dentists, and dental laboratories were omitted from study at this point as a result of information obtained during the orientation survey.

TABLE 5

MINNESOTA HEALTH DEPARTMENT LICENSED HEALTH CARE FACILITIES

<u>Health Care Facility</u>	<u>No. in TCMR</u>
General Hospitals	38
Nursing Homes	131
Supervised Living Facility	43
Boarding Care Home	37
Independent Laboratories	15
Home Health Agencies	13
Portable X-Ray	4
Mental Hospitals	2
Convalescent & Nursing Care	2
Outpatient Physical Therapy	1
Other Specialized Hospitals	3
	<hr/>
Total est.	289

TABLE 6

ADDITIONAL HEALTH CARE FACILITY CATEGORIES

<u>Category</u>	<u>No. in TCMR</u>
Veterinary Clinics & Hospitals	105
Medical Clinics	160
Offices of Physicians	274 (est. 2200 physicians)
Dental Laboratories	90
Offices of Dentists	158 (est. 1100 dentists)
	<hr/>
Total est.	787

TABLE 7

PRIMARY GENERATORS FOR MORE EXTENSIVE ANALYSIS

<u>Category of HHC</u>	<u>Est. No. in TCMR</u>
Hospitals	38
Nursing Homes	131
Veterinary Hospitals and Clinics	105
Federal Hospitals	1

TABLE 8

SECONDARY GENERATORS FOR LESSER ANALYSIS

<u>Category of HHC</u>	<u>Est. No. in TCMR</u>
Supervised Living Facility	43
Boarding Care Home	37
Independent Laboratories	15
Home Health Agencies	13
Portable X-Ray	4
Mental Hospitals	2
Convalescent and Nursing Care	2
Outpatient Physical Therapy	1
Other Specialized Hospitals	3

PRIMARY GENERATORS

The primary generators were identified as hospitals, nursing homes, and veterinaries. Veterinary institutions were included as a primary due mainly to the number of animal carcasses, and amounts of animal tissues generated for disposal.

In determining the number of personal observations to be taken for each of the primary institutional categories Table 9 presents the initial sample size selected, and the follow-up adjusted sample size calculated to yield the desired confidence level for waste quantities estimates.

TABLE 9

PERSONAL SAMPLE SIZE OBSERVED

<u>Institutional Category</u>	<u>Initial Sample (n)</u>	<u>Adjusted Sample (n')</u>
Hospitals	5	7
Nursing Homes	8	10
Veterinaries	8	11

Each institution was assigned a code number to record the results of the survey, and for presenting the information for analysis. Tables 10 through 26 present the tabularized results of the data and information received as a result of personal and letter questionnaire surveys.

Table 27 presents the resulting summation of response received from each of the primary surveys.

Maps 1 through 6 have been included representing the geographic locations of the primary generators. In each case a 7-county representation, and a Twin City representation have been included.

Map #1

GRID ICES PHASE II OPTION II
GEOGRAPHIC DISTRIBUTION MODEL OF HOSPITAL/HEALTH CARE FACILITIES
TWIN CITY METROPOLITAN REGION

NOTE: For Location of Facilities within $2\frac{1}{2}$ Mile Zone - See Map #2

GRID ICES PHASE II OPTION II
 GEOGRAPHIC DISTRIBUTION MODEL OF HOSPITAL/HEALTH CARE FACILITIES
 MINNEAPOLIS/ST. PAUL AND SUBURBAN AREAS

Map #2

Map #3

**GRID ICES PHASE II OPTION II
GEOGRAPHIC DISTRIBUTION MODEL OF HOSPITAL/HEALTH CARE FACILITIES
TWIN CITY METROPOLITAN REGION**

NOTE: For Location of Facilities within 2½ Mile Zone - See Map #4

GRID ICES PHASE II OPTION II
GEOGRAPHIC DISTRIBUTION MODEL OF HOSPITAL/HEALTH CARE FACILITIES
MINNEAPOLIS/ST. PAUL AND SUBURBAN AREAS

Map #4

Map #5

▲ VETERINARY CLINICS

GRID ICES PHASE II OPTION II
GEOGRAPHIC DISTRIBUTION MODEL OF HOSPITAL/HEALTH CARE FACILITIES
TWIN CITY METROPOLITAN REGION

NOTE: For Location of Facilities within 2½ Mile Zone - See Map #6

GRID ICES PHASE II OPTION II
GEOGRAPHIC DISTRIBUTION MODEL OF HOSPITAL/HEALTH CARE FACILITIES
MINNEAPOLIS/ST. PAUL AND SUBURBAN AREAS

Map #6

TABLE 10

FORM H-1

GENERAL & SPECIALIZED HOSPITALS
QUANTITY - TOTAL SOLID WASTE

NO.	TYPE OF SURVEY	TOTAL WEIGHT (LBS.)	TOTAL VOLUME (CU. FT.)	DENSITY LB./CU. FT.	# OF PATIENTS	S.W. GENERATION RATE PER PATIENT LBS./DAY/PAT.
23	Personal	274	67	4.09	30	9.133
26	Personal	1,891	561	3.37	240	7.879
30	Personal	4,100	689	6.17	336	12.202
12	Personal	1,036	295	3.51	87	11.908
9	Personal	810	219	3.70	105	7.704
2	Personal	2,813	648	4.34	206	13.655
16	Personal	847	272	3.11	131	6.465
						AVE = 9.85
25	Mail	1,003	-	-	65	15.430
20	Mail	6,440	-	-	485	13.278
18	Mail	2,400	540	4.44	180	13.333
22	Mail	13,000	-	-	425	30.588
10	Mail	9,360	-	-	675	13.866
13	Mail	700	-	-	84	8.33
21	Mail	13,900	-	-	567	24.514
14	Mail	2,400	-	-	285	8.421
36	Mail	650	-	-	68	9.588
1	Mail	1,600	-	-	225	7.111
7	Mail	2,000	-	-	87	22.988
24	Mail	3,000	-	-	220	13.636
	TOTAL	= 68,224		AVE = 4.09		
SP. H.	Personal	64.5	28	2.3	29	2.22

TABLE 11

FORM H-2

GENERAL & SPECIALIZED HOSPITALS
QUANTITY TYPE OF SOLID WASTE

NO.	TYPE OF SURVEY	TOTAL WEIGHT (LBS.)	% OF RUBBISH	% OF GARBAGE	% OF SPECIAL W.	% OF OTHERS
28	Personal	274	59.5	35.0	5.5	-
26	Personal	1,891	62.0	12.0	18.0	8.0
30	Personal	4,250	66.0	24.0	10.0	-
12	Personal	1,036	78.5	13.5	8.0	-
9	Personal	810	58.1	34.4	7.5	-
2	Personal	648	40.5	44.5	11.5	3.5
16	Personal	847	45.0	39.0	11.0	5.0
						-
24	Mail	3,000	80.0	10.0	10.0	-
20	Mail	6,440	64.0	16.0	-	20.0
18	Mail	2,400	60.0	34.0	2.0	4.0
22	Mail	13,000	100.0	-	-	-
10	Mail	9,360	70.0	30.0	-	-
13	Mail	700	94.0	5.0	1.0	-
21	Mail	13,900	28.0	40.0	32.0	-
14	Mail	2,400	78.0	2.0	-	20.0
1	Mail	1,600	80.0	20.0	-	-
36	Mail	650	60.0	40.0	-	-
7	Mail	2,000	95.0	5.0	-	-

TABLE 12

FORM H-3

GENERAL & SPECIALIZED HOSPITALS
GENERAL INFORMATION

NO.	TYPE OF SURVEY	HOSP. CENSUS & NEWBORN	+ BASSINETS BED CAPACITY	% OF OCCUP.	# OF EMPLOYEES	# OF TRAINEES	# OF OUTPAT. PER YR.	# OF SUR. OP. PER YR.	ACCREDITED BY JOINT COMMISSION
23	Personal	30	75 + 22	30.9	141	0	7,344	727	Yes
26	Personal	240	334 + 48	62.8	800	0	25,000	6,100+	Yes
30	Personal	316	444 + 26	67.2	2,557	350	40,000	7,089	Yes
12	Personal	87	107	81.3	500	12	12,000	4,169	Yes
9	Personal	105	178 + 22	52.5	450	0	—	1,800	Yes
2	Personal	206	310	66.4	950	0	27,000	6,000	Yes
16	Personal	131	276	47.5	730	126	8,400	3,000	Yes
24	Mail	220	298 + 43	64.5	946	135	22,000	4,527	Yes
25	Mail	65	90	72.2	370	55	15,749	2,294	Yes
20	Mail	485	493 + 40	91.0	1,467	32	53,000	6,673	Yes
18	Mail	180	256	70.3	750	10	26,541	5,696	Yes
22	Mail	425	550 + 42	71.8	1,800	—	—	—	—
10	Mail	675	854 + 28	76.5	2,340	120	77,153	15,121	Yes
13	Mail	84	144 + 16	52.5	314	24	3,500	2,566	Yes
21	Mail	567	768 + 31	71.0	3,800	—	201,523	16,000	Yes
14	Mail	285	381 + 35	68.5	1,035	—	18,000	5,200	Yes
36	Mail	68	126 + 12	49.3	255	—	2,100	1,500	Yes
1	Mail	225	296 + 38	67.4	746	20	21,000	5,300	Yes
7	Mail	87	130 + 22	57.2	447	0	44,000	1,512	Yes
			AVE = 64.25						
SP. H.	Mail	22	60	36.7	157	7	10,000	—	Yes
SP. H.	Personal	29	40	72.5	70	0	2,646	222	Yes

TABLE 13

FORM H-4

GENERAL & SPECIALIZED HOSPITALS
TYPE AND QUANTITY - SPECIAL S.H.

NO.	TYPE OF SURVEY	INFECTIOUS S.W.	NEEDLES & SYRINGES	MICROBIAL CULTURES, BLOOD, ETC.	HAZARDOUS CHEMICALS	RADIOACTIVE MATERIAL	ANIMAL REMAINS	OTHERS	TOTAL QUANTITY (LBS/DAY)	
28	Personal	X	X	X	-	-	-	-	140	
26	Personal	50	3	96	-	-	-	-	149	
30	Personal	X	X	X	-	X	-	-	425	
12	Personal	X	15	X	-	-	-	-	85	
9	Personal	X	X	X	-	-	-	-	61	
2	Personal	268	4	22	-	-	-	-	294	
16	Personal	X	X	-	-	-	-	-	93	
24	Mail	40	60	25	-	-	-	-	125	
25	Mail	15	2	6	-	<1	-	-	24	
20	Mail	160	5	550	-	-	-	-	715	
18	Mail	25	6	40	-	-	-	-	71	
22	Mail	800	50	190	-	-	-	-	1040	
10	Mail	375	-	-	-	-	-	-	3000	
13	Mail	40	3	7	-	-	-	-	50	
14	Mail	60	20	-	-	-	-	-	80	
1	Mail	200	6	12	-	-	-	-	218	
7	Mail	40	2	6	-	1.5	-	-	49.5	
Hosp	Personal	4	2.5	-	-	-	-	-	6.5	

TABLE 14

H-5

HOSPITALS
ESTIMATED GENERATION RATE

NO.	BED CAPACITY	ESTIMATED NUMBER OF PATIENTS=BC x 64.25	ESTIMATED TOTAL S.W. GENERATION RATE LBS./DAY
3	129	82.88	816.37
4	44	28.27	278.46
5	57	36.62	360.71
6	112	71.96	708.81
8	451	289.77	2,854.23
11	48	30.84	303.77
15	397	255.07	2,512.43
17	637	409.27	4,031.31
19	467	300.05	2,955.49
23	474	304.54	2,999.72
27	137	88.02	867.00
29	341	219.09	2,158.04
31	150	96.37	949.24
32	305	195.96	1,930.27
33	361	231.94	2,284.61
34	522	335.38	3,303.49
35	77	49.47	487.28
37	131	84.16	829.00
38	61	39.19	386.02
			TOTAL = 31,016.25
SP. Hosp. (1)	48	30.84	68.46
Federal Hospital	863	554.48	5,461.63
		28	GRAND TOTAL = 104,835 lbs/day

TABLE 15
CONTAINMENT & DISPOSAL METHOD

NO.	TYPE OF FACILITY	TYPE OF SURVEY	REGULAR S.W. CONT. METHOD				REGULAR S.W. DISPOSAL METHOD				SPECIAL S.W. CONT. METHOD				SPECIAL S.W. DISP. METHOD			
			PLASTIC BAGS	NON-DISPOSABLE CONTAINER	NO CONTAINMENT	OTHER	ON-SITE INCINERATION	HAULING AWAY TO LANDFILL	HAULING AWAY TO INCINERATE	RECYCLE	OTHER	ALONG WITH OTHER WASTES	IDENTIFIED PLASTIC BAG	CAN, JAR, BOX, ETC.	OTHER	ON-SITE INCINERATION	HAULING AWAY TO LANDFILL	HAULING AWAY TO INCINERATE
28	Hosp.	Pers.	X				X	X				X		X		X		
26	Hosp.	Pers.	X				X	X					X	X		X	X	
30	Hosp.	Pers.	X	X		X	X	X				X		X		X	X	
12	Hosp.	Pers.	X					X					X					X
9	Hosp.	Pers.	X					X					X	X				X
2	Hosp.	Pers.	X					X		X			X	X		X		
16	Hosp.	Pers.	X					X					X	X			X	
24	Hosp.	Mail	X				X	X					X			X		
25	Hosp.	Mail	X		X	X	X	X	X		X		X			X		X
20	Hosp.	Mail	X		X	X	X	X					X			X		
18	Hosp.	Mail	X					X	X				X					X
22	Hosp.	Mail	X					X				X	X					
10	Hosp.	Mail	X				X	X				X	X			X		
13	Hosp.	Mail	X				X	X		X			X			X		
21	Hosp.	Mail	X						X				X					X
14	Hosp.	Mail	X					X	X		X		X				X	X
1	Hosp.	Mail	X					X					X				X	
36	Hosp.	Mail	X				X	X					X			X		
7	Hosp.	Mail	X				X	X	X		X		X					X
	SP. H.	Mail	X		X	X	X	X		X			X			X		
	SP. H.	Pers.			X		X	X					X		X	X		
										29								

OPINION POLL

A-Z

FACILITY NO.	TYPE OF FACILITY	1ST QUESTION				2ND QUESTION				3RD QUESTION				4TH QUEST.		5TH QUEST.									
		WILLING TO PARTICIPATE IN THE CENTRALIZED SYSTEM			PRIVATE OWNERSHIP	MUNICIPALITIES OWNERSHIP	OWNERSHIP BY PARTICIPANT INSTS.	OWNERSHIP BY STATE INSTS.	ECONOMICS	SAFETY RELIABILITY	LOCATION	METHODS OF HANDLING & DISPOSAL	OTHER	MUNICIPALITIES	INDIVIDUAL CONTRACTS WITH PRIV. HAULERS	THE INSTITUTIONS THEMSELVES	THE CENTRALIZED SYSTEM	PRIVATE HAULERS	HAZARDOUS & NON-HAZARDOUS	HAZARDOUS ONLY	NON-HAZARDOUS ONLY	NEED CHANGE THE PRESENT SYSTEM		NEED FOR A CENTRALIZED	
		YES	NO	DO NOT KNOW YET																		YES	NO		YES
12	Hosp.	X					X		X	X		X	X					X	X						
16	Hosp.	X						X	1	4	2	3						X		X					
2	Hosp.			X								X						X		X					
9	Hosp.	X				2	1		1	2			X					X		X					
26	Hosp.			X					X	X	X	X								X					
28	Hosp.	X					X		2	1	3	4						X		X					
7	Hosp.			X	X				X		X	X			X					X			X		
1	Hosp.	X					X		1		2	3						1	2	X			X		
36	Hosp.	X							X	X										X			X		
14	Hosp.	X					X		X	X		X						X		X			X		X
21	Hosp.	X						X	X	X	X	X						X		X			X		X
13	Hosp.	X						X	X	X	X	X						X		X			COMMENT		
10	Hosp.	X					X		X	X	X	X						X				X	X		X
22	Hosp.	X					X		X	X		X			X			X		X					
18	Hosp.	X					1	2	X	X	X	X								X			X		X
20	Hosp.	X					X		X	X		X			X			X		X			X	COMMENT	
25	Hosp.	X					X		1	3	4	2	5	4	2			3	1	X			X		X
24	Hosp.	X					X		X	X		X		X						X			X		
1	SP. H.			X					X			X		X						X					
												30													

TABLE 17
NURSING HOMES
QUANTITY - TOTAL SOLID WASTE

NO.	TYPE OF SURVEY	TOTAL WEIGHT (LBS.)	TOTAL VOLUME (CU. FT.)	DENSITY (LBS./CU. FT.)	NUMBER OF RESIDENTS	S.W. GEN. R PER RESIDE LBS./DAY/RI
103	Personal	184	44	4.18	140	1.314
84	Personal	288	76	3.79	186	1.548
75	Personal	544	153	3.56	270	2.014
1	Personal	76	22	3.45	59	1.288
102	Personal	195	52	3.75	148	1.317
92	Personal	283	74	3.82	186	1.521
97	Personal	79	27	2.93	43	1.837
72	Personal	188	59	3.19	141	1.333
87	Personal	315	67	4.70	188	1.675
66	Personal	262	51	5.14	156	1.679
				AVE = 3.851		AVE=1.553
12	Mail	50	-	-	64	.781
24	Mail	(500)?	-	-	66	-
51	Mail	800	-	-	-	-
70	Mail	1,000	-	-	485	2.062
80	Mail	-	243	-	132	-
10	Mail	350	-	-	109	3.211
37	Mail	(300)?	-	-	43	6.976
53	Mail	150	-	-	54	2.777
63	Mail	400	-	-	370	1.081
69	Mail	500	-	-	170	2.941
86	Mail	(700)?	-	-	101	6.930
89	Mail	200	-	-	65	3.077
91	Mail	50	-	-	64	.781
114	Mail	200	-	-	90	2.222
124	Mail	300	29	-	119	2,521

NURSING HOMES

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TABLE 18

FORM NH-2

NURSING HOMES

QUANTITY - TYPE OF SOLID WASTE

NO.	TYPE OF SURVEY	TOTAL WEIGHT (LBS).	% OF RUBBISH	% OF GARBAGE	% OF SP. S.W.	% OF OTHERS
103	Personal	184	56	44	< 1	—
84	Personal	288	35.2	64.8	< 1	—
75	Personal	544	30	70	< 1	—
1	Personal	76	47.4	50	2.6	—
102	Personal	195	67.6	30.9	1.5	—
92	Personal	283	48.7	35	< 1	16.3
97	Personal	79	50	50	< 1	—
72	Personal	188	56.3	42	1.7	—
87	Personal	315	61.9	37.8	.3	—
66	Personal	262	61	38.5	.5	—
12	Mail	50	70	15	15	—
24	Mail	500	75	25	—	—
51	Mail	800	30	50	0	20
70	Mail	1,000	100	0	0	—
10	Mail	350	90	10	—	—
37	Mail	300	75	25	—	—
53	Mail	150	50	50	—	—
63	Mail	400	40	60	—	—
69	Mail	500	95	0	0	5
86	Mail	700	43	57	0	—
83	Mail	—	88	10	—	2
89	Mail	200	60	40	—	—
94	Mail	50	75	25	—	5
91	Mail	—	90	10	—	—
114	Mail	200	40	60	—	—

QUANTITY - TYPE OF SOLID WASTE

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TABLE 19
NURSING HOMES
GENERAL INFORMATION

NO.	TYPE OF SURVEY	TOTAL CENSUS	BED CAPACITY	% OF OCCUPANCY	SNF CENSUS	ICF CENSUS	# OF EMPLOYEES	ACCREDIT BY JOINT COMMISSION
103	Personal	140	149	93.96	98	42	157	—
84	Personal	186	194	95.88	179	7	172	No
75	Personal	270	272	99.26	230	40	240	Yes
1	Personal	59	66	89.39	59	0	65	No
102	Personal	148	154	96.10	52	96	140	Yes
92	Personal	186	194	95.88	109	77	—	No
97	Personal	43	43	100	43	0	69	No
72	Personal	141	144	97.92	133	8	125	No
87	Personal	188	215	87.44	138	50	175	Yes
66	Personal	156	160	97.50	62	94	70	Yes
12	Mail	64	76	84.21	0	64	67	No
24	Mail	66	66	100	58	8	79	No
51	Mail	—	477	—	179	—	850	Yes
70	Mail	485	490	98.99	—	—	360	Yes
80	Mail	132	132	100	132	0	252	Yes
10	Mail	109	109	100	54	55	135	No
15	Mail	80	80	100	80	0	110	Yes
37	Mail	43	43	100	0	43	32	No
53	Mail	54	54	100	0	54	34+	Yes
63	Mail	370	400	92.50	—	—	390	No
69	Mail	170	173	98.26	115	55	160	No
85	Mail	101	117	86.32	53	43	108	Yes
83	Mail	300	300	100	150	150	250	No
89	Mail	65	75	86.67	4	61	74	No
94	Mail	64	64	100	—	—	60	No

TABLE 19(Continued)

NURSING HOMES

GENERAL INFORMATION

NO.	TYPE OF SURVEY	TOTAL CENSUS	BED CAPACITY	% OF OCCUPANCY	SNF CENSUS	ICF CENSUS	# OF EMPLOYEES	ACCREDITED BY JOINT COMMISSION
91	Mail	159	159	100	65	94	150	Yes
114	Mail	90	90	100	20	70	88	No
124	Mail	119	120	99.16	76	43	140	No
131	Mail	159	164	96.95	82	77	165	Yes
113	Mail	286	289	98.96	200	86	250	No
22	Mail	150	162	92.59	120	30	150	No
47	Mail	11	15	73.33	-	-	30	Yes
56	Mail	64	68	94.11	0	64	45	No
85	Mail	209	212	98.58	179	30	211	Yes
105	Mail	131	131	100	0	131	75	No
110	Mail	200	256	78.12	112	88	183	Yes
4	Mail	69	69	100	-	-	70	Yes
8	Mail	40	41	97.56	40	0	45	Yes
11	Mail	92	106	86.79	-	-	116	Yes
16	Mail	79	80	98.75	-	-	81	No
17	Mail	102	102	100	-	-	80	Yes
38	Mail	63	81	77.77	0	63	52	No
41	Mail	172	178	96.63	138	34	140	Yes
107	Mail	150	150	100	150	0	150	No
2	Mail	119	125	95.20	75	44	126	Yes
5	Mail	129	129	100	-	-	135	Yes
				AVE = 95.22				
				36				

TABLE 20

FORM NH-4

NURSING HOMES
TYPE AND QUANTITY - SPECIAL S.W.

NO.	TYPE OF SURVEY	INFECTIOUS S.W.	NEEDLES AND SYRINGES	MICROBIAL CULTURES, BLOOD, ETC.	HAZARDOUS CHEMICALS	RADIO-ACTIVE MATERIAL	OTHERS	TOTAL QUANTITY LBS./DAY
103	Personal	X	45/mo.	-	-	-	-	< 1
84	Personal	1.5 lb.	30/day	-	-	-	-	~ 2
75	Personal	~ 2 lbs.	~ .5 lb.	-	-	-	-	~ 2.5
1	Personal	-	2 lbs./mo.	-	-	-	-	< .1
102	Personal	4	~ .3	-	-	-	-	4.3
92	Personal	~ 1	8/day	-	-	-	-	~ 1.0
97	Personal	2 lbs./mo.	5/day	-	-	-	-	< .2
72	Personal	X	X	X	-	-	-	4
87	Personal	X	X	X	-	-	-	1
66	Personal	X	X	-	-	-	-	1
12	Mail	2	1/8	-	-	-	-	2 1/8
24	Mail	X	X	-	-	-	-	-
51	Mail	X	X	-	-	-	-	~ 1
80	Mail	X	.5 lb.	-	-	-	-	5-10
10	Mail	1/4	1/16	-	-	-	-	5/16
53	Mail	-	X	-	-	-	-	-
63	Mail	4	1	-	-	-	-	5
69	Mail	-	X	-	-	-	-	-
86	Mail	X	X	-	-	-	-	~ 1
33	Mail	3-5 lbs.	1/2 lbs.	-	4-5 lbs.	-	-	7-10
89	Mail	-	4-5/day	-	-	-	-	-
94	Mail	-	.05 lb.	-	-	-	-	-
91	Mail	X	X	-	-	-	-	-
124	Mail	1/4 lb.	1/8 lb.	-	-	-	-	3/8

TYPE AND QUANTITY - SPECIAL S.W.

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NURSING HOMES
ESTIMATED GENERATION RATE

NO.	BED CAPACITY	ESTIMATED NUMBER OF RESIDENTS	ESTIMATED TOTAL S.W. GENERATION RATE (LBS./DAY)
3	122	116.2	180.5
6	54	51.4	79.8
7	55	52.4	81.4
9	107	101.9	158.3
13	187	178.1	276.6
14	63	60.0	93.2
18	406	386.6	600.4
19	98	13.3	144.9
20	192	182.8	283.9
21	21	20.0	31.1
23	121	115.2	178.9
25	151	143.8	223.3
26	64	60.9	94.6
27	287	273.3	424.4
28	88	83.3	130.1
29	128	121.9	189.3
30	183	174.3	270.7
31	52	49.5	76.9
32	67	63.8	99.1
33	104	99.0	153.7
34	101	96.2	149.4
35	84	80.0	124.2
36	370	352.3	547.1
39	91	86.7	134.6
40	35	33.3	51.7

TABLE 21 (Continued)

NURSING HOMES

ESTIMATED GENERATION RATE

NO.	BED CAPACITY	ESTIMATED NUMBER OF RESIDENTS	ESTIMATED TOTAL S.W. GENERATION RATE (LBS./DAY)
42	96	91.4	141.9
43	150	142.8	221.8
44	131	124.7	193.7
45	152	144.7	224.7
46	93	88.6	137.6
48	147	140.0	217.4
49	19	18.1	28.1
50	172	163.8	254.4
52	114	108.6	168.7
54	69	65.7	102.0
55	34	32.4	50.3
57	163	155.2	241.0
58	35	33.3	51.7
59	139	132.3	205.5
60	49	46.7	72.5
61	152	144.7	224.7
62	139	132.4	205.6
64	44	41.9	65.1
65	115	109.6	170.2
67	66	62.8	97.5
68	12	11.4	17.7
71	172	163.8	254.4
73	84	80.0	124.2
74	114	108.6	168.7
76	302	287.6	446.6

TABLE 21 (Continued)

NURSING HOMES

ESTIMATED GENERATION RATE

NO.	BED CAPACITY	ESTIMATED NUMBER OF RESIDENTS	ESTIMATED TOTAL S.W. GENERATION RATE (LBS./DAY)
77	137	130.5	202.7
78	175	166.6	258.7
79	168	160.0	248.5
81	16	15.2	23.6
82	121	115.2	178.9
88	579	551.3	856.2
90	226	215.2	334.2
93	130	123.8	192.3
95	189	180.0	279.5
96	176	167.6	260.3
98	144	137.1	212.9
99	230	219.0	340.1
100	85	80.9	125.6
101	79	75.2	116.8
104	108	102.8	159.6
106	47	44.8	69.6
108	111	105.7	164.2
109	114	108.6	168.7
111	84	80.0	124.2
112	49	46.7	72.5
115	145	133.1	214.5
116	112	106.6	165.5
117	234	222.8	346.0
118	120	114.2	177.4
119	197	187.6	291.3

TABLE 21 (Continued)

NURSING HOMES

ESTIMATED GENERATION RATE

NO.	BED CAPACITY	ESTIMATED NUMBER OF RESIDENTS	ESTIMATED TOTAL S.W. GENERATION RATE (LBS./DAY)
120	151	143.8	223.3
121	186	177.1	275.0
122	128	121.9	189.3
123	102	97.1	150.8
125	76	72.4	112.4
126	83	79.0	122.7
127	50	47.6	73.9
128	132	125.7	195.2
129	76	72.4	112.4
130	50	47.6	73.9
15	-	80	124.2
83	-	300	465.9
91	-	159	246.9
47	-	11	17.1
105	-	131	203.4
8	-	40	62.1
16	-	79	122.7
41	-	172	267.1
37	-	43	66.8
24	-	66	102.5
56	-	64	99.4
17	-	102	158.4
80	-	132	205.0
			TOTAL = 18,051.5
		42	GRAND TOTAL = 27,301.5

TABLE 22-

FORM A-1

CONTAINMENT & DISPOSAL METHOD

NO.	TYPE OF FACILITY	TYPE OF SURVEY	REGULAR S.W. CONT. METHOD				REGULAR S.W. DISPOSAL METHOD					SPECIAL S.W. CONT. METHOD				SPECIAL S.W. DISP. METHOD			
			PLASTIC BAGS	NON-DISPOSABLE CONTAINER	NO CONTAINMENT	OTHER	ON-SITE INCINERATION	HAULING AWAY TO LANDFILL	HAULING AWAY TO INCINERATE	RECYCLE	OTHER	ALONG WITH OTHER WASTES	IDENTIFIED PLASTIC BAG	CAN, JAR, BOX, ETC.	OTHER	ON-SITE INCINERATION	HAULING AWAY TO LANDFILL	HAULING AWAY TO INCINERATE	OTHER
103	NH	Pers.	X					X				X		X			X		
84	NH	Pers.	X		X			X				X					X		
75	NH	Pers.	X					X				X		X			X		
1	NH	Pers.	X					X				X		X			X		
102	NH	Pers.	X					X				X		X			X	X	
92	NH	Pers.	X				X	X				X				X			
97	NH	Pers.	X					X				X					X		
72	NH	Pers.	X					X				X					X		
87	NH	Pers.	X					X				X		X		X			
66	NH	Pers.	X				X	X				X				X			
12	NH	Mail	X						X				X					X	
24	NH	Mail	X					X					X				X		
51	NH	Mail	X				X	X			X					X	X		
70	NH	Mail	X				X		X					X		X			
60	NH	Mail	X						X			X						X	
10	NH	Mail	X						X					X				X	
15	NH	Mail	X																
37	NH	Mail	X						X			X						X	
53	NH	Mail	X					X									X		
33	NH	Mail	X				X	X					X			X			
39	NH	Mail	X					X					X				X		
3	NH	Mail	X				X	X					X			X			
4	NH	Mail	X		X	X		X	43			X					X		

TABLE 22 (Continued)

CONTAINMENT & DISPOSAL METHOD

NO.	TYPE OF FACILITY	TYPE OF SURVEY	REGULAR S.W. CONT. METHOD				REGULAR S.W. DISPOSAL METHOD					SPECIAL S.W. CONT. METHOD				SPECIAL S.W. DISP. METHOD			
			PLASTIC BAGS	NON-DISPOSABLE CONTAINER	NO CONTAINMENT	OTHER	ON-SITE INCINERATION	HAULING AWAY TO LANDFILL	HAULING AWAY TO INCINERATE	RECYCLE	OTHER	ALONG WITH OTHER WASTES	IDENTIFIED PLASTIC BAG	CAN, JAR, BOX, ETC.	OTHER	ON-SITE INCINERATION	HAULING AWAY TO LANDFILL	HAULING AWAY TO INCINERATE	OTHER
39	NH	Mail	X						X			X						X	
94	NH	Mail	X					X					X						
91	NH	Mail	X					X											
114	NH	Mail	X						X									X	
124	NH	Mail	X						X		X	X						X	
131	NH	Mail	X				X	X			X		X			X	X		
113	NH	Mail	X					X						X					
22	NH	Mail	X					X						X			X		
42	NH	Mail	X					X											
56	NH	Mail	X						X			X						X	
85	NH	Mail	X						X					X				X	
105	NH	Mail	X				X		X			X				X		X	
110	NH	Mail	X				X	X			X	X				X	X		
4	NH	Mail	X					X				X					X		
8	NH	Mail	X						X									X	
11	NH	Mail	X					X					X					X	
16	NH	Mail	X					X				X						X	
17	NH	Mail	X					X				X					X		
38	NH	Mail	X					X				X					X		
41	NH	Mail	X					X	X		X			X				X	
107	NH	Mail	X					X					X	X				X	
2	NH	Mail	X					X				X					X		
5	NH	Mail	X						X	44	X	X						X	

OPINION POLL

A-2

TABLE 23

NO.	TYPE OF FACILITY	1ST QUESTION				2ND QUESTION				3RD QUESTION				4TH QUEST.		5TH QUEST.									
		WILLING TO PARTICIPATE IN THE CENTRALIZED SYSTEM			PRIVATE OWNERSHIP	MUNICIPALITIES OWNERSHIP	OWNERSHIP BY PARTICIPANT INSTS.	OWNERSHIP BY STATE INSTS.	ECONOMICS	SAFETY RELIABILITY	LOCATION	METHODS OF HANDLING & DISPOSAL	OTHER	MUNICIPALITIES	INDIVIDUAL CONTRACTS WITH PRIV. HAULERS	THE INSTITUTIONS THEMSELVES	THE CENTRALIZED SYSTEM	PRIVATE HAULERS	HAZARDOUS & NON-HAZARDOUS	HAZARDOUS ONLY	NON-HAZARDOUS ONLY	NEED CHANGE THE PRESENT SYSTEM		NEED FOR A CENTRALIZED	
		YES	NO	DO NOT KNOW YET																		YES	NO	YES	NO
103	NH	X				X			X					X							X				
84	NH	X			X		X		1	2		3		X					X						
75	NH	X				X						X			X				X						
1	NH	X			X								X		X				X						
102	NH	X				X			X	X	X	X	X		X				X						
92	NH	X					X		1	2	3							X	X						
97	NH	X						X	X	X			X		X		X		X						
72	NH	X				X			X			X					X				X				
87	NH	X					X		X	X		X							X						
66	NH	X			X					X		X					X		X						
5	NH	X			X				X	X	X	X					X	X					X		
2	NH		X						X			X					X		X				X		
107	NH	X			X				X			X			X								X		
41	NH		X						X	X	X	X		X					X			X			X
38	NH			X					X	X		X					X		X			X			X
17	NH	X						X	X	X		X						X	X			Comment			
16	NH		X						X		X				X								X		
11	NH																					X			X
8	NH														X					X			X		
4	NH	X						X	X			X			X						X	X			X
10	NH	X				X			X		X	X	45		X				X				X		

TABLE 23 (Continued)

OPINION POLL

A-2

FACILITY NO.	TYPE OF FACILITY	1ST QUESTION				2ND QUESTION				3RD QUESTION				4TH QUEST.				5TH QUEST.							
		WILLING TO PARTICIPATE IN THE CENTRALIZED SYSTEM			PRIVATE OWNERSHIP	MUNICIPALITIES OWNERSHIP	OWNERSHIP BY PARTICIPANT INSTS.	OWNERSHIP BY STATE INSTS.	ECONOMICS	SAFETY RELIABILITY	LOCATION	METHODS OF HANDLING & DISPOSAL	OTHER	MUNICIPALITIES	INDIVIDUAL CONTRACTS WITH PRIV. HAULERS	THE INSTITUTIONS THEMSELVES	THE CENTRALIZED SYSTEM	PRIVATE HAULERS	HAZARDOUS & NON-HAZARDOUS	HAZARDOUS ONLY	NON-HAZARDOUS ONLY	NEED CHANGE THE PRESENT SYSTEM		NEED FOR A CENTRALIZED	
		YES	NO	DO NOT KNOW YET																		YES	NO		YES
105	NH	X				X			X	X	X	X						X			X		X		
85	NH		X						X	X		X			X					X			X		
56	NH	X							X	X	X	X			X					X		X		X	
47	NH	X						X	X			X			X										
22	NH	X				X			X	X	X	X							X			X			X
13	NH			X	X				X									X	X				X		
131	NH	X				X			X	X	X	X					X		X				X		
124	NH		X						X	X	X	X			X								X		
114	NH		X						X	X	X	X			X							X			
94	NH	X						X	3	4	2	1			X						X	X			X
89	NH	X				X			X	X	X	X					X		X						
83	NH	X			X	X		X	X	X		X			X			X	X						
86	NH		X						X	X	X	X			X				X				X		
69	NH				X				X	X	X	X			X				X			Comm.			
63	NH	X			X				X	X		X			X				X				X		
53	NH		X		X				X						X								X		
37	NH	X						X				X			X				X						X
15	NH														X										
10	NH	X							X	X	X	X			X			X	X				X		Cor
70	NH	X			X				X	X					X				X				X		
51	NH	X			X				X	X	X	X	X	46				X	X			X		X	

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TABLE 24
VETERINARY HOSPITALS
GENERAL INFORMATION

FORM VH-1

NO.	TYPE OF SURVEY	TYPE OF HOSPITAL, SIZE OF ANIMALS	# OF ANIMALS KEPT IN THE HOSPITAL	# OF CLIENTS PER DAY	# OF SURG. OPERATIONS PER WEEK	# OF EMPLOYEES
74	Personal	Small	6	20-25	8	2
102	Personal	Small	6	20	20	2
50	Personal	Small	20	50	25	5
101	Personal	Small	7	23	15	4
61	Personal	Small	35	—	10	5
39	Personal	Small	20-30	40	25	8
99	Personal	Small	14	10	15	2
40	Personal	Small	10-15	20	3-4	5
77	Personal	Small	15-20	20	25	4
33	Personal	Small	30	80	15	10
66	Mail	Small	10-20	20	10-15	4
65	Mail	Small	10	18	10	3
98	Mail	Small	25	—	5	6
91	Mail	Small	26	8	5	1
96	Mail	Small	12	10-25	20	5
100	Mail	Small	5	20	10	3
106	Mail	Small	15-20	35	35	7
70 & 87	Mail	Small	20	40	35-50	10
94	Mail	Small	6	22	15	1
103	Mail	Small	8	25	20	2
30	Mail	Small	12-15	20	15-20	6
31	Mail	Small	5	20	20	3
44	Mail	Small	5	25	10	3
70	Mail	Small	10	30-40	15-20	7
23	Mail	Small	0-25	20-25	6	3
6	Mail	Small	48 35	50	55	13

TABLE 24 (Continued)
 VETERINARY HOSPITALS
 QUANTITY - TOTAL SOLID WASTE

NO.	TYPE OF SURVEY	REGULAR S.W. GENERATION (LBS./DAY)	ANIMAL CARCASSES GENERATION (LBS./WEEK)	SPECIAL S.W. GENERATION (LBS./DAY)	TOTAL GENERATION RATE (LBS./DAY)
74	Personal	14	25	< .5	39
102	Personal	40	10	< .5	50
50	Personal	33	30	~1.5	64.5
47	Personal	35	25	~1.0	61
61	Personal	42	20	~3.0	65
101	Personal	19	25	~1.0	45
39	Personal	65	30	~1.0	96
99	Personal	50	10	<1.0	60
40	Personal	19	5	~1.5	25.5
77	Personal	23	25	~2.0	50
33	Personal	34	25	~1.5	60.5
		AVE = 34	AVE = 20.9		AVE = 56
66	Mail	25	—	8.5	—
65	Mail	10-25	15	~3	28-43
98	Mail	20	—	~2	—
91	Mail	15	20	~1	36
96	Mail	40	30	~3	73
100	Mail	10	30	~3	43
106	Mail	25	40	<1.0	65
107	Mail	120	100	15	235
94	Mail	5	20-80	<1.0	25-85
103	Mail	30	—	—	—
30	Mail	100	50-100	22	177-222
31	Mail	5	5	<1.0	10
32	Mail	10	49 10	~1.0	21

FORM VH-2

[illegible]

CONTAINMENT & DISPOSAL METHOD

NO.	TYPE OF FACILITY	TYPE OF SURVEY	REGULAR S.W. CONT. METHOD				REGULAR S.W. DISPOSAL METHOD				SPECIAL S.W. CONT. METHOD				SPECIAL S.W. DISP. METHOD			
			PLASTIC BAGS	NON-DISPOSABLE CONTAINER	NO CONTAINMENT	OTHER	ON-SITE INCINERATION	HAULING AWAY TO LANDFILL	HAULING AWAY TO INCERATE	RECYCLE	OTHER	ALONG WITH OTHER WASTES	IDENTIFIED PLASTIC BAG	CAN, JAR, BOX, ETC.	OTHER	ON-SITE INCINERATION	HAULING AWAY TO LANDFILL	HAULING AWAY TO INCINERATE
74	Vet.H.	Pers.	X					X			X					X		
102	Vet.H.	Pers.	X					X			X					X		
50	Vet.H.	Pers.	X		X			X			X					X		
47	Vet.H.	Pers.	X					X			X					X		
61	Vet.H.	Pers.	X					X			X		X			X		
101	Vet.H.	Pers.	X		X			X			X		X		X	X	X	
39	Vet.H.	Pers.		X			X	X		X	X				X			
99	Vet.H.	Pers.			X			X			X					X		
110	Vet.H.	Pers.		X				X			X		X			X		
77	Vet.H.	Pers.	X					X			X					X		
33	Vet.H.	Pers.	X					X			X					X		
6	Vet.H.	Mail	X			X		X			X					X		
26	Vet.H.	Mail	X					X	X		X						X	
70	Vet.H.	Mail	X					X	X		X					X	X	
44	Vet.H.	Mail	X					X			X					X		
31	Vet.H.	Mail		X				X			X					X		
30	Vet.H.	Mail						X			X					X		
03	Vet.H.	Mail	X					X			X					X		
04	Vet.H.	Mail	X			X		X				X					X	
87	Vet.H.	Mail				X		X			X					X		
5	Vet.H.	Mail				X	X	X				X						
1	Vet.H.	Mail	X					X			X					X		

* Does not include animal carcasses

CONTAINMENT & DISPOSAL METHOD

[illegible]

FACILITY NO.	TYPE OF FACILITY	1ST QUESTION				2ND QUESTION				3RD QUESTION				4TH QUEST.				5TH QUEST.						
		WILLING TO PARTICIPATE IN THE CENTRALIZED SYSTEM			PRIVATE OWNERSHIP	MUNICIPALITIES OWNERSHIP	OWNERSHIP BY PARTICIPANT INSTS.	OWNERSHIP BY STATE INSTS.	ECONOMICS	SAFETY RELIABILITY	LOCATION	METHODS OF HANDLING & DISPOSAL	OTHER	MUNICIPALITIES	INDIVIDUAL CONTRACTS WITH PRIV. HAULERS	THE INSTITUTIONS THEMSELVES	THE CENTRALIZED SYSTEM	PRIVATE HAULERS	HAZARDOUS & NON-HAZARDOUS	HAZARDOUS ONLY	NON-HAZARDOUS ONLY	NEED CHANGE THE PRESENT SYSTEM		NEED FOR A CENTRALIZED
		YES	NO	DO NOT KNOW YET																		YES	NO	
33	VH	X					X		X	X		X	X	X			X		X				Comment	
77	VH	X			X				X	X		X					X		X				X	
40	VH	X			X				X	X	X	X			X				X			X		X
99	VH		X												X								X	
39	VH		X		X		X		X															
101	VH	X			X				X	X		X					X		X			X		
61	VH			X			X		X						X				X				X	
47	VH	X						X	X	X	X	X	X		X				X			X		X
50	VH	X						X	X			X					X	X					X	
74	VH	X			X				X		X	X			X				X				X	
102	VH	X			X				X										X			X		X
66	VH			X					X	X		X											X	
65	VH		X												X								X	
98	VH	X			X				X	X	X	X			X				X			X		X
91	VH	Comment																						
96	VH	X			X				X	X	X				X				X			Comment		
90	VH		X																				X	
95	VH	X			X				X						X		X	X					X	
90	VH	X			2	3		1	1	4	3	2	X		X				X			Comment		
94	VH	X			X			X	X	X	X	X	X		X				X			X	Com	X
97	VH	X				X			X			53	X		X				X				X	

TABLE 26. (Continued)

TABLE 27

<u>INSTITUTIONAL CATEGORY</u>	<u>TOTAL NUMBER</u>	<u>NO. PER OBSERV.</u>	<u>NO. QUEST. MAILED</u>	<u>NO. QUEST. RETURN</u>	<u>% QUEST. RETURN</u>	<u>TOTAL RETURN</u>
Hospitals	38	7	31	12	38.7	50.0
Nursing Homes	131	10	121	36	29.7	35.1
Veterinaries	105	11	94	16	17.0	25.7
<hr/>						
TOTAL	274	28	246	64	26.0	33.0

The remaining HHC institutions identified as secondary generators for study were surveyed by letter questionnaire alone. Each institution was again assigned a code number for recording survey results. Tables 28 through 30 present the tabularized results of the data and information received from the survey.

Table 31 presents the resulting summation of responses received from each of the secondary generators surveyed.

TABLE 23
FACILITIES IN SECONDARY GROUP
QUANTITY AND GENERAL INFORMATION

NO.	TYPE OF FACILITY	AVERAGE # OF PERSONS SERVED PER DAY	# OF EMPLOYEES	SPECIAL S.W. GENERATION RATE	TOTAL S.W. GENERATION RATE
21	Supervised Living Fac.	62	107	~ 0	1 cu.ft./day
41	Supervised Living Fac.	150	52	—	2 cu.yds./day
29	Supervised Living Fac.	40	9	0	—
13	Supervised Living Fac.	15	8	—	—
16	Supervised Living Fac.	34	18	—	—
26	Supervised Living Fac.	25	5	0	5 cu.yds./day
	Supervised Living Fac.	—	—	2 1/2 lbs./day	20 lbs./day
24	Supervised Living Fac.	63	55	0	700 lbs./day
20	Supervised Living Fac.	6	14	0	35 lbs./day
	Supervised Living Fac.	—	—	1.0 lbs./day	95 lbs./day
5	Supervised Living Fac.	60	34	0	1.0 cu.yds./day
6	Supervised Living Fac.	6	5	—	30 lbs./day
43	Supervised Living Fac.	9	15	0	15 lbs./day
2	Convalescent & Nurs. Care	350	307	Minimal	2 cu.yds./day
3	Convalescent & Nurs. Care	37	13	Minimal	5 bags/day
1	Convalescent & Nurs. Care	165	315	16 lbs./day	1000 lbs./day
2	Home Health Agency	—	24	—	—
13	Home Health Agency	450	42	1.1 lbs./day	—
12	Home Health Agency	25-50	10	5-10 lbs./day	—
3	Home Health Agency	50-75	60	2/wk.	10 lbs./day
8	Independent Lab	1500	93	10 lbs./day	50 cu.ft./day
4	Boarding Care Home	200	95	—	—
1	Boarding Care Home	105	50	—	—
	Boarding Care Home	50	51	~ 1 lb./day	150 lbs./day
		57			

TABLE 29-

FORM A-1

CONTAINMENT & DISPOSAL METHOD

NO.	TYPE OF FACILITY	TYPE OF SURVEY	REGULAR S.W. CONT. METHOD				REGULAR S.W. DISPOSAL METHOD				SPECIAL S.W. CONT. METHOD				SPECIAL S.W. DISP. METHOD			
			PLASTIC BAGS	NON-DISPOSABLE CONTAINER	NO CONTAINMENT	OTHER	ON-SITE INCINERATION	HAULING AWAY TO LANDFILL	HAULING AWAY TO INCINERATE	RECYCLE	OTHER	ALONG WITH OTHER WASTES	IDENTIFIED PLASTIC BAG	CAN, JAR, BOX, ETC.	OTHER	ON-SITE INCINERATION	HAULING AWAY TO LANDFILL	HAULING AWAY TO INCINERATE
21	SLF	Mail	X					X	X				X				X	
41	SLF	Mail	X					X			X							
29	SLF	Mail	X						X									
13	SLF	Mail	X					X										
16	SLF	Mail	X					X										
26	SLF	Mail	X						X		X							
	SLF	Mail	X						X			X						X
24	SLF	Mail	X		X	X		X			X							
20	SLF	Mail	X						X									
	SLF	Mail	X					X				X					X	
5	SLF	Mail	X					X			X							
6	SLF	Mail	X					X										
43	SLF	Mail	X					X			X							
2	CNC	Mail	X					X					X					X
	CNC	Mail	X					X					X				X	
1	CNC	Mail	X		X	X	X	X					X					
7	BCH	Mail	X					X										
	BCH	Mail	X			X			X		X		X					
4	BCH	Mail	X					X										
7	L43	Mail	X					X		58			X					

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FACILITY NO.	TYPE OF FACILITY	1ST QUESTION			2ND QUESTION								3RD QUESTION				4TH QUEST.		5TH QUEST.					
		WILLING TO PARTICIPATE IN THE CENTRALIZED SYSTEM			PRIVATE OWNERSHIP	MUNICIPALITIES OWNERSHIP	OWNERSHIP BY PARTICIPANT INSTS.	OWNERSHIP BY STATE INSTS.	ECONOMICS	SAFETY RELIABILITY	LOCATION	METHODS OF HANDLING & DISPOSAL	OTHER	MUNICIPALITIES	INDIVIDUAL CONTRACTS WITH PRIV. HAULERS	THE INSTITUTIONS THEMSELVES	THE CENTRALIZED SYSTEM	PRIVATE HAULERS	HAZARDOUS & NON-HAZARDOUS	HAZARDOUS ONLY	NON-HAZARDOUS ONLY	NEED CHANGE THE PRESENT SYSTEM		NEED FOR A CENTRALIZED
		YES	NO	DO NOT KNOW YET																		YES	NO	
21	SLF		X						X					X						X			X	Comm.
29	SLF					X			X	X	X	X		X					X					
16	SLF			X																				
26	SLF	X				X	X		X			X			X				X				X	
	SLF	X					X		X	X					X					X		X		
24	SLF	X					X	X	X			X						X			X		X	
20	SLF	X						X	X			X						X						
	SLF		X						X						X			X	X				X	
5	SLF	X			X				X			X					X		X			X		X
6	SLF			X					X			X			X				X			Comm.		
43	SLF		X						X	X	X	X		X									X	
2	CNC			X					X	X		X			X					X			X	
3	CNC		X												X					X			X	
1	CNC	X				X		X	X	X		X			X				X			X		X
1	BCH			X	X				X	X		X						X	X					
	BCH	X			X				2			1			X				X			Comm.		
8	LAB	X				X			X	X	X	X			X				X			X		X
3	HHA			X					X	X	X	X			X				X			X	Comm.	
12	HHA	X							X	X	X	X							X					
13	HHA		X						X				X					X						

TABLE 31

<u>Institutional Category</u>	<u>Total Number</u>	<u>No. Quest. Mailed</u>	<u>No. Quest. Returned</u>	<u>% Quest. Returned</u>
Sup. Living Facility	43	43	13	30.2
Boarding Care Home	37	37	2	5.4
Ind. Labs	15	15	2	13.3
Convalescent Nursing	2	2	2	100.0
Mental Hospital	2	2	0	0.0
Home Health Agency	13	13	5	38.5
Portable X-Ray	4	4	0	0.0
Speciality Hospital	3	2	2	66.7
Outpatient Physical Therapy	1	1	0	0.0
	—	—	—	—
	120	119	26	21.0

COMPARISON OF HOSPITAL AND NURSING HOME
MEASURED QUANTITIES WITH LITERATURE VALUES

From previous literature discussions estimating parameters have been presented for the purposes of calculating solid waste quantity estimates from hospitals, and with modifications to these parameters, also from nursing homes. It was, therefore, of interest to compare the measured values obtained by this study for these institutional categories, with those calculated using the literature. Table 32 indicates the comparison from hospitals, while Table 33 indicates the comparison for nursing homes.

TABLE 32.
HOSPITALS
CALCULATED QUANTITIES
(USING LITERATURE)

NO.	TYPE OF SURVEY	MEASURED GEN.RATE (M) LB/DAY	CALCULATED* GEN.RATE (I) LB/DAY	CALCULATED* GEN.RATE (II) LB/DAY	DIFF I = I - M	DIFF II = II - M	% OFF DIFF I/M	% OFF DIFF II/M
28	Personal	274	274.0	267.0	0.0	- 7.0	0.0	2.5
26	Personal	1,891	2,118.0	2,029.0	227.0	138.0	+ 12.0	+ 7.3
30	Personal	4,100	3,056.0	3,779.0	-1,044.0	- 321.0	25.4	7.8
12	Personal	1,036	772.0	790.0	- 264.0	- 246.0	25.5	23.7
9	Personal	810	917.0	885.0	107.0	75.0	+ 13.2	+ 9.2
2	Personal	2,813	2,065.0	1,767.0	- 748.0	- 1,046.0	- 26.6	- 37.2
16	Personal	847	1,146.0	1,265.0	299.0	418.0	+ 35.3	+ 40.3
TOTAL		11,771	10,349.0	10,782.0	- 1,423	- 989.0	12.1	- 8.4

AVERAGE GENERATION RATE PER PATIENT - I = 9.06

AVERAGE GENERATION RATE PER PATIENT - II = 9.19

refers to values calculated using "Study of the Economics of Hospital Solid Waste Systems" by R.G. Bond, et al.

refers to values calculated using "Hospital Solid Waste Disposal in Community Facilities" by A.F. Iglar and R.G. Bond.

TABLE 33
NURSING HOMES
CALCULATED QUANTITIES
(USING LITERATURE)

NO.	TYPE OF SURVEY	MEASURED GEN. RATE (M) LB/DAY	CALCULATED* GEN. RATE (I) LB/DAY	CALCULATED* GEN. RATE (II) LB/DAY	DIFF I = I - M	DIFF II = II - M	% OFF DIFF I/M	% OFF DIFF II/M
103	Personal	184	994	881	810	697	440.2	378.8
84	Personal	288	1,314	865	1,026	577	356.2	200.3
75	Personal	544	1,924	1,550	1,380	1,006	253.6	181.9
1	Personal	76	410	305	334	229	439.4	301.3
102	Personal	195	1,073	949	878	754	450.2	386.6
92	Personal	283	1,305	858	1,022	575	361.1	203.2
97	Personal	79	300	228	221	149	279.7	188.6
72	Personal	188	982	674	794	486	422.3	258.5
87	Personal	315	1,352	1,094	1,037	779	329.2	247.3
66	Personal	262	1,078	950	816	688	311.4	262.6
TOTAL		2,414	10,732	8,354	8,318	5,940	344.6	246.0

AVERAGE GENERATION RATE PER RESIDENT - I = 7.05 lbs./day/resident

AVERAGE GENERATION RATE PER RESIDENT - II = 5.48 lbs./day/resident

refers to values calculated using "Study of the Economy of Hospital Solid Waste Systems" by R.G. Bond, et al.

I refers to values calculated using "Hospital Solid Waste Disposal in Community Facilities" by A.F. Iglar and R.G. Bond.

At the culmination of the study period some conclusions could be reached concerning the system input expected into the solid waste management system planned for the HHC institutions in the TCMR.

The operating size or capacity of the centralized disposal system is to be planned based upon the following parameters.

Tables 34, 35, and 36 represent the parameters derived from the study for hospitals, nursing homes and veterinary facilities.

Based upon the measured values of solid waste quantities obtained through personal observations, and letter questionnaires, and the above estimating parameters in Tables 34 through 36, the total quantities of solid waste estimated for the TCMR, primary generators is presented in Table 37.

TABLE 34

HOSPITAL SOLID WASTE ESTIMATING PARAMETERS

<u>Parameter</u>	<u>Calculated Value</u>
Average Pounds per patient	9.85
Average Cubic feet per patient	2.47
Average Density Units	4.09
Average Percent Occupancy	64.25*
Average Percent Rubbish	58.5
Average Percent Garbage	28.9
Average Percent Special	10.2

*Determined by total number of beds per patient census

TABLE 35

NURSING HOME SOLID WASTE ESTIMATING PARAMETERS

<u>Parameter</u>	<u>Calculated Value</u>
Average Pounds per Resident	1.553
Average Cubic Feet per Resident	0.414
Average Density Units	3.85
Average Percent Occupancy	95.22
Average Percent Rubbish	51.4
Average Percent Garbage	46.4
Average Percent Special	2.0

TABLE 36

VETERINARY FACILITIES SOLID WASTE ESTIMATING PARAMETERS

<u>Parameter</u>	<u>Calculated Value</u>
Average Total pounds per facility	56.0
Average Total Animal Carcasses per facility	20.9

TABLE 37

TOTAL ESTIMATE SOLID WASTE QUANTITIES FOR PRIMARY TCMR

<u>Institutional Category</u>	<u>Measured thru Survey (Pounds/Day)</u>	<u>Estimated by Parameter (Pounds/Day)</u>	<u>Total for TCMR</u>
Hospital	68,224	31,016	99,240
Nursing Homes	9,250	18,209	27,459
Veterinary Facilities	<u>1,419</u>	<u>4,648</u>	<u>6,067</u>
Total	78,893	53,873	132,766
Federal Hospital	-	5,462	138,228
Approximately 70 Tons per Day			

Since the secondary generators were surveyed by letter questionnaire alone the results were somewhat more diverse, and not so easily interpreted. Also, not all categories were directly involved in patient care, and therefore solid waste quantities could not be estimated based upon this factor. Table 38 represents the solid waste estimating parameters determined.

Based upon the values of solid waste quantities obtained through the letter questionnaires and the above estimating parameters in Table 38 the total quantity of solid waste estimated for the TCMR, secondary generators is presented in Table 39.

TABLE 38

<u>Institutional Category</u>	<u>Estimating Parameter</u>	<u>Average Parameter Value (Per Day)</u>
Supervised Living Facility	Pounds per Employee	8.34
Convalescent and Nursing Care	Pounds per Employee	7.76
Home Health Agency	Pounds per Facility	10.00
Independent Laboratory	Pounds per Facility	200.00
Boarding Care Home	Pounds per Facility	150.00

TABLE 39

TOTAL ESTIMATE SOLID WASTE QUANTITIES FOR SECONDARY, TCMR

<u>Institutional Category</u>	<u>Measured thru Survey (Pounds/Day)</u>	<u>Estimated by Parameter (Pounds/Day)</u>	<u>Total for TCMR (Pounds/Day)</u>
Supervised Living Facility	1,180	7,548	8,728
Convalescent and Nursing Care	1,250	(All Facilities Included)	1,250
Home Health Agency	30	100	130
Independent Laboratory	200	2,800	3,000
Boarding Care Home	<u>150</u>	<u>5,400</u>	<u>5,550</u>
Totals	2,810	15,848	18,658

3.1.4.1(c)

TOTAL QUANTITY ESTIMATES

Based upon the estimates obtained for the primary and secondary groups, the following total quantity estimates for solid waste generated is presented in Table 40.

TABLE 40

<u>Generation Category</u>	<u>Total Quantity for TCMR (Pounds/Day)</u>
Primary	138,228
Secondary	<u>18,658</u>
Total	156,884 = 78.44 tons/day

The collection system to be designed for moving the solid waste generated from the HHC institutions to the centralized disposal system is to be planned to accommodate as nearly as possible the following institutional characteristics as summarized in Tables 41 through 49.

TABLE 41
CONTAINMENT METHOD USED FOR GENERAL SOLID WASTE

Containment Method, Percent Using	(19)* Hospitals	(46) Nursing Homes	(27) Veterinary Facilities	(13) Supervised Living Facility	(3) Convalescent and Nursing Care	(3) Boarding Care Home	(1) Independent Laboratory	(2) Home Health Agency	(2) Speciality Hospital
Plastic bags	100	100	73	100	100	100	100	100	50
No containment **	16	4	31	8	33	0	0	0	100
Other	16	2	15	8	33	33	0	50	50

* Numbers in parentheses indicate the number of institutions used in determination.

**No containment refers to whether or not disposable containers are used such as liners in addition to non-disposable collection container.

TABLE 12
DISPOSAL METHODS FOR REGULAR SOLID WASTE

Method (%)	Institutional Category	(19)	(45)	(27)	(13)	(3)	(3)	(1)	(4)	(2)
		Hospitals	Nursing Homes	Veterinary Facilities	Supervised Living Facility	Convalescent and Nursing Care	Boarding Care Home	Independent Laboratory	Home Health Agency	Speciality Hospital
On-site incineration		53	20	7	0	33	0	0	50	100
Haul to landfill		95	65	100	69	100	67	100	50	100
Off-site incineration		26	35	100	38	0	33	0	25	0
Other		26	13	4	33	0	33	0	0	50

TABLE 43

CONTAINMENT METHOD FOR SPECIAL SOLID WASTE

Institutional Category	(19) Hospitals	(37) Nursing Homes	(26) Veterinary Facilities	(3) Supervised Living Facility	(3) Convalescent and Nursing Care	(1) Boarding Care Home	(1) Independent Laboratory	(4) Home Health Agency	(2) Specialty Hospital
Method (%)									
Along with regular waste	21	52	84	67	0.0	0.0	0.0	50.0	0.0
Identified plastic bags, boxes, cans, etc.	100	44.5	27	33	100	100	100	75	100
Other	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	50.0

TABLE 41

DISPOSAL METHOD FOR SPECIAL SOLID WASTE

Institutional Category	(18) Hospitals	(41) Nursing Homes	(25) Veterinary Facilities	(3) Supervised Living Facility	(2) Convalescent and Nursing Care	(0) Boarding Care Home	(1) Independent Laboratory	(3) Home Health Agency	(2) Specialty Hospital
Method (%)									
On-site incineration	53	22.7	7.4	0.0	0.0	-	0.0	66.7	100.0
Hauling to landfill	28	43.5	96	50.0	50.0	-	0.0	33.3	0.0
Hauling to off-site incineration	39	34.8	96.0	50.0	50.0	-	0.0	0.0	0.0
Other methods	0.0	2.2	3.7	0.0	0.0	0.0	100.0	0.0	0.0

TABLE 45

OPINION POLL: FIRST QUESTION.

PART 1: Would you consider supporting and participating in a centralized system for resource recovery from solid waste.

	(18) Hospitals	(40) Nursing Homes	(26) Veterinary Facilities	(10) Supervised Living Facility	(3) Convalescent and Nursing Care	(2) Boarding Care Home	(1) Independent Laboratory	(3) Home Health Agency	(1) Speciality Hospital
Response (%)									
Yes	83.3	75.0	61.5	10.0	3	2	1	3	1
No	0.0	20.0	23.1	30.0	33.3	0.0	0.0	33.3	0.0
PART 2: If yes, what would be your choice of management for such a system.									
	(15)	(31)	(21)	(16.6)	(1)	(2)	(1)	(0)	(10)
Response (%)									
Private ownership	5.5	38.9	57.9	16.6	0.0	100.0	0.0	-	-
Municipal ownership	16.7	27.8	5.3	33.3	100.0	0.0	100.0	-	-
Ownership by participating institutions	50.0	13.9	15.8	50.0	0.0	0.0	0.0	-	-
Ownership by state institution (U of M)	27.8	16.6	31.8	33.3	100.0	0.0	0.0	-	-

TABLE 46

OPINION POLL: SECOND QUESTION.

What factors would you consider before participating in such an integrated system.

	Hospitals (18)	Nursing Homes (41)	Veterinary Facilities (22)	Supervised Living Facility (10)	Convalescent and Nursing Care (2)	Boarding Care Home (2)	Independent Laboratory (1)	Home Health Agency (3)	Speciality Hospital (1)
Response (%)									
Economics	88.9	87.8	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Safety and reliability	66.7	61.0	59.1	30.0	100.0	50.0	100.0	67.7	0.0
Location	33.3	43.9	45.4	20.0	0.0	0.0	100.0	66.7	0.0
Methods of hauling and and disposal	66.7	78.0	63.6	70.0	100.0	100.0	100.0	66.7	100.0

TABLE 17

OPINION POLL: THIRD QUESTION.

Which system of collection and hauling do you prefer?

	Hospitals (15)	Nursing Homes (41)	Veterinary Facilities (22)	Supervised Living Facility (10)	Convalescent and Nursing Care (3)	Boarding Care Home (2)	Independent Laboratory (1)	Home Health Agency (2)	Speciality Hospital (1)
Responses (%)									
Municipalities	6.2	7.3	9.1	30.0	0.0	0.0	0.0	0.0	100.0
Private hauler based upon contracts with institution	18.7	58.5	63.6	40.0	100.0	50.0	100.0	50.0	0.0
Institutions themselves	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Centralized system itself	62.5	17.0	13.6	100.0	0.0	0.0	0.0	0.0	0.0
Private hauler based upon contract with centralized system	18.7	24.4	22.7	30.0	0.0	50.0	0.0	50.0	0.0

TABLE 4S

OPINION POLL: FOURTH QUESTION.

Which disposal system do you suggest?

	Hospitals (18)	Nursing Homes (39)	Veterinary Facilities (20)	Supervised Living Facility (8)	Convalescent and Nursing Care (3)	Boarding Care Home (2)	Independent Laboratory (1)	Home Health Agency (2)	Speciality Hospital (1)
Response (%)									
Hazardous and non-hazardous waste combined	94.4	75.0	95.0	62.5	33.3	100.0	100.0	100.0	100.0
Hazardous waste only	0.0	8.3	5.0	25.0	66.7	0.0	0.0	0.0	0.0
Non-hazardous waste only	5.6	16.7	0.0	12.5	0.0	0.0	0.0	0.0	0.0

TABLE 49

OPINION POLL: FIFTH QUESTION.

PART 1: Do you feel the need for a change in the present methods of collection and disposal of your solid waste in the community?

	Hospitals (10)	Nursing Homes (27)	Veterinary Facilities (20)	Supervised Living Facility (7)	Convalescent and Nursing Care (3)	Boarding Care Home (0)	Independent Laboratory (1)	Home Health Agency (1)	Speciality Hospital (0)
Response (%)									
Yes	80.0	37.0	35.0	28.6	33.3	-	100.0	100.0	-
No	20.0	63.0	65.0	71.4	66.7	-	0.0	0.0	-
PART 2: If yes, do you think of a centralized system as the answer?									
	(7)	(11)	(7)	(2)	(1)	(0)	(1)	(0)	(0)
Response (%)									
Yes	57.1	54.5	71.4	50.0	100.0	-	100.0	-	-
No	0.0	9.1	14.3	0.0	0.0	-	0.0	-	-
Don't know	42.9	36.4	14.3	5.0	0.0	-	0.0	-	-

In addition to quantity estimates of solid waste to be processed by the centralized system, for determining operating capacities, other properties associated with the incineration of the waste are necessary for design and performance criteria. Of primary importance is the necessity to estimate the thermodynamics of the system, and specifically the solid waste heat content to be released during the incineration process. Also of importance though to a lesser degree are properties such as moisture content, plastic content, and percent of inerts.

Since the HHC solid waste is generated about numerous locations throughout the 7-county region, and is recognized as representing a very heterogenous material, gathering a small, representative sample for laboratory testing from sample institutions was felt impractical. Therefore, it was decided that the the University of Minnesota's existing incinerator should be utilized in estimating these properties. Essentially this porcedure involved bringing into the incinerator known quantities of solid waste from selected HHC facilities, incinerating this material and monitoring the process for the desired properties. University general campus solid waste was used to establish the procedures and baseline operating data on the incinerator, before testing the HHC material.

The University of Minnesota, Department of Physical Plant maintains and operates a municipal type incinerator as part of its solid waste management program. Approximately 30 tons per day of municipal type solid waste is generated from Minneapolis/St. Paul campus activities. Most of this waste, collected by University vehicles, is delivered to the incinerator for volume reduction before final disposal at a TCMR sanitary landfill. Of this 30 tons per day, approximately seven to eight tons per day comes from the University hospitals and health sciences related activities. In addition to the 30 tons per day, approximately 3,000 pounds per day of research animal carcasses and related materials are also collected and delivered for destruction.

Essentially, the incinerator is comprised of two separate incineration units, each capable of independent operation, in conjunction, or concurrently as disposal requires. Each unit basically operates about a Detroit reciprocating grate stoker, manufactured by the Detroit Stoker Company. The oldest of the units was put into operation in January, 1963, and the newest unit in February, 1966. Both units are of comparable size with each unit having a designed loading capacity of 50 tons per 24 hours, or approximately 2 tons per hour.

Grates are arranged in lateral rows, each overlapping its immediate forward neighbor in a shingle-like manner. Alternate rows are linked to a power source which reciprocates them forward and backward across the faces of intermediate or stationary rows. Each reciprocal grate movement tends to tear and tumble the refuse mass, thus aerating its elements and providing maximum surface exposure to the flame without manual poking. Another advantage of this grate action lies in its ability to maintain a uniform continuous refuse bed. Holes caused by the flash-burning of random spots of highly volatile refuse are promptly filled by material pushed from behind. The grates are constructed in such a way that the air supply is forced through self-cleaning venturi openings which assure optimum distribution of air for complete combustion of waste. The general campus solid waste is incinerated through this portion of the units.

Animal carcasses and related materials are burned in a separate pathological hearth adjoining each main combustion area. Each hearth is elevated two feet above the moving grate, and orientated so that flames and combustion gases from the main incineration area pass through and over the animals on the hearth and into the incinerator breeching. This material is received in plastic bags, and charged separately into the hearth.

Disposal of the ash residue from the main combustion is accomplished by the moving grate which transports the ashes to a "roll-off" collection container for hauling to a sanitary landfill.

Figures 2 through 4 depict the basic design of each incineration unit.

Each incineration unit connects into a common breeching passing overhead and running to the discharge stack. Hydraulic dampers serve to isolate the breeching connection for each unit. The stack height is 190 feet, and is constructed of independent firebrick lining laid in high temperature cement.

FIGURE 2

UNIVERSITY OF MINNESOTA INCINERATOR

BY	BUILDING	SCALE	SHEET
GDM			
CHECKED	DATE	REVISED	DRAWING
	1-23-78		

FIGURE 3

UNIVERSITY OF MINNESOTA INCINERATOR

BY	BUILDING	SCALE	SHEET
GDM			
CHECKED	DATE	REVISED	DRAWING
	1-23-78		

FIGURE 4

UNIVERSITY OF MINNESOTA - INCINERATOR

BY	BUILDING	SCALE	SHEET
GDM			
CHECKED	DATE	REVISED	CRASHING
	1-23-78		

Basically the Laws: Conservation of Energy and Mass were used in estimating the incineration properties of the solid waste. Identified solid waste collections would be weighed at the University of Minnesota's truck scale and then incinerated while monitoring heat balance parameters. Ash residue, and gas flow through the stack breeching were also monitored. The incineration operation was basically considered to be in steady-state condition, while making input/output measurements. The remaining unknown value, the heat of combustion was then solved for analytically.

3.2.1.2

DESCRIPTION OF TEST PROCEDURES FOR DETERMINING THE HIGHER HEAT OF COMBUATION OF SOLID WASTE

3.2.1.2(a)

TEST EQUIPMENT

The test equipment used was as described in EPA Method 5 test procedure and was manufactured by the Aerotherm Division of the Acurex Corporation.

The stack gas was drawn from a breeching port through a five foot long stainless steel probe by means of a carbon van vacuum pump. The gas then passed through a filter attached to the probe into a sixteen foot long copper cooling coil with a collection jar attached at the bottom submersed in an ice bath. Finally, the gas entered the dry gas meter located in the meter box.

Type S Pilot tubes were used to measure the velocity head of the stack gas, which was registered on a magnahelic gage on the meter box. Thermocouples attached to the meter box measured the stack temperature, ambient air temperature, and meter box inlet and outlet temperatures.

Each timed test began after the operators had started feeding the solid waste into the incinerator and the stack temperature had risen to 400° F or higher. The probe was then inserted and moved along a three-point horizontal traverse, with the position of the probe changed every minute. Readings of the velocity head, stack temperature, ambient air temperature, and meter inlet and outlet temperatures were taken every minute. An Orsat analysis for CO₂ and O₂ was performed every five to ten minutes.

After all the solid waste material had been combusted, the stack was allowed to cool down to approximately the initial temperature and testing was completed.

The solid waste was weighed before each test and the weight and the temperature of the ash were measured at the end of testing. The temperature at various points on the outside surface of the duct walls was measured during the tests,

Isokinetic sampling was not performed as the purpose of the gas sampling was only to determine the moisture content of the stack gas.

3.2.1.2(c)

DETERMINATION OF THE HIGHER HEAT OF COMBUSTION

Calculation of the higher heat of combustion of the solid waste material was done on the basis of an energy balance of the system; i.e. energy input equals energy output. The energy output was computed for the areas listed below and the quantity of heat used in each area was calculated as follows:

Vaporization of moisture in the solid waste and moisture formed during the combustion process--The amount of moisture present in the solid waste and formed during the combustion process is calculated by subtracting the amount of moisture in the air added to the system from the amount of water in the stack gas. Multiplying by the latent heat of vaporization (in our calculations, 1,000 BTU/lb) gives the heat used for vaporization.

Heating water vapor--The quantity of heat used in heating the water vapor in the stack gas to the operating temperature is found by use of the basic equation:

$$q = mc_p \Delta T$$

where:

m = total water in the stack gas, lbs

c_p = .46 BTU/lb $^{\circ}\text{F}$

ΔT = the difference between the average stack temperature and the average ambient air temperature

Heating the dry stack gas--After finding the density of the dry gas ($\rho = PM/RT$), the energy used in heating the dry gas from the ambient air temperature to the stack temperature is calculated using the basic equation with:

$$c_p = .25 \text{ BTU/lb } ^{\circ}\text{F}$$

Sensible heat contained in the ash--The sensible heat contained in the ash output is found using the basic equation with:

$$c_p = .20 \text{ BTU/lb } ^{\circ}\text{F}$$

A Leeds Northrop thermocouple was used to monitor this temperature.

Convection and radiation from the duct walls--The convection and radiation heat loss from the duct walls is based on the outside surface temperatures taken during the test. The quantity of heat used in this manner is determined using the equation:

$$q = tkA\Delta T$$

with:

t = length of test in hours

A = outside surface area of the duct work

ΔT = surface temperature-average ambient air temperature

k = 1.5 BTU/lb hr $^{\circ}\text{F}$

A Pyrometer was used to monitor this temperature.

The sum of these five quantities is the total energy output (assuming no energy was used or released elsewhere in the system) and this total must also equal the energy input of the system or the higher heat of combustion of the solid waste.

DATA OBTAINED IN CALCULATING THE
HIGHER HEATING VALUE OF SOLID WASTE

TABLE 50

TEST NUMBER AND DATE

	1- AUG. 24	2- SEPT. 19	3- SEPT. 19
TYPE OF SOLID WASTE	EAST BANK	HOSPITAL	HOSPITAL
AVERAGE AMBIENT AIR TEMP. (°F)	74	59	67
HUMIDITY (%)	40	87	87
BAROMETRIC PRESSURE (in. Hg.)	29.34	29.07	29.08
AVERAGE STACK TEMP. (°F)	744	684	718
STACK PRESSURE (in. Hg.)	29.29	29.02	29.03
LENGTH OF TEST (min.)	71	62	22
VOLUME OF GAS SAMPLED (SCF)	73.51	82.05	31.16
WEIGHT OF LIQUID COLLECTED (g.)	50	70	33
% CO ₂	2.7	2.4	2.3
% O ₂	16.5	17.4	17.7
% N ₂ and CO	80.8	80.2	80.0
WEIGHT OF ASH (LBS)	1388	420	
TEMP. OF ASH (°F)	134	99	
TOTAL DRY GAS FLOW (10 ⁶ SCF)	2.57	2.10	.73
VELOCITY OF STACK GAS (f.p.s.)	48.05	43.27	43.98
VOLUMETRIC FLOW RATE (10 ⁶ SCF)	2.17	2.03	1.98
AMOUNT OF AIR ADDED TO SYSTEM (10 ⁶ SCF)	2.63	2.13	.74
AMOUNT OF WATER IN AIR ADDED (LBS)	1399	1472	688
AMOUNT OF WATER IN STACK GAS (LBS)	4734	4639	1933
BREAKDOWN OF ENERGY (10 ⁶ BTU)			
HEATING WATER VAPOR	1.46	1.33	.60
VAPORIZATION OF WATER IN SOLID WASTE	3.34	3.17	1.31
HEATING DRY GAS	32.29	24.61	8.91
BTU CONTENT IN ASH	.02	.003	
HEAT LOSS THROUGH DUCTWORK			
TOTAL BTU CONTENT OF SOLID WASTE (10 ⁶ BTU)	37.11	29.11	10.82
WEIGHT OF SOLID WASTE (LBS)	6590	5390	2100
HEAT CONTENT PER LB. OF SOLID WASTE (BTU/LB.)	5630	5400	5150

DATA OBTAINED IN CALCULATING THE
HIGHER HEATING VALUE OF SOLID WASTE

TABLE 50 (Continued)

TEST NUMBER AND DATE

	4- SEPT. 22	5- SEPT. 22	6- SEPT.22
TYPE OF SOLID WASTE	WEST BANK	HOSPITAL	EAST BANK
AVERAGE AMBIENT AIR TEMP. (°F)	68	61	62
HUMIDITY (%)	90	90	90
BAROMETRIC PRESSURE (in. Hg.)	29.05	29.08	29.10
AVERAGE STACK TEMP. (°F)	680	813	776
STACK PRESSURE (in. Hg.)	29.00	29.03	29.05
LENGTH OF TEST (min.)	102	90	95
VOLUME OF GAS SAMPLED (SCF)	139.91	115.45	130.60
WEIGHT OF LIQUID COLLECTED (g.)	126	112	122
% CO ₂	3.3	3.4	3.0
% O ₂	16.9	16.3	17.1
% N ₂ and CO	79.8	80.3	79.9
WEIGHT OF ASH (LBS)	1620	1170	1170
TEMP. OF ASH (°F)	100	397	169
TOTAL DRY GAS FLOW (10 ⁶ SCF)	3.32	3.03	2.96
VELOCITY OF STACK GAS (f.p.s.)	41.60	46.46	43.28
VOLUMETRIC FLOW RATE (10 ⁶ SCF)	1.95	2.02	1.87
AMOUNT OF AIR ADDED TO SYSTEM (10 ⁶ SCF)	3.35	3.08	2.99
AMOUNT OF WATER IN AIR ADDED (LBS)	3338	2379	2397
AMOUNT OF WATER IN STACK GAS (LBS)	7915	7595	6995
BREAKDOWN OF ENERGY (10 ⁶ BTU)			
HEATING WATER VAPOR	2.23	2.63	2.30
VAPORIZATION OF WATER IN SOLID WASTE	4.58	5.22	4.60
HEATING DRY GAS	38.10	42.72	39.63
BTU CONTENT IN ASH	.01	.08	.03
HEAT LOSS THROUGH DUCTWORK			
TOTAL BTU CONTENT OF SOLID WASTE (10 ⁶ BTU)	44.92	50.65	46.56
WEIGHT OF SOLID WASTE(LBS)	9080	8780	8870
HEAT CONTENT PER LB. OF SOLID WASTE (BTU/LB)	4950	5770	5250

DATA OBTAINED IN CALCULATING THE
HIGHER HEATING VALUE OF SOLID WASTE

TABLE 50 (Continued) TEST NUMBER AND DATE

	7-SEPT. 22	8- SEPT. 22	9- OCT. 31
TYPE OF SOLID WASTE	ST. PAUL	HOSPITAL	DAILY
AVERAGE AMBIENT AIR TEMP. (°F)	63	65	61
HUMIDITY (%)	90	90	86
BAROMETRIC PRESSURE (in. Hg.)	29.10	29.11	28.90
AVERAGE STACK TEMP. (°F)	768	851	773
STACK PRESSURE (in. Hg.)	29.05	29.06	28.85
LENGTH OF TEST (min.)	67	58	18
VOLUME OF GAS SAMPLED (SCF)	92.26	79.68	41.46
WEIGHT OF LIQUID COLLECTED (g.)	88	84	32
% CO ₂	3.2	3.6	3.3
% O ₂	17.0	15.9	16.8
% N ₂ and CO	79.8	80.5	79.9
WEIGHT OF ASH (LBS)	1070	1020	
TEMP. OF ASH (°F)	450	165	
TOTAL DRY GAS FLOW (10 ⁶ SCF)	2.10	1.77	.606
VELOCITY OF STACK GAS (f.p.s.)	43.21	44.64	46.59
VOLUMETRIC FLOW RATE (10 ⁶ SCF)	1.88	1.83	2.02
AMOUNT OF AIR ADDED TO SYSTEM (10 ⁶ SCF)	2.12	1.80	.613
AMOUNT OF WATER IN AIR ADDED (LBS)	1765	1607	455
AMOUNT OF WATER IN STACK GAS (LBS)	5161	4834	1246
BREAKDOWN OF ENERGY (10 ⁶ BTU)			
HEATING WATER VAPOR	1.67	1.75	.408
VAPORIZATION OF WATER IN SOLID WASTE	3.40	3.23	.791
HEATING DRY GAS	27.76	26.09	8.090
BTU CONTENT IN ASH	.08	.02	
HEAT LOSS THROUGH DUCTWORK			
TOTAL BTU CONTENT OF SOLID WASTE (10 ⁶ BTU)	32.91	31.09	9.289
WEIGHT OF SOLID WASTE (LBS)	6980	5410	1830
HEAT CONTENT PER LB. OF SOLID WASTE (BTU/LB.)	4720	5750	5080

ASSUMPTIONS

Constant vertical velocity profile--From data obtained in previous tests on the incinerator, the velocity profile of the stack gas at the sampling site was shown to be relatively constant vertically.

Refractories are at operating temperature before the test is started; i.e. no energy was used in heating refractories.

Heat loss through the duct walls is negligible--From the measured temperature of the duct walls, the convection and radiation heat loss was calculated and found to be negligible.

All of the solid waste material is completely combusted.

Gas leaving the cooling coil is saturated at 32° F and no moisture is entrained in the gas as it leaves the cooling coil.

The percentage of CO in the stack gas is zero due to the high oxygen content.

According to procedures outlined in previous sections, eight loads of solid waste were tested for heat content, as a means of validating previous heat content design parameters used in establishing the pyrolysis operating envelope. These test loads originated from either the general campus areas, or the University of Minnesota Hospitals. Table 50 represents the BTU/lb results of these tests.

By averaging the four general campus loads and the four hospital loads the following BTU/lb heat content are found:

General Campus - 5,138 BTU/lb

University Hospitals - 5,518 BTU/lb

By considering the University Hospitals as representative of the HHC solid waste to be processed by the pyrolysis system (73%), and combining this value with that determined for general campus solid waste (27%) a weighted average of approximately 5,500 BTU/lb results.

ADJUSTMENT OF TEST RESULTS

The use of the University of Minnesota's incinerator to estimate the heat content value provides a good initial estimate of this parameter. However, since it is recognized that incomplete combustion is experienced, and all heat losses are not accounted for, the estimated value can be considered on the conservative side. In attempt to estimate how conservative this value was, a ninth validation test was performed, during which a known quantity of material (newsprint) was tested, while sending a test sample to Van Cleve Testing Laboratories in Minneapolis, for laboratory analysis. This allowed comparison between incinerator results and those obtained through a bomb calorimeter since the newsprint obtained was fairly homogeneous. The results of the calorimeter test are as follows:

6.23% Moisture
 0.73% Ash
 8,140 BTU/lb as Received
 8,681 BTU/lb Dry

One problem experienced which does not allow calculating a multiplying constant directly from this dual testing was that some rain had been experienced on the day the newsprint was collected, yielding some additional moisture in the test load. While an Orsat analysis was run during the testing, from which a moisture balance can be estimated, the method is not considered accurate, and also requires guessing at a carbon-hydrogen ratio for the newsprint. Therefore, it was decided to estimate a moisture range increase of up to 15%, which would in turn yield a multiplying constant range. Multiplication factors ranging from 1.2 to 1.4 could be expected by this method, yielding the following BTU/lb range:

<u>Multiplication Factor</u>	<u>Adjusted Heat Content (BTU/lb)</u>
1.2	6,600
1.4	7,700

While it is probably not valid to conclude either of these values as probable, it does seem to indicate that the heat content expected will fall within these limits, therefore, somewhat substantiating the 6,900 BTU/lb used previously by Andco design engineers.

Figures 5 through 10 illustrate the incinerator tests described above.

At this point in the testing program only solid waste from University Hospitals was tested and values obtained considered as representing HHC solid waste. For further study it will be necessary to bring in additional loads from TCMR, HHC institutions for testing, in order to refine this assumption.

DATA OBTAINED IN CALCULATING THE
HIGHER HEATING VALUE OF SOLID WASTE

TABLE 50

TEST NUMBER AND DATE

	1- AUG. 24	2- SEPT. 19	3- SEPT. 19
TYPE OF SOLID WASTE	EAST BANK	HOSPITAL	HOSPITAL
AVERAGE AMBIENT AIR TEMP. ($^{\circ}\text{F}$)	74	59	67
HUMIDITY (%)	40	87	87
BAROMETRIC PRESSURE (in. Hg.)	29.34	29.07	29.08
AVERAGE STACK TEMP. ($^{\circ}\text{F}$)	744	684	718
STACK PRESSURE (in. Hg.)	29.29	29.02	29.03
LENGTH OF TEST (min.)	71	62	22
VOLUME OF GAS SAMPLED (SCF)	73.51	82.05	31.16
WEIGHT OF LIQUID COLLECTED (g.)	50	70	33
% CO_2	2.7	2.4	2.3
% O_2	16.5	17.4	17.7
% N_2 and CO	80.8	80.2	80.0
WEIGHT OF ASH (LBS)	1388	420	
TEMP. OF ASH ($^{\circ}\text{F}$)	134	99	
TOTAL DRY GAS FLOW (10^6 SCF)	2.57	2.10	.73
VELOCITY OF STACK GAS (f.p.s.)	48.05	43.27	43.98
VOLUMETRIC FLOW RATE (10^6 SCF)	2.17	2.03	1.98
AMOUNT OF AIR ADDED TO SYSTEM (10^6 SCF)	2.63	2.13	74
AMOUNT OF WATER IN AIR ADDED (LBS)	1399	1472	688
AMOUNT OF WATER IN STACK GAS (LBS)	4734	4639	1933
BREAKDOWN OF ENERGY (10^6 BTU)			
HEATING WATER VAPOR	1.46	1.33	.60
VAPORIZATION OF WATER IN SOLID WASTE	3.34	3.17	1.31
HEATING DRY GAS	32.29	24.61	8.91
BTU CONTENT IN ASH	.02	.003	
HEAT LOSS THROUGH DUCTWORK			
TOTAL BTU CONTENT OF SOLID WASTE (10^6 BTU)	37.11	29.11	10.82
WEIGHT OF SOLID WASTE (LBS)	6590	5390	2100
HEAT CONTENT PER LB. OF SOLID WASTE (BTU/LB)	5630	5400	5150

DATA OBTAINED IN CALCULATING THE HIGHER HEATING VALUE OF SOLID WASTE

TABLE 50 (Continued) TEST NUMBER AND DATE

	4- SEPT. 22	5- SEPT. 22	6- SEPT.22
TYPE OF SOLID WASTE	WEST BANK	HOSPITAL	EAST BANK
AVERAGE AMBIENT AIR TEMP. (°F)	68	61	62
HUMIDITY (%)	90	90	90
BAROMETRIC PRESSURE (in. Hg.)	29.05	29.08	29.10
AVERAGE STACK TEMP. (°F)	680	813	776
STACK PRESSURE (in. Hg.)	29.00	29.03	29.05
LENGTH OF TEST (min.)	102	90	95
VOLUME OF GAS SAMPLED (SCF)	139.91	115.45	130.60
WEIGHT OF LIQUID COLLECTED (g.)	126	112	122
% CO ₂	3.3	3.4	3.0
% O ₂	16.9	16.3	17.1
% N ₂ and CO	79.8	80.3	79.9
WEIGHT OF ASH (LBS)	1620	1170	1170
TEMP. OF ASH (°F)	100	397	169
TOTAL DRY GAS FLOW (10 ⁶ SCF)	3.32	3.03	2.96
VELOCITY OF STACK GAS (f.p.s.)	41.60	46.46	43.28
VOLUMETRIC FLOW RATE (10 ⁶ SCF)	1.95	2.02	1.87
AMOUNT OF AIR ADDED TO SYSTEM (10 ⁶ SCF)	3.35	3.08	2.99
AMOUNT OF WATER IN AIR ADDED (LBS)	3338	2379	2397
AMOUNT OF WATER IN STACK GAS (LBS)	7915	7595	6995
BREAKDOWN OF ENERGY (10 ⁶ BTU)			
HEATING WATER VAPOR	2.23	2.63	2.30
VAPORIZATION OF WATER IN SOLID WASTE	4.58	5.22	4.60
HEATING DRY GAS	38.10	42.72	39.63
BTU CONTENT IN ASH	.01	.08	.03
HEAT LOSS THROUGH DUCTWORK			
TOTAL BTU CONTENT OF SOLID WASTE (10 ⁶ BTU)	44.92	50.65	46.56
WEIGHT OF SOLID WASTE(LBS)	9080	8780	8870
HEAT CONTENT PER LB. OF SOLID WASTE (BTU/LB)	4950	5770	5250

DATA OBTAINED IN CALCULATING THE
HIGHER HEATING VALUE OF SOLID WASTE

TABLE 50 (Continued) TEST NUMBER AND DATE

	7-SEPT. 22	8- SEPT. 22	9- OCT. 31
TYPE OF SOLID WASTE	ST. PAUL	HOSPITAL	DAILY
AVERAGE AMBIENT AIR TEMP. (°F)	63	65	61
HUMIDITY (%)	90	90	86
BAROMETRIC PRESSURE (in. Hg.)	29.10	29.11	28.90
AVERAGE STACK TEMP. (°F)	768	851	773
STACK PRESSURE (in. Hg.)	29.05	29.06	28.85
LENGTH OF TEST (min.)	67	58	18
VOLUME OF GAS SAMPLED (SCF)	92.26	79.68	41.46
WEIGHT OF LIQUID COLLECTED (g.)	88	84	32
% CO ₂	3.2	3.6	3.3
% O ₂	17.0	15.9	16.8
% N ₂ and CO	79.8	80.5	79.9
WEIGHT OF ASH (LBS)	1070	1020	
TEMP. OF ASH (°F)	450	165	
TOTAL DRY GAS FLOW (10 ⁶ SCF)	2.10	1.77	.606
VELOCITY OF STACK GAS (f.p.s.)	43.21	44.64	46.59
VOLUMETRIC FLOW RATE (10 ⁶ SCF)	1.88	1.83	2.02
AMOUNT OF AIR ADDED TO SYSTEM (10 ⁶ SCF)	2.12	1.80	.613
AMOUNT OF WATER IN AIR ADDED (LBS)	1765	1607	455
AMOUNT OF WATER IN STACK GAS (LBS)	5161	4834	1246
BREAKDOWN OF ENERGY (10 ⁶ BTU)			
HEATING WATER VAPOR	1.67	1.75	.408
VAPORIZATION OF WATER IN SOLID WASTE	3.40	3.23	.791
HEATING DRY GAS	27.76	26.09	8.090
BTU CONTENT IN ASH	.08	.02	
HEAT LOSS THROUGH DUCTWORK			
TOTAL BTU CONTENT OF SOLID WASTE (10 ⁶ BTU)	32.91	31.09	9.289
WEIGHT OF SOLID WASTE(LBS)	6980	5410	1830
HEAT CONTENT PER LB. OF SOLID WASTE (BTU/LB)	4720	5750	5080

FIGURE 5
UNIVERSITY OF MINNESOTA - INCINERATOR
SOLID WASTE DEPOSITED FOR INCINERATION

FIGURE 6
UNIVERSITY OF MINNESOTA - INCINERATOR
SAMPLE STATION FOR STACK GASES

FIGURE 7
UNIVERSITY OF MINNESOTA - INCINERATOR
MONITORING STACK GAS PARAMETERS

FIGURE 8
TAKING ORSAT ANALYSIS

FIGURE 9
COLLECTION OF ASH RESIDUE

FIGURE 10
MONITORING ASH TEMPERATURE

Although the entire 7-county planning area has been used initially to define system input into the pyrolysis sytem, it is recognized that dense and sparse generating areas exist within this area, and that the most economical system may be defined by those greatest densities. Collection costs shall undoubtedly be the limiting factor in defining these areas, and will be increasingly proportional to the distance outward from the pyrolysis unit and a function of the quantity of general and special waste generated. Therefore, waste-shed zones have been defined radiating about the Southeast Steam Plant location for analysis of these factors.

Five zone areas defined by one-mile, two and one-half-mile, ten-mile and twenty-mile radius and the remaining 7-county area have been selected for analysis. These zones have been selected arbitrarily as representing divisions in numbers of facilities, and generating densities.

Beginning from the pyrolysis location and radiating outward, the number of Hospitals and Nursing Homes included have been determined. The quantity of solid waste expected has then been determined which corresponds to each inclusive zone area. Each area is assumed to include the generations from internal areas to yield cumulative totals. Only hospitals and nursing homes have been used to perform this analysis. Maps 7 & 8, represent the facilities located within the waste-shed zones, and Table 51, presents the solid waste quantities generated per zone, cumulative values.

Based upon the designated zones selected, the ten-mile radius appears to include the majority of facilities generating solid waste (73%), and practically the entire quantity (88%). Therefore, using a ten-mile radius zone to define the system waste collection area, the basic pyrolysis should be sized to process 56 tons per day of HHC solid waste. Including the current University of Minnesota general campus solid waste of 23 tons per day yield a capacity of 79 tons per day, or a planned 80 tons per day system.

TABLE 51

WASTE SHED ZONESINDIVIDUAL TOTALS (CUM.)

<u>Zone Number</u>	<u>Zone Dist.</u>	<u>Number Hospitals</u>	<u>% of Total</u>	<u>Number N.H.</u>	<u>% of Total</u>
1	1 Mile	6	15.8	3	12
2	2½ Miles	11	29.0	24	18
3	10 Miles	27	71.0	96	73.3
4	20 Miles	30	79.0	114	87.0
5	7-County	38	100.0	131	100.0

QUANTITY TOTALS (CUM.)

<u>Zone Number</u>	<u>Zone Dist.</u>	<u>Hospitals Qty (Tons/Day)</u>	<u>N.H. Qty Tons/Day</u>	<u>Comb. Tons/Day</u>	<u>% of Total</u>
1	1 Mile	14.8 (29.77%)	.65 (4.76%)	15.45	24.4
2	2½ Miles	23.4 (47.2%)	2.47 (18.1%)	25.9	40.9
3	10 Miles	44.9 (90.38%)	10.95 (80.2%)	55.8	88.1
4	20 Miles	47.7 (96%)	12.75 (93.5%)	60.45	95.5
5	7-County	49.7 (100%)	13.65 (100%)	63.35	100.0

QUANTITY TOTALS + UNIVERSITY SOLID WASTE + PROJECTED INCREASES

<u>Zone Number</u>	<u>Zone Dist.</u>	<u>Total HHC</u>	<u>Plus University</u>	<u>1980</u>	<u>1990</u>
1	1 Mile	15.45	38.45	38.8	40.56
2	2½ Miles	25.9	48.90	49.4	51.58
3	10 Miles	55.8	78.8	79.6	83.13
4	20 Miles	60.45	83.45	84.28	88.00
5	7-County	63.35	86.3	87.16	91.00

U of M Waste 23 TPD @ 5,500

Selected Size 100 TPD + 30%

Steam Economics Based upon 80 TPD

Map #7

GRID ICES PHASE II OPTION II
 GEOGRAPHIC DISTRIBUTION MODEL OF HOSPITAL/HEALTH CARE FACILITIES
 TWIN CITY METROPOLITAN REGION

NOTE: For Location of Facilities within 2½ Mile Zone - See Map #8

GRID ICES PHASE II OPTION II
 GEOGRAPHIC DISTRIBUTION MODEL OF HOSPITAL/HEALTH CARE FACILITIES
 MINNEAPOLIS/ST. PAUL AND SUBURBAN AREAS

Map #8

3.4

CENTRALIZED PYROLYSIS SYSTEM

3.5

PYROLYSIS BASE DESIGN CAPACITY

According to the quantity estimates determined by the selected waste-shed zones, it appears that the base design capacity for the pyrolysis system should correspond to the ten-mile radius zone, yielding a base module of 80 tons per day. The assumption is here made that generating HHC facilities beyond this perimeter are beyond practical collection distances. This assumption will not preclude the possibility of including those facilities outside the ten-mile zone should this solid waste management system become a reality. Also noted is that the 80 tons per day quantity includes approximately 23 tons per day of general campus waste from the University of Minnesota.

An additional factor to be considered is the escalation rate of generation of solid waste both for municipal and more-so for hospital solid waste, the majority source of system input. Since the facility could not become operational for another two years, and would likely operate over a twenty year lifetime, it seems necessary to provide for a larger design capacity to accommodate these future increases. The base design capacity has, therefore, been established at 100 tons per day, with an operating envelope of ± 30 percent (70 to 130 tons per day module).

In order to estimate economic performance of the pyrolysis system, initial system input will be used for analysis at the 80 tons per day operation, since actual performance as opposed to design will determine cost/effectiveness. See Section 3.8 for this analysis.

Having established the pyrolysis base capacity design at 100 tons per day, $\pm$ 30 percent envelope, it has also been determined desirable to analyze supplementing the pyrolysis based module with municipal solid waste from the system's proximity to possibly increase the viability of the system. The following impetus leads to this desirability:

- increasing the module design capacity, decreases capital cost per processed ton of solid waste
- increasing the module performance capacity decreased operating cost per processed ton of solid waste
- introduction of municipal solid waste increases applicability of project to other solid waste management reviews

The following factors are indicated as negative to increasing the size of the system:

- requires dealing with municipal waste stream which is harder to contract
- increases number of vehicles coming into the system, possibly causing environmental concern

As a result, Phoenix, Incorporated was contacted to explore the possibility of supplementing the base module with municipal solid waste on an "as need" basis to increase the system performance. Phoenix, Inc., operates a transfer station in proximity of the Southeast Steam Plant for the City of Minneapolis. This station daily receives approximately 400 tons of municipal solid waste, which is in turn transferred to semi-trailers for hauling to a landfill in the Pine Bend area. The contact was very favorable, Phoenix, Inc., indicating a willingness to negotiate such a contract for one to three transfer trailer loads per day on an "as need" basis, at a cost to be paid to the pyrolysis system for processing and disposal. However, contracting for a greater portion of their waste load would have greater implication, and would have to be analyzed further.

It should be noted that each transfer trailer carries approximately 20 tons of solid waste, thereby limiting the increase in vehicles to supplement the base module.

As a result of these discussions, cost/effectiveness analysis has been performed on the following systems: 80, 100, 130, and 250 tons per day. In each case the 80 tons per day is considered HHC solid waste, the remaining received from Phoenix, Inc.. Table 52 represents this loading. See Section 3.8 for the cost/effectiveness analysis.

TABLE 52

PYROLYSIS DESIGN CAPACITIES
WITH SUPPLIMENTAL SOLID WASTE

Base Loaded System (TPD)	80	80	80	80
Suppli- mental from Phoenix	0	20	50	170
Total Design Capacity TPD	80	100	130	250

Basically three types of solid waste input are to be considered for collection and transport to the pyrolysis system. These three types are considered as requiring: specific vehicle types to satisfy design and performance specifications to be established in contracting this service. The relationship between solid waste category and vehicle type is listed in Table 53.

From the information obtained by surveying the HHC institutional categories, approximately 10 percent of HHC solid waste shall be considered as special waste, requiring non-compaction collection and transport. The remaining portion shall be assumed collected and transported by load compaction vehicles.

According to the design capacities selected for analysis, Table 54 represents the number of vehicles expected into the pyrolysis system.

TABLE 53

RELATIONSHIP OF SOLID WASTE TO VEHICLE TYPE

<u>Solid Waste Category</u>	<u>Vehicle Type and Estimated Capacity</u>
HHC General	Load Pack (7 to 10 ton capacity)
HHC Special	Non-Compacting (1 to 2 ton capacity)
Municipal, Transfer	Semi-trailer, low density compaction (approximately 20 ton capacity)

TABLE 54

QUANTITY OF WASTE TYPES

Design Capacity	HHC General (TPD)	HHC Special (TPD)	Transfer Municipal (TPD)	Total Number of Vehicles per day
80	72 (10)*	8 (4)	0	(14)
100	72 (10)	8 (4)	20 (1)	(15)
130	72 (10)	8 (4)	50 (2.5)	(16.5)
250	72 (10)	8 (4)	170 (8.5)	(22.5)

*Numbers in parenthesis refer to vehicle numbers

COST ANALYSIS

It is anticipated that the collection and transportation of solid waste from health care facilities will be provided for on a service contract basis. This service contract will be according to design and performance specifications formulated according to general and special waste categories, or compacted, non-compacted, respectively.

The contracting of municipal solid waste from Phoenix, Inc., will involve dealing with an established operation, simply diverting transfer trailers from landfill to the pyrolysis.

In essence the costs incurred or estimated for these service contracts will be established by the respective service contractor, according to the purposed specifications of the planned system. The company Waste Control, Inc., has expressed interest in bidding competitively for the service contract to collect and transport the HHC solid waste categories to the pyrolysis facility. This company represents one of the largest commercial haulers in the 7-county area, and is noted for providing a wide range of service vehicles tailored to the particular service task. Waste Control, Inc., representatives were given an outline of the proposed Grid-ICES project for the purposes of estimating costs for a HHC solid waste service contract. The following costs per ton are estimates provided by Waste Control., Inc.

TABLE 55

ESTIMATED SERVICE CONTRACT FORCOLLECTION AND TRANSPORT

<u>Solid Waste Category</u>	<u>Cost per Ton to Pyrolysis</u>
IHC General, Compacted	\$ 6.00 (Within 10 Mile Zone)
	\$ 8.00 (Outside 10 Mile Zone)
HHC Special, Non-Compacted	\$20.00 (Within 10 Mile Zone)
	\$25.00 (Outside 10 Mile Zone)

From discussions with Phoenix, Inc., and estimated price to be paid to the pyrolysis system has been established at \$4.00 per ton.

HHC CURRENT DISPOSAL COSTS

Discussion was held with representatives from Waste Control, Inc., for the purposes of estimating the current disposal cost incurred by HHC facilities. Waste Control, representing one of the largest commercial haulers in the TCMR, currently provides collection and disposal service to better than 50% of HHC facilities in the TCMR. At University request, Waste Control monitored HHC facility service and determined the following:

HHC Collection, Transportation, Disposal = 11.33 \$/Ton

Of this figures, approximately 70% (7.83 \$/Ton) is expended in collection and transportation and approximately 30% (3.50 \$/Ton) is expended in disposal at Waste Control's landfill.

3.7.4

HHC DISPOSAL COST ESCALATION

In review of records maintained by Waste Control, Inc., the following cost history and projection is determined:

LANDFILL DISPOSAL COST HISTORY

<u>Time Period</u>	<u>Cost Per Ton</u>	<u>\$ Change</u>	<u>\$ Per Year</u>
8 years ago	\$1.50	-	-
5 years ago	\$2.00	+33	11.0
Current	\$3.50	+42	8.4
5 years hence	\$5.00	+42	8.4

Transportation costs have increased and are expected to increase approximately 10 percent per year.

Since a service contractor will be used to bring the solid waste into the pyrolysis facility, collection and transportation routes will be defined according to their judgement. However, regional travel pathways, Map #9 can be indicated as most probable routes to the facility. Map \$10 illustrates the interconnection through the adjacent community from the interstate system. Map #11 illustrates the current corridor used for travel to Waste Control, Inc., sanitary landfill, which is currently utilized for disposal of incinerator ashes, and coal ash.

Map #9

GRID ICES PHASE II OPTION II
REGIONAL TRAVEL PATHS
SOUTHEAST GENERATING PLANT

minimum travel time paths —

Map #11

GRID ICES PHASE II OPTION II
FRIT AND COAL ASH WASTE DISPOSAL ROUTE

GRID CONNECTED INTEGRATED
COMMUNITY ENERGY SYSTEM

PHASE II
STAGE 1 FINAL REPORT
March 8, 1978

CONCEPTUAL DESIGN
PYROLYSIS AND WASTE MANAGEMENT SYSTEMS

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3.8

COST ANALYSIS FOR PYROLYSIS SYSTEM

3.8.1

OPERATING COSTS

Operating costs are based on the pyrolysis unit operating at a refuse feed rate of 80 tons per day for 350 days, 15 days being allocated for down time and overhaul. The annual refuse handled by the system will be:

$$80 \times 350 = 28,000 \text{ tons per year}$$

Operating Costs include the following:

- Labor
- Fuel Oil
- Electric Power
- City Water
- Maintenance and Repair

3.8.2

LABOR COST

The following personnel schedule assumes a three shift operation per day with a swing shift for vacations, holidays, 40 hour week, etc. Overall staffing of the Southeast Plant has been assessed to determine the personnel chargeable to the pyrolysis system. Proposed shift charges appear below.

	Shift			
	1	2	3	Swing
Principal Operator	1	1	1	1.3
Junior Operator	1.5	1.5	1.5	.65
Crane Operator	1	1	1	1.3

Operating labor costs have been based on the following wage rate schedule.

<u>Designation</u>	<u>Type</u>	<u>Base Rate</u>	<u>Fringes</u>	<u>Vac., Sick Leave & Hol.</u>	<u>Total</u>	<u>Annual</u>
Principal Operator	Civil Service	\$7.89	\$1.56	\$1.16	\$10.61	\$22,069
Jr. Operator	Civil Service	6.93	1.37	1.02	9.32	19,386
Crane Operator	Civil Service	7.62	1.51	1.12	10.25	21,320

The total labor will be:

$$22,069 \times 4.3 + 19,386 \times 5.15 + 21,320 \times 4.3$$

$$94,897 + 99,838 + 91,676 = \$286,411$$

The labor cost per ton will be:

$$\frac{286,411}{28,000} = \$10.23 \text{ per ton}$$

3.8.3

FUEL OIL

Fuel Oil (No. 2) requirements have been estimated by Andco and appear below. One start-up per year and 350 days of normal operation has been budgeted.

FUEL OIL REQUIREMENTS FOR START-UP

<u>Item</u>	<u>Start-Up Time Hours</u>	<u>Rate of Flow GPH</u>	<u>Total Flow Gallons</u>
Cowpers - burner	120	39.60	4,752
S.C.C. - burner	16	47.52	760
S.C.C. - slag Burner	10	7.92	79
Tuyeres (8 in number)	10	50.69	507
Gasifier - slag burner	24	6.60	158
Hearth - burners	12	52.80	634
			<u>6,890</u>

FUEL OIL REQUIREMENTS FOR NORMAL OPERATION

<u>Item</u>	<u>Daily Requirement Gallon</u>
Gasifier	179.75
S.C.C.	<u>215.57</u>
TOTAL	395.32

Annual fuel oil requirements will be $6,890 + 395.32 \times 350 = 145,250$ gallons. At a price of \$.365 per gallon, the annual cost of fuel oil will be \$53,016 and the cost per ton of refuse will be:

$$\frac{53,016}{28,000} = \$1.89$$

3.8.4

ELECTRIC POWER

Electric power requirements have been estimated for a refuse rate of 100 tons per day and have been assumed directly proportionate for a rate of 80 tons per day. The induced draft fans include the induced draft fan for the waste heat boiler and the portion of the power of the baghouse induced draft fan which is allocated to the pyrolysis system.

<u>Item</u>	<u>Motor Size HP</u>	<u>Power Demand KW</u>	<u>Power Required-KWH Per ton of Refuse</u>
Primary air fan	100	75.00	18.00
Secondary air fan	75	56.25	13.50
Induced draft fans	500	375.00	43.50
Andco feed system	5	3.75	.18
Vibrating feeder	20	15.00	1.08
Slag conveyor - belt	4	3.00	.72
Slag conveyor - bucket	4	3.00	.72
Slag grapple - bucket	2	1.50	.36
Heat exchanges (2)	50	37.50	9.00
Closed circuit cooling pump	50	37.50	9.00
Open circuit cooling pump	100	75.00	18.00
Slag quench reservoir pump	20	15.00	3.50
Instrument air compressor			
Controls (120 volt)		10.00	2.40
Burner fans (total)	<u>15</u>	<u>11.25</u>	<u>2.70</u>
TOTAL			124.11

With an electric energy rate of \$.0272 per KWh, the electric power cost per ton of refuse will be:

$$124.11 \times .0272 = \$3.37$$

Water make-up requirements for normal operations have been estimated by Andco to be 25 gpm for the open water loop and 25 gpm for the closed loop or a total of 50 gpm for the system. Daily water make-up will be:

$$50 \times 60 \times 24 = 72,000 \text{ gallons.}$$

At a refuse rate of 80 tons per day and a water cost of \$.088 per 1,000 gallons, the cost of make-up water will be:

$$\frac{72,000}{80} \times \frac{.088}{1,000} = \$.08 \text{ per ton of refuse}$$

3.8.6

MAINTENANCE AND REPAIR

Andco has estimated the annual cost of maintenance and repair to be \$106,000 for the frame size of 132 T/day. At a refuse rate of 46,200 tons per year, the cost of maintenance and repair will be:

$$\frac{106,000}{46,200} = \$2.30 \text{ per ton}$$

The cost of maintenance and repair for the 100 T/day unit is assumed to be:

$$106,000 \times \frac{4,105,000}{4,894,000} = \$88,900$$

and the cost per ton will be:

$$\frac{88,900}{28,000} = \$3.18 \text{ per ton of refuse}$$

SUMMARY

Total operating costs are summarized below:

<u>Item</u>	<u>Estimated Cost</u> <u>\$/Ton Refuse</u>
Labor	\$10.23
Fuel Oil	1.89
Electric Power	3.37
City Water & Sewer	.08
Maintenance & Repair	<u>3.18</u>
TOTAL	\$18.75

The credit for the slag from this process has not been calculated because neither the market nor the product value is available at this time. Further study has not been considered within the scope of this report. It has been assumed that the value of the product would pay for the hauling so no charge has been made for slag removal.

A waste heat boiler has been included with the pyrolysis system to recover energy in the form of steam that will be supplied to the 450 psig header. Gas from the secondary combustion chamber at a temperature of 2300° F will be admitted to the waste heat boiler, super heater, and economizer where the temperature will be reduced to 460° F at the economizer outlet. With steam conditions of 450 psig, 725° F and feedwater at 250° F, steam will be produced at a rate of 26,000 pounds per hour at a refuse rate of 80 tons per day. The refuse is assumed to have a HHV at 6,993 BTU per pounds. Daily steam production will be:

$$\frac{26,000 \times 24}{1,000} = 624,000 \text{ pounds per day}$$

or

$$\frac{624}{80} = 7.8 \times 1,000 \text{ pounds of steam per ton of refuse}$$

The average cost of steam generated by Boiler No. 3 and Boiler No. 4 is estimated to be \$1.66 per 1,000 pounds.

The value of steam generated is:

$$1.66 \times 7.8 = \$12.95/\text{ton of refuse}$$

ESTIMATED CAPITAL COST

The following budget estimate is based on an Andco unit rate $100 \pm 30\%$ tons of refuse per day. The unit will be located in the area of the Southeast plant east of Boiler No. 4. A refuse pit has been sized to contain 264 tons. A bridge crane with cab will handle normal waste and also "red bag" hospital waste. The gas clean-up will be done in the baghouse that will also clean the gas for Boiler No. 3 and Boiler No. 4. The proportionate cost burden has been allocated for the pyrolysis unit. Estimated costs are "order of magnitude" based on 1977 prices. The general arrangement of equipment has been shown on Helmick and Lutz Company drawing 625 - Task 11.

OPTION II PYROLYSIS
BASED ON ANDCO UNIT RATES 100 ± 30% T/DAY

<u>Item</u>	<u>Estimated Cost</u>
Andco System Delivered and Erected	\$4,105,000*
Waste Heat Boiler	387,000
Induced Draft Fan and V. Speed Drive	128,000
Boiler Instruments and Controls	30,000
Gas Clean-up Equipment, Delivered and Erected	565,000
Refuse Crane and Auxiliaries	60,000
Equipment Erection (not including Andco)	60,000
Fly Ash System	10,000
General Construction, Including Slag Tank	980,000
Mechanical Construction	172,000
Electrical Construction	210,000
Contingencies (not including Andco) 10%	<u>260,000</u>
Total Estimated Budget Cost	\$6,967,000

*Include engineering for Andco System

CAPITAL COST COMPARISON

<u>Item</u>	<u>Estimated Cost</u>		
Refuse Rate, Tons per day	100 ± 30%	132 ± 15%	250 ± 15%
Max. Refuse Rate, Tons per day	130	152	288
Andco System, Delivered and Erected	\$4,105,000	\$4,894,000	\$5,877,000
Waste Heat Boiler	387,000	445,000	535,000
Induced Draft Fan and V. Speed Drive	128,000	147,000	177,000
Boiler Instruments and Controls	30,000	30,000	30,000
Gas Clean-up Equipment, Delivered and Erected	565,000	650,000	780,000
Refuse Crane and Auxiliaries	60,000	60,000	60,000
Equipment Erection (not including Andco)	60,000	69,000	83,000
Fly Ash System	10,000	10,000	10,000
General Construction, Including Slag Tank	980,000	1,030,000	1,130,000
Mechanical Construction	172,000	198,000	238,000
Electrical Construction	210,000	247,000	290,000
Contingencies (not including Andco)	<u>260,000</u>	<u>289,000</u>	<u>333,000</u>
Total Estimated Budget Cost	\$6,967,000	\$8,069,000	\$9,543,000
Cost per rated tons per day	\$ 69,700	\$ 61,000	\$ 39,100
Cost per max rated tons per day	\$ 53,400	\$ 53,500	\$ 33,100

OPERATING COST COMPARISON

Refuse Rate, Tons per day	80	100	132	250
Labor, \$/Ton	10.23	8.18	6.20	3.27
Fuel Oil	1.89	1.89	1.63	1.51
Electric Power	3.37	3.37	3.37	3.37
City Water & Sewer	.08	.08	.08	.08
Maintenance & Repair	<u>3.18</u>	<u>2.54</u>	<u>2.30</u>	<u>1.45</u>
Total, \$/Ton	18.75	16.06	13.58	9.68
Credit for Steam Generation \$/Ton	12.95	12.95	12.95	12.95

General

The existing incinerator plant is located west of the Minneapolis heating plant and is shown in location on Helmick & Lutz Company Drawing No. 625-Task 13A and in detail on University of Minnesota Drawing No. 11960. Each of the two incinerators is rated 50 tons per day and consists of a reciprocating grate for burning normal refuse and a separate hearth for burning animals. Forced draft air is admitted under the grate and over fire air is admitted above the grate. Exit gas is transported via breeching to a concrete-masonry stack. Refuse is moved on the tipping floor to the area of the incinerator inlets with a 4 wheel vehicle fitted with a front end blade. Refuse is transferred manually to the incinerator inlets. Ashes from under the grates are pulled manually and transported to a truck. Ashes from the discharge of the grates drop into a container outside the building and are transported via truck to landfill.

A series of tests were conducted on September 19, 1977 and September 22, 1977 burning general campus waste and hospital waste. Results of the tests include the following:

<u>Test No.</u>	<u>Burning Rate Tons/Hour</u>	<u>Heat Content of Refuse BTU/lb HHV</u>
1	2.78	5,594
2	2.60	5,427
3	2.66	5,176
4	2.66	4,970
5	2.92	5,526
6	2.80	5,271
7	3.14	4,586
8	2.81	5,691
Average		5,280

A review of the test results leads to the following conclusions:

1. Excess air is abnormally high
2. Exit gas temperature is abnormally low
3. Ash collected appears high

It appears that immediate consideration should be given to improve the combustion process within the incinerator by reducing air infiltration and raising the temperature of combustion, which will improve the destruction of the refuse. Visual observation of the stack discharge on an intermittent basis indicates that under some conditions the incinerators are operated poorly.

As a back-up facility for the pyrolysis unit, the existing incinerator plant would operate only during a scheduled outage of 15 days per year for maintenance and repair or for relatively short periods during an unscheduled outage. During these periods the incinerator would burn the waste collected

by the hospitals and health care centers and general waste from the University of Minnesota. This waste load is estimated to be 80 tons per day which is within the capabilities of the existing plant.

Since the existing plant will be required to operate on a standby basis, a minimum investment should be made to bring the operation of the incinerators to meet code compliance. The following recommendations are made:

1. Inspect the complete system and repair as necessary to reduce air infiltration and increase the combustion temperature which will result in improved combustion efficiency and lower particulate emission from the stack.
2. Replace the gas burners rated 1,800 C.F.H. at the animal hearths with larger burners fired with No. 2 oil. Install additional burners fired with No. 2 oil located downstream of the vertical baffle in the furnace. These burners would operate only as required to improve the combustion process and lower the particulate emission to the stack.
3. Install smoke density recorders to monitor the exit gas streams and assist the operators to maintain a "clean stack".

The estimated cost for these improvements follows:

	<u>Estimated Cost</u>
Inspection and repair of exiting incinerators	Under Contract
Oil burners, flame safeguards, burner control, installed	\$ 73,000
Smoke density recorders	7,000
Oil piping from heating plant	10,000
Contingencies (20 per cent)	<u>18,000</u>
Total Estimated Project Cost	\$108,000

UNIVERSITY OF MINNESOTA MINNEAPOLIS, MINNESOTA			
GRID 1-1'S STUDY			
EXISTING INCINERATOR BUILDING			
McNish & Lutz	Engineers	Minneapolis, Minnesota	TASK 13A

AREA PLAN
(SCALE 1/8"=1'-0")

PLAN
(SCALE 1/4"=1'-0")

NAME PLATE SCHEDULE

CONTROL	OPERATION
1	FD FAN
2	OVERFIRED FAN
3	HYDRAULIC POWER PLANT
4	BURNER CONTR.
5	FD DAMPER
6	(LEAVE BLANK)
7	OVER CHARGING DOOR
8	INNER CHARGING DOOR

NOTE:
BACK OF PANEL SHALL BE FINISHED ON RIGHT.
ALL CONTROL WIRING FROM PANEL TO ENCL. MOTOR, ETC. SHALL BE RUN IN SEPARATE CONDUITS.
DEPTH SUITABLE FOR ALL UNITS - 1" CLEARANCE FROM BACK.
PANEL SHALL BE MADE FROM 12 GA STEEL.
ALL WIRING SHALL BE SERVED WITH ARMATURE TWINING WITH 1/2" INTERVALS.
ALL WIRING SHALL BE ACCESSIBLE FROM BACK.

CONTROL PANEL DETAIL
(NO SCALE)

GENERAL ARRANGEMENT

MUNICIPAL TYPE
BOSTON INCINERATOR #2
MINNEAPOLIS CAMPUS

UNIVERSITY OF MINNESOTA
DEPARTMENT OF PLANT SERVICES
MINNEAPOLIS, MINNESOTA 55455

ON SITE INCINERATION VERSUS PYROLYSIS

The site selected was the University of Minnesota Hospital on the East Bank Campus. The refuse load was estimated to be 7 tons per day with an average heating value of 5,700 BTU per pound of refuse. The incinerator unit selected must be designed to burn general waste, pathological waste and research animals. The unit must be designed to burn clean so that stack emission will be within compliance without the need for exit gas clean-up equipment. The incinerator manufactured by the Comtro Division of Sunbeam Equipment Corporation was selected for this study. This equipment consists of a primary combustion chamber which operates at a normal temperature of 1500° F and a secondary combustion chamber which operates at a normal temperature of 2000° F. These temperatures are maintained with auxiliary fuel oil burners if the combustion so requires. The gas at 2000° F is available for temperature reduction to 500° F in a waste heat boiler.

With an assumed burn time of 8 hours, the burning rate will be:

$$\frac{7 \times 2,000}{8} = 1,750 \text{ pounds per hour}$$

This is equivalent to:

$$\frac{5,700}{6,500} \times 1,750 = 1,500 \text{ pounds per hour of type 1 waste having an assumed heating value of 6,500 BTU per pound}$$

The unit selected is a Comtro A-48 which has a rated burning rate of 2,100 pounds per hour of No. 1 waste at 6,500 BTU per pound. This unit will burn at a higher rate of lower BTU refuse or will burn 7,800 BTU per pound refuse at the design rate of 1,750 pounds per hour. The equipment is limited by the energy input to the primary furnace.

The waste heat boiler will be of the fire tube type, generating steam to float on the 55 psig steam header. Feedwater make-up will be condensate from the hospital system.

OPERATING COST

Operating costs are based on the unit running 8 hours per day, 350 days per year with 15 days allowed for scheduled maintenance and repair. Total annual refuse burned with be:

$$7 \times 350 = 2,450 \text{ tons per year}$$

Operating labor cost has been based on 1 man per 8 hour shift for 365 days per year. The hourly rate has been assumed to be \$7.89/hour base rate, \$1.56/hour fringes and \$1.16/hour for vacations, sick leave and holidays. The total hourly rate will be \$10.61. The annual labor charge will be:

$$10.61 \times 8 \times 365 = \$31,000 \text{ per year}$$

or

$$\frac{31,000}{2,450} = \$12.65 \text{ per ton of refuse}$$

Fuel oil cost has been based on No. 2 oil at a cost of \$.365 per gallon. The primary furnace is essentially self-sustaining and requires negligible auxiliary fuel. The secondary burner is required to maintain the secondary combustion exit temperature at 2000° F. Fuel oil consumption is estimated to be 90 gallons per hour. At \$.365 per gallon, the fuel oil cost will be:

$$90 \times .365 \times 8 = \$26.40 \text{ per day}$$

or

$$\frac{26.40}{7} = \$3.77 \text{ per ton}$$

Electric power cost is estimated at \$.75 per hour, \$6.00 per day or:

$$\frac{6}{7} = $.86 \text{ per ton}$$

Burn down is estimated to \$10.00 per day or:

$$\frac{10.00}{7} = \$1.43 \text{ per ton}$$

Total operating cost is tabulated below:

<u>Item</u>	<u>Operating Cost</u>	
	<u>8 hour day</u>	<u>per ton refuse</u>
Labor	\$ 88.55	\$12.65
Fuel oil, operating	26.40	3.77
Electric power, operating	6.00	.86
Burn down, oil and electric	10.00	1.43
Water	neg.	neg.
Ash handling (estimate)	4.00	.57
Maintenance and Repair (estimate)	4.28	.61
TOTAL	\$139.23	\$19.89

HEAT RECOVERY

The refuse will have a daily heating value of:

$$7 \times 2,000 \times 5,700 = 79.8 \times 10^6 \text{ BTU}$$

The fuel oil used in the secondary burner will have a daily heating value of:

$$9.0 \times 140,000 \times 8 = 10 \times 10^6 \text{ BTU}$$

The total daily heat input will be:

$$79.8 \times 10^6 + 10 \times 10^6 = 89.8 \times 10^6 \text{ BTU}$$

or

$$\frac{89.8}{8} \times 10^6 = 11.2 \times 10^6 \text{ BTU per hour}$$

With an estimated boiler efficiency of .65, the steam generated will be:

$$\frac{11.2 \times 10^6 \times .65}{1,050} = 6,900 \text{ pounds per hour}$$

With a fuel cost of steam at \$1.45/1,000 pounds. The value of heat recovery will be:

$$6.9 \times 1.45 = \$10.00/\text{hour}$$

or

$$10.00 \times 8 = \$80.00 \text{ per day}$$

or

$$\frac{80.00}{7} = \$11.43 \text{ per ton of refuse}$$

CAPITAL COST

The quoted price of the equipment selected including a 3 cubic yard in-line loader, automatic ash removal, fire tube boiler, breeching, stack, dampers and controls is \$270,000 installed. The space required for this equipment is 44 feet long, 23 feet wide and 17 feet high. If 6 feet is allowed on each side and the end, and 20 feet at the loader end for storage, the plan width required will be $23 + 12$ or 35 feet and the plan length will be $44 + 6 + 20$ or 70 feet. The general arrangement of this equipment has been shown on Helmick & Lutz Co. drawing No. 625 - Task 21. The total area required will be 35×70 or 2,450 square feet. At \$50 per square foot, the site value is \$122,000. The estimated budget cost to install equipment of this type appears below:

ON-SITE HOSPITAL INCINERATION - ESTIMATED COST

<u>Item</u>	<u>Estimated Cost</u>	
	<u>With Heat Recovery</u>	<u>Without Heat Recovery</u>
Equipment Cost	\$270,000	\$230,000
Site Value and General Construction	122,000	122,000
Mechanical Construction	40,000	0
Electrical Construction	15,000	15,000
Contingencies, 10%	<u>45,000</u>	<u>37,000</u>
Total Estimated Budget Cost	\$492,000	\$404,000

SUMMARY

A comparison of operating cost for the on-site unit rated 7 tons per day and pyrolysis unit operating at 80 tons per day and 250 tons per day follows:

<u>Item</u>	<u>On-Site 7 T/day</u>		<u>Pyrolysis 80 T/day</u>	<u>250 T/day</u>
	<u>Without Heat Recovery</u>	<u>With Heat Recovery</u>		
<u>Operating Cost</u>				
Labor \$/ton	12.65	12.65	10.73	3.27
Fuel oil \$/ton	3.77	3.77	1.89	1.51
Electric power \$/ton	.86	.86	3.37	3.37
City and Sewer \$/ton	neg.	neg.	.08	.08
Maintenance and Repair \$/ton	.61	.61	3.18	1.45
Burn down, oil and electric, \$/ton	1.43	1.43	-	-
Ash handling \$/ton	<u>.57</u>	<u>.57</u>	<u>-</u>	<u>-</u>
Total \$/ton	19.89	19.89	18.75	9.68
Steam credit \$/ton	0	11.45	12.95	12.95
<u>Capital Investment</u>	\$404,000	\$492,000	\$6,967,000	\$9,543,000
Cost per ton of rating	\$ 57,600	\$ 70,300	\$ 53,400	\$ 38,172

A comparison of capital investment costs for the on-site unit rated 7 tons per day and the pyrolysis unit with a maximum rating of 130 tons per day follows:

<u>Item</u>	<u>On-Site 7 T/day</u>		<u>Pyrolysis 130 T/day</u>
	<u>Without Heat Recovery</u>	<u>With Heat Recovery</u>	
Capital Investment Cost	\$404,000	\$492,000	\$6,967,000
Cost per ton of rating	\$ 57,600	\$ 70,300	\$ 53,400

Incorporating collection and transportation cost results in the following comparison:

<u>OPERATING COST PER TON</u>				
<u>On Site 7 T/day</u>	<u>Pyrolysis 80 T/day</u>	<u>Pyrolysis 100 T/day</u>	<u>Pyrolysis 132 T/day</u>	<u>Pyrolysis 250 T/day</u>
\$11.43	\$11.80 (10 Mile Zone)	\$9.11 (10 Mile Zone)	\$6.63 (10 Mile Zone)	\$2.73 (10 Mile Zone)
	13.80 (out side 10 Mile Zone)	11.11 (outside 10 Mile Zone)	8.63 (outside 10 Mile Zone)	4.73 (outside 10 Mile Zone)

CAPACITY—7 TONS PER DAY

DRWN	DATE	UNIVERSITY OF MINNESOTA MINNEAPOLIS, MINNESOTA	SCALE $\frac{1}{8}" = 1'-0"$
B.L.	11-1-77		
		GRID I.C.E.S. STUDY	625
		TYPICAL HOSPITAL INCINERATOR — GEN. ARRANGEMENT PLAN	TASK 21

APPENDIX #1.

Metro Square Building, 7th Street and Robert Street, Saint Paul, Minnesota 55101

November 4, 1977

Mr. Warren E. Soderberg
Director of Physical Plant
200 Shops Building
University of Minnesota
Minneapolis, Minnesota 55455

RE: Hospital and Health Care Waste Management

Dear Mr. Soderberg:

The Metropolitan Council staff appreciates your coordination with the Council offices regarding the University of Minnesota's studies and planning for a grid connected integrated community energy system. We are following with interest your planning studies for the disposal and utilization of wastes from hospital and other health care facilities. Our interest arises from the opportunity that exists to properly manage and implement a system for handling these wastes. The planning for safe destruction of these wastes, combined with some potential heat recovery and integration into the grid energy system under investigation is commendable.

The Metropolitan Council is currently in the process of preparing a regional policy plan for solid and hazardous waste management. This policy plan is expected to be adopted in 1978. The preparation of this plan is mandated by State Law (Minnesota Statutes, Chapter 473) and is required to include a long-range plan for the collection and processing of solid and hazardous waste in the Twin Cities seven-county Metropolitan Area. Addressing the long-range management of hospital and other health care waste is an important component of this plan. We realize that much of the waste from hospital and other health care facilities is hazardous in nature and requires special handling, transport and disposal. Your work on this issue will certainly be of benefit in the Council's policy plan development.

The generation of these wastes is from all parts of the region. Inasmuch as the Council's planning is to address the region's waste management requirements we would highly encourage you to

Mr. Warren E. Soderberg
November 4, 1977
Page Two

continue to consider the regional needs for the management of hospital and health care wastes. In consideration of the volumes of wastes, it would appear that one facility would be sufficient to serve the regional needs.

We will maintain close contact with your staff regarding continued planning. Again, thank you for keeping us informed about your study efforts and findings.

Sincerely,

Raymond W. Thron

Raymond W. Thron, Ph.D., P.E.
Program Manager for Air Quality
and Solid Waste Management

RWT/cjd

APPDENDIX 2

ANDCO PRELIMINARY DESIGN, COST AND COMPUTER RUN DATA

UNITED STATES GOVERNMENT NOTICE

This report was prepared on an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product or process disclosed or represents that its use would not infringe privately owned rights.

AN EQUAL OPPORTUNITY EMPLOYER AFFIRMATIVE ACTION PROGRAM

ANDCO INCORPORATED

1. POLICY STATEMENT

Andco Incorporated under the leadership of its president and chief executive officer A. E. Anderson, III, pursues an active philosophy of promoting the full realization of equal employment for all its employees and applicants for employment. The following constitutes the attitude of A. E. Anderson, III, and accordingly the policy of Andco Incorporated.

The Company shall do all that is in its power to provide for actual progress in the area of equal employment opportunity. This policy extends to all matters concerning the employment relationship including recruiting, hiring, apprenticeship programming, promotion, compensation, benefits, and all the terms and conditions of employment. Moreover, everyone in the employ of Andco Incorporated shall be encouraged to do all in their power to actively foster the Company's policy of equal employment opportunity and more specifically to fulfill and see implemented in a constructive way this affirmative action program. Specifically, this program includes but is not limited to:

A. The recruitment and hire of employees in all job classifications without regard to race, color, religion, sex, national origin, handicap, a veteran's disability or being a veteran of the Vietnam Era, except where sex, handicap or disability is a true and bonafide occupational qualification or limitation.

B. All decisions on employment are to be based upon the principle of furthering equal employment opportunity and more specifically, this Affirmative Action Program.

C. Any promotions made are to be based upon valid requirements consistent with principles of equal employment opportunity and with the view of implementing this Affirmative Action Program.

D. All other personnel programs and actions are to be administered without regard to race, color, religion, sex, national origin, handicap, a veteran's disability or being a veteran of the Vietnam Era except where sex, handicap or disability is a bonafide occupational qualification or limitation and this is to include actions such as transfers, layoffs, compensation, benefits, return from layoff, and Company sponsored or financed training or education, and any social recreation programs in which the Company plays a role.

It is further the desire of the Company that our subcontractors and suppliers and those doing business with the Company adhere to the principles necessary for the active promotion of equal employment opportunity for all regardless of race, color, religion, sex, national origin, handicap, a veteran's disability or being a veteran of the Vietnam Era.

UNIVERSITY OF MINNESOTA

ANDCO CALCULATIONS

<u>Item</u>	<u>Preliminary Est. 1976 Dollars</u>		
	<u>132 T.P.D.</u>	<u>100 T.P.D.</u>	<u>250 T.P.D.</u>
Gasifier	\$ 818,355		
S.C.C.	442,720		
Towers	771,690		
Duct Work	623,100		
Slag Handling System	127,925		
Electrical	463,435		
Instrumentation	392,765		
Air Moving Eq.	133,780		
Piping/Cooling Water Systems	528,290		
Refuse Feed System	67,385		
Miscellaneous	<u>79,620</u>	<u> </u>	<u> </u>
Sub-Total	\$4,449,065		
Contingency 10%	<u>444,905</u>	<u> </u>	<u> </u>
*Total	<u>\$4,893,970</u>	<u>\$4,103,412</u>	<u>\$5,876,112</u>

*Includes Equipment Engineering, Construction, Start-Up and A-T Fees.

10-10-76

ELECTRIC POWER REQUIREMENTS

ANDCO CALCULATIONS

Description	Qu	Power Demand (HP)	Total Power Demand KW	% Used/Day %	Total Rated Power Per Day (KWh/Day)	Rated Power Per Ton of Refuse (KWh/T)
Primary Air Fan	1	100	75.00	100	1,800	18.00
Secondary Air Fan	1	75	56.25	100	1,350	13.50
Induced Air Fan	-	-	-	-	-	-
Auxiliary Fuel System	1	5	3.75	20	18	.18
Vibrating Feeder	1	20	15.00	30	108	1.08
Slag Conveyor Belt	1	4	3.00	100	72	.72
Slag Conveyor Bucket	1	4	3.00	100	72	.72
Slag Grapple Bucket	1	2	1.50	100	36	.36
Heat Exchanger	2 (25 each)	50	37.50	100	900	9.00
Water Treatment Unit	1	1	.75	30	5	.05¢
Closed Circuit Cooling Pump	1	50	37.50	100	900	9.00
Open Circuit Cooling Pump	1	100	75.00	100	1,800	18.00
Slag Quench Reservoir Pumps	1	20	15.00	100	360	3.60
Air Compressor (Instrument)	1	15	11.25	50	135	1.35
Air Compressor (Stand By)	-	-	-	-	-	-
Controls (120 Volts)	-	10 KW	10.00	100	288	2.88
Burner Fans Totals	-	15 HP	11.25	100	270	2.70
Compressor Burner - 1						*81.44
Slag Taps, Gas & S.C.F.	- 10 + 2					
Boiler Burner	- 2					

*No Load Factor Applied

ΔT .7 = (56.80)

10-7-77

FUEL OIL REQUIREMENTS

ANDCO CALCULATIONS

START UP

Compressor Burner	150 L/HR	For 120 Hr	= 18,000 L
S. C. C. Burner	180 L/Hr	16 Hr	2,880
S. C. C. Slag Burner	30 L/Hr	10 Hr	300
Tuyeres 8 @ 24 L/Hr	192 L/Hr	10 Hr	1,920
Gasifier Slag Burners	25 L/Hr	24 Hr	600
Hearth Burners	200 L/Hr	12 Hr	<u>2,400</u>
			26,100 L
			<u>X .264</u>
			6,890 U.S. Gal.

NORMAL OPERATION - Point 8 118 Tons/Day @ 3,751 L.H.V.

Gasifier Tuyeres	0 L/T (Approximately 15 L/Hr)	
Gasifier Slag Tap	5.77 L/T x 118	= 680.86 L/D
S. C. C. Burner and Slag Tap	6.92 L/T	816.56 L/D
Health Burners	0	
Compressor Burner	0	
		<hr/>
		1,497.42 L/D
		x .264 = 395 Gal/Day
		Use 400 Gal/Day
		Use 500 Pump Sizing

OPEN COOLING WATER
 UN. OF MINN
 PHASE I
 OCT-6-77

CLIENT : UN OF MINN

RATE : 64. TONS/DAY

REFUSE : LHV = 2735.1 KCAL/KG, HHV = 3060.1 KCAL/KG

REFUSE ANALYSIS

PROXIMATE ANALYSIS

ULTIMATE ANALYSIS

% COMBUSTIBLES	53.90	% FIXED CARBON	5.76	% CARBON	32.00
% WATER	25.10	% VOLATILES	48.14	% HYDROGEN	3.41
% ASH-INERTS	21.00	% WATER	25.10	% OXYGEN	18.49
		% INERTS	21.00		

GASIFIER

SECONDARY COMBUSTION CHAMBER

HOT BLAST TEMP	1037.00 DEG C	SCC PROCESS AIR	12523.74 NM3/H
HOT BLAST AIR FLOW	1331.05 NM3/H	SCC EXCESS AIR	65. %
FUEL OIL TO TUYERES	2.50 L/T	FUEL OIL TO SCC	12.76 L/T
FUEL OIL TO SLAG TAP	10.63 L/T		
SLAG OUTPUT	560.18 KG/H		

EFFLUENT CONSTITUENTS
BY VOLUME

OFFGAS

% O2	6.6
% N2	70.6
% CO2	10.7
% H2O	12.2

FLOW 3916.19 NM3/H

TEMPERATURE 314.65 DEG C

EFFLUENT FLOW	15873.94 NM3/H
EFFLUENT TEMP	1259.85 DEG C

HEATING VALUE

SENSIBLE	115.97 KCAL/NM3
LATENT	96.90 KCAL/NM3
CHEM + PART	1739.76 KCAL/NM3

REGENERATIVE TOWER

EFFICIENCY 80%

TOTAL 1952.62 KCAL/NM3

GAS FLOW	1212.99 NM3/H
GAS TEMP IN	1150.00 DEG C
GAS TEMP OUT	237.18 DEG C

WASTE HEAT BOILER

HOT BLAST FLOW	1331.05 NM3/H
BLAST TEMP IN	37.00 DEG C
BLAST TEMP OUT	1038.00 DEG C

EFFICIENCY 98 %

BLEND AIR 145.70 NM3/H

GAS FLOW	14660.95 NM3/H
GAS TEMP IN	1259.85 DEG C
GAS TEMP OUT	290.00 DEG C

GAS CLEANING EQUIPMENT

ENERGY RECOVERY

ENERGY	6639133.13 KCAL/H
STEAM	8715.06 KG/H
KG STEAM/KG REFUSE	13.27

GAS FLOW	16019.64 NM3/H
PARTICULATE	51.73 KG/H
GAS TEMP IN	285.52 DEG C
GAS TEMP OUT	279.81 DEG C

OVERALL SYSTEM EFFICIENCY 68.49 %

CLIENT : UN OF MINN

RATE : 64, TONS/DAY

REFUSE : LHV = 2735, KCAL/KG, HHV = 3060, KCAL/KG

HEAT AND MASS BALANCE

=====

IN

OUT

KG/H

KCAL/H

KG/H

KCAL/H

GASIFIER

REFUSE	2667.	7293333.	OFFGAS	3914.	7267357.
HOT BLAST	1721.	462271.	SLAG	504.	166189.
FUEL OIL	30.	308689.	HEAT LOSS		630748.
TOTAL	4418.	8064294.	TOTAL	4418.	8064294.

SECONDARY COMBUSTION CHAMBER

OFFGAS	3914.	7267357.	WASTE GAS	20502.	7411820.
TOTAL AIR	16015.	0.	SLAG	56.	18491.
FUEL OIL	29.	300000.	HEAT LOSS		137046.
TOTAL	20558.	7567357.	TOTAL	20558.	7567357.

WASTE HEAT BOILER

WASTE GAS	18936.	6845453.	WASTE GAS	18936.	1296492.
FEED WATER	8715.	1227081.	STEAM	8715.	6639133.
			HEAT LOSS		136909.
TOTAL	27651.	8072534.	TOTAL	27651.	8072534.

REGENERATIVE TOWERS

WASTE GAS	1567.	566366.	WASTE GAS	1755.	96282.
COLD BLAST	1721.	9178.	HOT BLAST	1721.	462271.
BLEND AIR	180.		HEAT LOSS		16991.
TOTAL	3476.	575544.	TOTAL	3476.	575544.

GAS CLEANING SYSTEM

WASTE GAS	20691.	1392774.	WASTE GAS	20691.	1364918.
			PARTICULATE	52.	
			HEAT LOSS		27855.
TOTAL	20691.	1392774.	TOTAL	20691.	1392774.

CLIENT : UN OF MINN

RATE : 64, TONS/DAY

REFUSE : LHV = 2735, KCAL/KG, HPV = 3060, KCAL/KG

ASSUMPTIONS :

1) SUPPLEMENTAL FUEL TYPE IS FUEL OIL.

2) SUPPLEMENTAL FUEL DATA :

COMPOSITION : 87.20 % CARBON

(BY WEIGHT) 12.50 % HYDROGEN

0.30 % ASH

0. % WATER

SPECIFIC GRAVITY : 0.865 (WATER = 1.0)

LOWER HEATING VALUE : 10196, KCAL/KG

3) BOILER DATA :

STEAM PRESSURE : 34.0 ATMOSPHERES

STEAM TEMPERATURE : 385.0 DEGREES CELCIUS

STEAM ENTHALPY : 761.8 KCAL/KG

FEEDWATER ENTHALPY : 140.8 KCAL/KG

NOTES :

1) AMBIENT TEMPERATURE IS 15.56 DEGREES CELCIUS.

2) AMBIENT PRESSURE IS 1.0 ATMOSPHERE (760 MM HG).

3) GASES AND SOLIDS HAVE ZERO ENTHALPY AT 15.56 DEGREES CELCIUS.

4) WATER AND WATER VAPOR HAVE ZERO ENTHALPY AT 15.56 DEGREES CELCIUS.

5) PROCESS AND COMBUSTION AIR IS DRY,

6) ONE NORMAL CUBIC METER OF GAS IS AT 0.0 DEGREES CELCIUS AND 1.0 ATMOSPHERE.

7) ALL SUPPLEMENTAL FUEL IS COMBUSTED TO CARBON DIOXIDE AND WATER VAPOR WITH 100 % HEAT RELEASE.

8) ANCILLARY EQUIPMENT HEAT LOSSES ARE DETERMINED AS FOLLOWS :

$$LOSS = (1 - N) \times \text{HOT FLUID SENSIBLE HEAT IN}$$

WHERE -N- IS THE EQUIPMENT ASSUMED EFFICIENCY.

9) OVERALL SYSTEM EFFICIENCY IS DETERMINED AS FOLLOWS :

$$EFFICIENCY = \frac{(\text{STEAM HEAT OUT} - \text{FEEDWATER HEAT IN})}{(\text{REFUSE HEAT IN} + \text{TOTAL FUEL HEAT IN})}$$

WHERE REFUSE AND FUEL HEATS ARE DETERMINED FROM THEIR LOWER HEATING VALUES.

ANDCO-TORRAX SOLID WASTE DISPOSAL SYSTEM -V 8,7 N

DATE 09/16/77

CLIENT : UN OF MINN

RATE : 85, TONS/DAI

REFUSE : LHV = 2735, KCAL/KG, HHV = 3060, KCAL/KG

REFUSE ANALYSIS

PROXIMATE ANALYSIS

ULTIMATE ANALYSIS

% COMBUSTIBLES	53.90	% FIXED CARBON	5.76	% CARBON	32.00
% WATER	25.10	% VOLATILES	48.14	% HYDROGEN	3.41
% ASH-INERTS	21.00	% WATER	25.10	% OXYGEN	18.49
		% INERTS	21.00		

GASIFIER

SECONDARY COMBUSTION CHAMBER

HOT BLAST TEMP	1037.00 DEG C	SCC PROCESS AIR	16671.00 NM3/H
HOT BLAST AIR FLOW	1672.68 NM3/H	SCC EXCESS AIR	66, %
FUEL OIL TO TUYERES	2.32 L/T	FUEL OIL TO SCC	9.60 L/T
FUEL OIL TO SLAG TAP	8.00 L/T		
SLAG OUTPUT	743.93 KG/H		

EFFLUENT CONSTITUENTS
BY VOLUME

OFF GAS

% O2	6.7
% N2	70.6
% CO2	10.6
% H2O	12.2

FLOW 5100.03 NM3/H

TEMPERATURE 315.11 DEG C

EFFLUENT FLOW 20905.53 NM3/H
EFFLUENT TEMP 1259.94 DEG C

HEATING VALUE

REGENERATIVE TOWER

SENSIBLE 116.36 KCAL/NM3
LATENT 97.80 KCAL/NM3
CHEM + PART 1774.26 KCAL/NM3

EFFICIENCY 80%

TOTAL 1988.43 KCAL/NM3

GAS FLOW 1524.53 NM3/H
GAS TEMP IN 1150.00 DEG C
GAS TEMP OUT 237.21 DEG C

WASTE HEAT BOILER

HOT BLAST FLOW 1672.68 NM3/H
BLAST TEMP IN 37.00 DEG C
BLAST TEMP OUT 1038.00 DEG C

EFFICIENCY 98 %

BLEND AIR 183.22 NM3/H

GAS FLOW 19380.99 NM3/H
GAS TEMP IN 1259.94 DEG C
GAS TEMP OUT 290.00 DEG C

GAS CLEANING EQUIPMENT

ENERGY RECOVERY

ENERGY 8775594.13 KCAL/H
STEAM 11519.55 KG/H
KG STEAM/KG REFUSE 3.25GAS FLOW 21088.75 NM3/H
PARTICULATE 68.09 KG/H
GAS TEMP IN 285.72 DEG C
GAS TEMP OUT 280.01 DEG C

OVERALL SYSTEM EFFICIENCY 69.39 %

CLIENT : UN OF MINN

RATE : 85, TONS/DAY

REFUSE : LHV = 2735. KCAL/KG, HHV = 3060. KCAL/KG

HEAT AND MASS BALANCE

=====

IN				OUT			
		KG/H	KCAL/H			KG/H	KCAL/H
GASIFIER							
REFUSE	3542.	9686458.		OFFGAS	5067.	9642247.	
HOT BLAST	2163.	580917.		SLAG	669.	220711.	
FUEL OIL	32.	322483.		HEAT LOSS		726901.	
TOTAL	5736.	10589858.		TOTAL	5736.	10589858.	
SECONDARY COMBUSTION CHAMBER							
OFFGAS	5067.	9642247.		WASTE GAS	26999.	9759759.	
TOTAL AIR	21977.	0.		SLAG	74.	24549.	
FUEL OIL	29.	300000.		HEAT LOSS		157938.	
TOTAL	27073.	9942247.		TOTAL	27073.	9942247.	
WASTE HEAT BOILER							
WASTE GAS	25030.	9048031.		WASTE GAS	25030.	1713429.	
FEED WATER	11520.	1621953.		STEAM	11520.	8775594.	
				HEAT LOSS		180961.	
TOTAL	36550.	10669983.		TOTAL	36550.	10669984.	
REGENERATIVE OWERS							
WASTE GAS	1969.	711729.		WASTE GAS	2206.	120994.	
COLD BLAST	2163.	11534.		HOT BLAST	2163.	580917.	
BLEND AIR	237.			HEAT LOSS		21352.	
TOTAL	4369.	723262.		TOTAL	4369.	723262.	
GAS CLEANING SYSTEM							
WASTE GAS	27236.	1834423.		WASTE GAS	27168.	1797734.	
				PARTICULATE	68.		
				HEAT LOSS		36688.	
TOTAL	27236.	1834423.		TOTAL	27236.	1834423.	

CLIENT ; UN OF MINN

RATE ; 85, TONS/DAY

REFUSE ; LHV = 2735, KCAL/KG, HHV = 3066, KCAL/KG

ASSUMPTIONS :

1) SUPPLEMENTAL FUEL TYPE IS FUEL OIL.

2) SUPPLEMENTAL FUEL DATA :

COMPOSITION : 87.20 % CARBON

(BY WEIGHT) 12.50 % HYDROGEN

0.30 % ASH

0. % WATER

SPECIFIC GRAVITY : 0.865 (WATER = 1.0)

LOWER HEATING VALUE : 10196, KCAL/KG

3) BOILER DATA :

STEAM PRESSURE : 34.0 ATMOSPHERES

STEAM TEMPERATURE : 385.0 DEGREES CELCIUS

STEAM ENTHALPY : 761.8 KCAL/KG

FEEDWATER ENTHALPY : 140.8 KCAL/KG

NOTES :

1) AMBIENT TEMPERATURE IS 15.56 DEGREES CELCIUS.

2) AMBIENT PRESSURE IS 1.0 ATMOSPHERE (760 MM HG).

3) GASES AND SOLIDS HAVE ZERO ENTHALPY AT 15.56 DEGREES CELCIUS.

4) WATER AND WATER VAPOR HAVE ZERO ENTHALPY AT 15.56 DEGREES CELCIUS.

5) PROCESS AND COMBUSTION AIR IS DRY.

6) ONE NORMAL CUBIC METER OF GAS IS AT 0.0 DEGREES CELCIUS AND 1.0 ATMOSPHERE.

7) ALL SUPPLEMENTAL FUEL IS COMBUSTED TO CARBON DIOXIDE AND WATER VAPOR WITH 100 % HEAT RELEASE.

8) ANCILLARY EQUIPMENT HEAT LOSSES ARE DETERMINED AS FOLLOWS :

$$LOSS = (1 - N) * HOT FLUID SENSIBLE HEAT IN$$

WHERE -N- IS THE EQUIPMENT ASSUMED EFFICIENCY.

9) OVERALL SYSTEM EFFICIENCY IS DETERMINED AS FOLLOWS :

$$EFFICIENCY = \frac{(STEAM HEAT OUT - FEEDWATER HEAT IN)}{(REFUSE HEAT IN + TOTAL FUEL HEAT IN)}$$

WHERE REFUSE AND FUEL HEATS ARE DETERMINED FROM THEIR LOWER HEATING VALUES.

ANDCO-TORRAX SOLID WASTE DISPOSAL SYSTEM -V 8,7 N

DATE 09/16/77

CLIENT ; UN OF MINN

RATE ; 91, TONS/DAY

REFUSE ; LHV = 2735, KCAL/KG, HHV = 3060, KCAL/KG

REFUSE ANALYSIS

PROXIMATE ANALYSIS

ULTIMATE ANALYSIS

% COMBUSTIBLES	53.90	% FIXED CARBON	5.76	% CARBON	32.00
% WATER	25.10	% VOLATILES	48.14	% HYDROGEN	3.41
% ASH-INERTS	21.00	% WATER	25.10	% OXYGEN	18.49
		% INERTS	21.00		

GASIFIER

SECONDARY COMBUSTION CHAMBER

HOT BLAST TEMP	1037.00 DEG C	SCC PROCESS AIR	17864.12 NM3/H
HOT BLAST AIR FLOW	1768.90 NM3/H	SCC EXCESS AIR	66, %
FUEL OIL TO TOWERS	2.25 L/T	FUEL OIL TO SCC	8.97 L/T
FUEL OIL TO SLAG TAP	7.48 L/T		
SLAG OUTPUT	796.43 KG/H		

EFFLUENT CONSTITUENTS
BY VOLUME

OFF GAS

% O2	6.7
% N2	70.6
% CO2	10.6
% H2O	12.2

FLOW 5436.79 NM3/H

TEMPERATURE 315.31 DEG C

EFFLUENT FLOW	22349.84 NM3/H
EFFLUENT TEMP	1259.78 DEG C

HEATING VALUE

REGENERATIVE TOWER

SENSIBLE	116.57 KCAL/NM3
LATENT	98.00 KCAL/NM3
CHEM + PART	1781.85 KCAL/NM3

EFFICIENCY 80%

TOTAL 1996.41 KCAL/NM3

GAS FLOW	1612.61 NM3/H
GAS TEMP IN	1150.00 DEG C
GAS TEMP OUT	237.17 DEG C

WASTE HEAT BOILER

HOT BLAST FLOW	1768.90 NM3/H
BLAST TEMP IN	37.00 DEG C
BLAST TEMP OUT	1038.00 DEG C

EFFICIENCY 98 %

BLEND AIR 193.49 NM3/H

GAS FLOW	20737.23 NM3/H
GAS TEMP IN	1259.78 DEG C
GAS TEMP OUT	290.00 DEG C

GAS CLEANING EQUIPMENT

ENERGY RECOVERY

ENERGY	9387162.75 KCAL/H
STEAM	12322.35 KG/H
KG STEAM/KG REFUSE	3.25

GAS FLOW	22543.33 NM3/H
PARTICULATE	72.78 KG/H
GAS TEMP IN	285.77 DEG C
GAS TEMP OUT	280.05 DEG C

OVERALL SYSTEM EFFICIENCY 69.59 %

CLIENT : UN OF MINN

RATE : 91, TONS/DAY

REFUSE LHV = 2735, KCAL/KG, HHV = 3060, KCAL/KG

HEAT AND MASS BALANCE

=====

IN

OUT

KG/H KCAL/H

KG/H KCAL/H

GASIFIER

REFUSE	3792.	10370208.	OFFGAS	5394.	10321282.
HOT BLAST	2287.	614333.	SLAG	717.	236289.
FUEL OIL	32.	325148.	HEAT LOSS		752119.
TOTAL	6111.	11309690.	TOTAL	6111.	11309690.

SECONDARY COMBUSTION CHAMBER

OFFGAS	5394.	10321282.	WASTE GAS	28864.	10431585.
TOTAL AIR	23520.	0.	SLAG	80.	26280.
FUEL OIL	29.	300000.	HEAT LOSS		163417.
TOTAL	28943.	10621282.	TOTAL	28943.	10621282.

WASTE HEAT BOILER

WASTE GAS	26781.	9678915.	WASTE GAS	26781.	1833160.
FEED WATER	12322.	1734986.	STEAM	12322.	9387163.
			HEAT LOSS		193578.
TOTAL	39104.	11413901.	TOTAL	39104.	11413901.

REGENERATIVE TOWERS

WASTE GAS	2083.	752670.	WASTE GAS	2353.	127954.
COLD ELAST	2287.	12197.	HOT BLAST	2287.	614333.
BLEND AIR	250.		HEAT LOSS		22580.
TOTAL	4620.	764867.	TOTAL	4620.	764867.

GAS CLEANING SYSTEM

WASTE GAS	29114.	1961114.	WASTE GAS	29041.	1921891.
			PARTICULATE	73.	
			HEAT LOSS		39222
TOTAL	29114.	1961114.	TOTAL	29114.	1961114.

CLIENT : ON OF MINN

RATE : 91, TONS/DAY

REFUSE : LHV = 2735, KCAL/KG, HHV = 3060, KCAL/KG

ASSUMPTIONS :

1) SUPPLEMENTAL FUEL TYPE IS FUEL OIL.

2) SUPPLEMENTAL FUEL DATA :

COMPOSITION : 87.20 % CARBON

(BY WEIGHT) 12.50 % HYDROGEN

0.30 % ASH

0. % WATER

SPECIFIC GRAVITY : 0.865 (WATER = 1.0)

LOWER HEATING VALUE : 10196, KCAL/KG

3) BOILER DATA :

STEAM PRESSURE : 34.0 ATMOSPHERES

STEAM TEMPERATURE : 385.0 DEGREES CELCIUS

STEAM ENTHALPY : 761.8 KCAL/KG

FEEDWATER ENTHALPY : 140.8 KCAL/KG

NOTES :

1) AMBIENT TEMPERATURE IS 15.56 DEGREES CELCIUS.

2) AMBIENT PRESSURE IS 1.0 ATMOSPHERE (760 MM HG).

3) GASES AND SOLIDS HAVE ZERO ENTHALPY AT 15.56 DEGREES CELCIUS.

4) WATER AND WATER VAPOR HAVE ZERO ENTHALPY AT 15.56 DEGREES CELCIUS.

5) PROCESS AND COMBUSTION AIR IS DRY.

6) ONE NORMAL CUBIC METER OF GAS IS AT 0.0 DEGREES CELCIUS AND 1.0 ATMOSPHERE.

7) ALL SUPPLEMENTAL FUEL IS COMBUSTED TO CARBON DIOXIDE AND WATER VAPOR WITH 100 % HEAT RELEASE.

8) ANCILLARY EQUIPMENT HEAT LOSSES ARE DETERMINED AS FOLLOWS :

$$LOSS = (1 - N) \times \text{HOT FLUID SENSIBLE HEAT IN}$$

WHERE -N- IS THE EQUIPMENT ASSUMED EFFICIENCY.

9) OVERALL SYSTEM EFFICIENCY IS DETERMINED AS FOLLOWS :

$$EFFICIENCY = \frac{(\text{STEAM HEAT OUT} - \text{FEEDWATER HEAT IN})}{\text{REFUSE HEAT IN} + \text{TOTAL FUEL HEAT IN}}$$

WHERE REFUSE AND FUEL HEATS ARE DETERMINED FROM THEIR LOWER HEATING VALUES.

CLIENT : UN OF MINN

RATE : 118. TONS/DAY

REFUSE : LHV = 2735. KCAL/KG. HHV = 3060. KCAL/KG

REFUSE ANALYSIS

PROXIMATE ANALYSIS

ULTIMATE ANALYSIS

% COMBUSTIBLES	53.90	% FIXED CARBON	5.76	% CARBON	32.00
% WATER	25.10	% VOLATILES	48.14	% HYDROGEN	3.41
% ASH-INERTS	21.00	% WATER	25.10	% OXYGEN	18.49
		% INERTS	21.00		

GASIFIER

SECONDARY COMBUSTION CHAMBER

HOT BLAST TEMP	1037.00 DEG C	SCC PROCESS AIR	23204.73 NM3/H
HOT BLAST AIR FLOW	2190.51 NM3/H	SCC EXCESS AIR	66. %
FUEL OIL TO LAYERS	1.77 L/T	FUEL OIL IC SCC	6.92 L/T
FUEL OIL TO SLAG TAP	5.77 L/T		
SLAG OUTPUT	1032.68 KG/H		

EFFLUENT CONSTITUENTS
BY VOLUME

OFFGAS

% O2	6.8
% N2	70.5
% CO2	10.5
% H2O	12.2

FLOW 6940.14 NM3/H

TEMPERATURE 315.10 DEG C

EFFLUENT FLOW 26808.72 NM3/H
EFFLUENT TEMP 1260.41 DEG C

HEATING VALUE

REGENERATIVE TOWER

SENSIBLE 116.69 KCAL/NM3
LATENT 98.73 KCAL/NM3
CHEM + PART 1610.03 KCAL/NM3

EFFICIENCY 80%

TOTAL 2025.45 KCAL/NM3

GAS FLOW 1996.18 NM3/H
GAS TEMP IN 1150.00 DEG C
GAS TEMP OUT 237.31 DEG C

WASTE HEAT BOILER

HOT BLAST FLOW 2190.51 NM3/H
BLAST TEMP IN 37.00 DEG C
BLAST TEMP OUT 1038.00 DEG C

EFFICIENCY 98 %

BLEND AIR 240.82 NM3/H

GAS FLOW 26812.53 NM3/H
GAS TEMP IN 1260.41 DEG C
GAS TEMP OUT 290.00 DEG C

GAS CLEANING EQUIPMENT

ENERGY RECOVERY

ENERGY 12143825.00 KCAL/H
STEAM 15940.96 KG/H
KG STEAM/KG REFUSE 3.24

GAS FLOW 29049.54 NM3/H
PARTICULATE 93.79 KG/H
GAS TEMP IN 285.94 DEG C
GAS TEMP OUT 280.22 DEG C

OVERALL SYSTEM EFFICIENCY 70.34 %

CLIENT : UN OF MINN

RATE : 118, TONS/DAY

REFUSE : LHV = 2235, KCAL/KG, HHV = 3060, KCAL/KG

HEAT AND MASS BALANCE

=====

		IN		OUT	
		KG/H	KCAL/H	KG/H	KCAL/H
GASIFIER					
REFUSE	4917.	13447083.	OFFGAS	6852.	13371675.
HOT BLAST	2832.	760759.	SLAG	929.	306387.
FUEL OIL	32.	326679.	HEAT LOSS		856459.
TOTAL	7781.	14534521.	TOTAL	7781.	14534521.
SECONDARY COMBUSTION CHAMBER					
OFFGAS	6852.	13371675.	WASTE GAS	37203.	13451519.
TOTAL AIR	30425.	0.	SLAG	103.	34069.
FUEL OIL	29.	300000.	HEAT LOSS		186088.
TOTAL	37307.	13671675.	TOTAL	37307.	13671675.
WASTE HEAT BOILER					
WASTE GAS	34625.	12519450.	WASTE GAS	34625.	2369723.
FEED WATER	15941.	2244487.	STEAM	15941.	12143825.
			HEAT LOSS		250389.
TOTAL	50566.	14763938.	TOTAL	50566.	14763937.
REGENERATIVE TOWERS					
WASTE GAS	2578.	932069.	WASTE GAS	2809.	158452.
COLD BLAST	2832.	15104.	HOT BLAST	2832.	760759.
BLEND AIR	311.		HEAT LOSS		27962.
TOTAL	5722.	947173.	TOTAL	5722.	947173.
GAS CLEANING SYSTEM					
WASTE GAS	37515.	2528175.	WASTE GAS	37421.	2477612.
			PARTICULATE	94.	
			HEAT LOSS		50564.
TOTAL	37515.	2528175.	TOTAL	37515.	2528175.

CLIENT : UN OF MINN

RATE : 118. TONS/DAY

REFUSE : LHV = 2735. KCAL/KG, HHV = 3060. KCAL/KG

ASSUMPTIONS :

1) SUPPLEMENTAL FUEL TYPE IS FUEL OIL.

2) SUPPLEMENTAL FUEL DATA :

COMPOSITION : 87.20 % CARBON

(BY WEIGHT) 12.50 % HYDROGEN

0.30 % ASH

0. % WATER

SPECIFIC GRAVITY : 0.865 (WATER = 1.0)

LOWER HEATING VALUE : 10196. KCAL/KG

3) BOILER DATA :

STEAM PRESSURE : 34.0 ATMOSPHERES

STEAM TEMPERATURE : 385.0 DEGREES CELCIUS

STEAM ENTHALPY : 761.8 KCAL/KG

FEEDWATER ENTHALPY : 140.6 KCAL/KG

NOTES :

1) AMBIENT TEMPERATURE IS 15.56 DEGREES CELCIUS.

2) AMBIENT PRESSURE IS 1.0 ATMOSPHERE (760 MM HG).

3) GASES AND SOLIDS HAVE ZERO ENTHALPY AT 15.56 DEGREES CELCIUS.

4) WATER AND WATER VAPOR HAVE ZERO ENTHALPY AT 15.56 DEGREES CELCIUS.

5) PROCESS AND COMBUSTION AIR IS DRY.

6) ONE NORMAL CUBIC METER OF GAS IS AT 0.0 DEGREES CELCIUS AND 1.0 ATMOSPHERE.

7) ALL SUPPLEMENTAL FUEL IS COMBUSTED TO CARBON DIOXIDE AND WATER VAPOR WITH 100 % HEAT RELEASE.

8) ANCILLARY EQUIPMENT HEAT LOSSES ARE DETERMINED AS FOLLOWS :

$$LOSS = (1 - N) \times \text{HOT FLUID SENSIBLE HEAT IN}$$

WHERE -N- IS THE EQUIPMENT ASSUMED EFFICIENCY.

9) OVERALL SYSTEM EFFICIENCY IS DETERMINED AS FOLLOWS :

$$EFFICIENCY = \frac{(\text{STEAM HEAT OUT} - \text{FEEDWATER HEAT IN})}{(\text{REFUSE HEAT IN} + \text{TOTAL FUEL HEAT IN})}$$

WHERE REFUSE AND FUEL HEATS ARE DETERMINED FROM THEIR LOWER HEATING VALUES.

ANDCO-TORRAX SOLID WASTE DISPOSAL SYSTEM -V 8.7 N

DATE 09/16/77

CLIENT : UN OF MINN

RATE : 64. TONS/DAY

REFUSE : LHV = 3751. KCAL/KG, HHV = 4142. KCAL/KG

REFUSE ANALYSIS

PROXIMATE ANALYSIS

ULTIMATE ANALYSIS

% COMBUSTIBLES	86.82	% FIXED CARBON	7.92	% CARBON	42.75
% WATER	7.25	% VOLATILES	76.90	% HYDROGEN	6.65
% ASH-INERTS	5.93	% WATER	7.25	% OXYGEN	37.43
		% INERTS	5.93		

GASIFIER

SECONDARY COMBUSTION CHAMBER

HOT BLAST TEMP	1037.00 DEG C	SCC PROCESS AIR	18350.60 NM3/H
HOT BLAST AIR FLOW	1569.20 NM3/H	SCC EXCESS AIR	76. %
FUEL OIL TO TIERES	0. L/T	FUEL OIL TO SCC	12.76 L/T
FUEL OIL TO SLAG TAP	10.63 L/T		
SLAG OUTPUT	158.30 KG/H		

EFFLUENT CONSTITUENTS
BY VOLUME

OFF GAS

% O2	7.5
% N2	72.1
% CO2	10.0
% H2O	10.4

FLOW 4385.40 NM3/H

TEMPERATURE - 568.46 DEG C

EFFLUENT FLOW	22181.26 NM3/H
EFFLUENT TEMP	1259.38 DEG C

HEATING VALUE

REGENERATIVE TOWER

SENSIBLE	237.52 KCAL/NM3
LATENT	27.19 KCAL/NM3
CHEM + PART	2071.18 KCAL/NM3

EFFICIENCY 80%

TOTAL 2335.89 KCAL/NM3

GAS FLOW	1441.02 NM3/H
GAS TEMP IN	1150.00 DEG C
GAS TEMP OUT	238.02 DEG C

WASTE HEAT BOILER

HOT BLAST FLOW	1569.20 NM3/H
BLAST TEMP IN	37.00 DEG C
BLAST TEMP OUT	1038.00 DEG C

EFFICIENCY 98 %

BLEND AIR 169.76 NM3/H

GAS FLOW	20740.23 NM3/H
GAS TEMP IN	1259.38 DEG C
GAS TEMP OUT	290.00 DEG C

GAS CLEANING EQUIPMENT

ENERGY RECOVERY

ENERGY	9329194.88 KCAL/H
STEAM	12246.25 KG/H
KG STEAM/KG REFUSE	4.59

GAS FLOW	22351.01 NM3/H
PARTICULATE	72.40 KG/H
GAS TEMP IN	296.26 DEG C
GAS TEMP OUT	280.53 DEG C

OVERALL SYSTEM EFFICIENCY 72.07 %

CLIENT : UN OF MINN

RATE : 64, TONS/DAY

REFUSE : LHV = 3751, KCAL/KG, HHV = 4142, KCAL/KG

HEAT AND MASS BALANCE

=====

IN

OUT

KG/H KCAL/H

KG/H KCAL/H

GASIFIER

REFUSE	2667.	10002667.	OFFGAS	4578.	10119952.
HOT BLAST	2029.	544977.	SLAG	142.	46944.
FUEL OIL	25.	250000.	HEAT LOSS		630748.
TOTAL	4720.	10797644.	TOTAL	4720.	10797644.

SECONDARY COMBUSTION CHAMBER

OFFGAS	4578.	10119952.	WASTE GAS	28740.	10277663.
TOTAL AIR	24149.	0.	SLAG	16.	5243.
FUEL OIL	29.	300000.	HEAT LOSS		137046.
TOTAL	28756.	10419952.	TOTAL	28756.	10419952.

WASTE HEAT BOILER

WASTE GAS	26873.	9609967.	WASTE GAS	26873.	1812845.
FEED WATER	12246.	1724272.	STEAM	12246.	9329195.
			HEAT LOSS		192199.
TOTAL	39119.	11334239.	TOTAL	39119.	11334239.

REGENERATIVE TOWERS

WASTE GAS	1067.	667696.	WASTE GAS	2087.	113508.
COLD BLAST	2029.	10820.	HOT BLAST	2029.	544977.
BLEND AIR	219.		HEAT LOSS		20031.
TOTAL	4116.	678516.	TOTAL	4116.	678516.

GAS CLEANING SYSTEM

WASTE GAS	28960.	1926353.	WASTE GAS	28887.	1887826.
			PARTICULATE	72.	
			HEAT LOSS		38527.
TOTAL	28960.	1926353.	TOTAL	28960.	1926353.

CLIENT : UN OF MIAN

RATE : 64. TONS/DAY

REFUSE : LHV = 3751. KCAL/KG, HHV = 4142. KCAL/KG

ASSUMPTIONS :

1) SUPPLEMENTAL FUEL TYPE IS FUEL OIL.

2) SUPPLEMENTAL FUEL DATA :

COMPOSITION : 82.20 % CARBON

(BY WEIGHT) 12.50 % HYDROGEN

0.30 % ASH

0. % WATER

SPECIFIC GRAVITY : 0.865 (WATER = 1.0)

LOWER HEATING VALUE : 10196. KCAL/KG

3) BOILER DATA :

STEAM PRESSURE : 34.0 ATMOSPHERES

STEAM TEMPERATURE : 385.0 DEGREES CELCIUS

STEAM ENTHALPY : 761.8 KCAL/KG

FEEDWATER ENTHALPY : 140.8 KCAL/KG

NOTES :

1) AMBIENT TEMPERATURE IS 15.56 DEGREES CELCIUS.

2) AMBIENT PRESSURE IS 1.0 ATMOSPHERE (760 MM HG).

3) GASES AND SOLIDS HAVE ZERO ENTHALPY AT 15.56 DEGREES CELCIUS.

4) WATER AND WATER VAPOR HAVE ZERO ENTHALPY AT 15.56 DEGREES CELCIUS.

5) PROCESS AND COMBUSTION AIR IS DRY.

6) ONE NORMAL CUBIC METER OF GAS IS AT 0.0 DEGREES CELCIUS AND 1.0 ATMOSPHERE.

7) ALL SUPPLEMENTAL FUEL IS COMBUSTED TO CARBON DIOXIDE AND WATER VAPOR WITH 100 % HEAT RELEASE.

8) ANCILLARY EQUIPMENT HEAT LOSSES ARE DETERMINED AS FOLLOWS :

$$LOSS = (1 - \eta) \times \text{HOT FLUID SENSIBLE HEAT IN}$$

WHERE η IS THE EQUIPMENT ASSUMED EFFICIENCY.

9) OVERALL SYSTEM EFFICIENCY IS DETERMINED AS FOLLOWS :

$$EFFICIENCY = \frac{(\text{STEAM HEAT OUT} - \text{FEEDWATER HEAT IN})}{\text{REFUSE HEAT IN} + \text{TOTAL FUEL HEAT IN}}$$

WHERE REFUSE AND FUEL HEATS ARE DETERMINED FROM THEIR LOWER HEATING VALUES.

CLIENT : UN OF MINN

RATE : 85, TONS/DAY

REFUSE : LHV = 3751. KCAL/KG, HHV = 4142. KCAL/KG

REFUSE ANALYSIS

PROXIMATE ANALYSIS

ULTIMATE ANALYSIS

% COMBUSTIBLES	86.62	% FIXED CARBON	7.92	% CARBON	42.75
% WATER	7.25	% VOLATILES	76.90	% HYDROGEN	6.65
% ASH-INERTS	5.93	% WATER	7.25	% OXYGEN	37.43
		% INERTS	5.93		

GASIFIER

SECONDARY COMBUSTION CHAMBER

HOT BLAST TEMP	1037.00 DEG C	SCC PROCESS AIR	24384.46 NM3/H
HOT BLAST AIR FLOW	1994.90 NM3/H	SCC EXCESS AIR	76, %
FUEL OIL TO TUYERES	0. L/T	FUEL OIL TO SCC	9.60 L/T
FUEL OIL TO SLAG TAP	8.00 L/T		
SLAG OUTPUT	210.18 KG/H		

EFFLUENT CONSTITUENTS
BY VOLUME

OFFGAS

% O2	7.6
% N2	72.1
% CO2	10.0
% H2O	10.4

FLOW 5720.86 NM3/H

TEMPERATURE 574.69 DEG C

EFFLUENT FLOW	29263.40 NM3/H
EFFLUENT TEMP	1260.88 DEG C

HEATING VALUE

REGENERATIVE TOWER

SENSIBLE	241.08 KCAL/NM3
LATENT	26.79 KCAL/NM3
CHEM + PART	2105.48 KCAL/NM3

EFFICIENCY 80%

TOTAL 2373.34 KCAL/NM3

GAS FLOW	1830.02 NM3/H
GAS TEMP IN	1150.00 DEG C
GAS TEMP OUT	238.30 DEG C

WASTE HEAT BOILER

HOT BLAST FLOW	1994.90 NM3/H
BLAST TEMP IN	37.00 DEG C
BLAST TEMP OUT	1038.00 DEG C

EFFICIENCY 98 %

BLEND AIR 218.48 NM3/H

GAS FLOW	27433.38 NM3/H
GAS TEMP IN	1260.68 DEG C
GAS TEMP OUT	290.00 DEG C

GAS CLEANING EQUIPMENT

ENERGY RECOVERY

ENERGY	12356517.50 KCAL/H
STEAM	16220.16 KG/H
KG STEAM/KG REFUSE	4.58

GAS FLOW	29481.88 NM3/H
PARTICULATE	95.50 KG/H
GAS TEMP IN	286.41 DEG C
GAS TEMP OUT	280.68 DEG C

OVERALL SYSTEM EFFICIENCY 72.81 %

CLIENT : UN OF MINN

RATE : 85, TONS/DAY

REFUSE : LHV = 3751, KCAL/KG, HHV = 4142, KCAL/KG

HEAT AND MASS BALANCE

=====

		IN		OUT	
		KG/H	KCAL/H	KG/H	KCAL/H
GASIFIER					
REFUSE	3542.	13284792.	OFFGAS	5957.	13438374.
HOT BLAST	2579.	692824.	SLAG	189.	62340.
FUEL OIL	25.	250000.	HEAT LOSS		726901.
TOTAL	6146.	14227615.	TOTAL	6146.	14227615.
SECONDARY COMBUSTION CHAMBER					
OFFGAS	5957.	13438374.	WASTE GAS	37916.	13573463.
TOTAL AIR	31951.	0.	SLAG	21.	6953.
FUEL OIL	29.	300000.	HEAT LOSS		157938.
TOTAL	37937.	13738374.	TOTAL	37937.	13738374.
WASTE HEAT BOILER					
WASTE GAS	35545.	12724648.	WASTE GAS	35545.	2397436.
FEED WATER	16220.	2283798.	STEAM	16220.	12356518.
			HEAT LOSS		254493.
TOTAL	51765.	15008446.	TOTAL	51765.	15008446.
REGENERATIVE TOWERS					
WASTE GAS	2671.	848835.	WASTE GAS	2654.	144302.
COLD BLAST	2579.	13755.	HOT BLAST	2579.	692824.
BLEND AIR	282.		HEAT LOSS		25465.
TOTAL	5233.	862591.	TOTAL	5233.	862591.
GAS CLEANING SYSTEM					
WASTE GAS	38196.	2541738.	WASTE GAS	38103.	2490903.
			PARTICULATE	95.	
			HEAT LOSS		50835.
TOTAL	38196.	2541738.	TOTAL	38198.	2541738.

CLIENT : UN OF MINN

RATE : 85. TONS/DAY

REFUSE : LHV = 3751. KCAL/KG, HHV = 4142. KCAL/KG

ASSUMPTIONS :

1) SUPPLEMENTAL FUEL TYPE IS FUEL OIL.

2) SUPPLEMENTAL FUEL DATA :

COMPOSITION : 82.20 % CARBON

(BY WEIGHT) 12.50 % HYDROGEN

0.30 % ASH

0. % WATER

SPECIFIC GRAVITY : 0.865 (WATER = 1.0)

LOWER HEATING VALUE : 10196. KCAL/KG

3) BOILER DATA :

STEAM PRESSURE : 34.0 ATMOSPHERES

STEAM TEMPERATURE : 385.0 DEGREES CELCIUS

STEAM ENTHALPY : 761.8 KCAL/KG

FEEDWATER ENTHALPY : 140.8 KCAL/KG

NOTES :

1) AMBIENT TEMPERATURE IS 15.56 DEGREES CELCIUS.

2) AMBIENT PRESSURE IS 1.0 ATMOSPHERE (760 MM HG).

3) GASES AND SOLIDS HAVE ZERO ENTHALPY AT 15.56 DEGREES CELCIUS.

4) WATER AND WATER VAPOR HAVE ZERO ENTHALPY AT 15.56 DEGREES CELCIUS.

5) PROCESS AND COMBUSTION AIR IS DRY.

6) ONE NORMAL CUBIC METER OF GAS IS AT 0.0 DEGREES CELCIUS AND 1.0 ATMOSPHERE.

7) ALL SUPPLEMENTAL FUEL IS COMBUSTED TO CARBON DIOXIDE AND WATER VAPOR WITH 100 % HEAT RELEASE.

8) ANCILLARY EQUIPMENT HEAT LOSSES ARE DETERMINED AS FOLLOWS :

$$LOSS = (1 - N) \times \text{HOT FLUID SENSIBLE HEAT IN}$$

WHERE -N- IS THE EQUIPMENT ASSUMED EFFICIENCY.

9) OVERALL SYSTEM EFFICIENCY IS DETERMINED AS FOLLOWS :

$$EFFICIENCY = \frac{(\text{STEAM HEAT OUT} - \text{FEEDWATER HEAT IN})}{(\text{REFUSE HEAT IN} + \text{TOTAL FUEL HEAT IN})}$$

WHERE REFUSE AND FUEL HEATS ARE DETERMINED FROM THEIR LOWER HEATING VALUES.

ANDCO-TORRAX SOLID WASTE DISPOSAL SYSTEM -V 8,7 N

DATE 09/16/77

CLIENT : UN OF MINN

RATE : 91, TONS/DAY

REFUSE : LHV = 3751, KCAL/KG, H+V = 4142, KCAL/KG

REFUSE ANALYSIS

PROXIMATE ANALYSIS

ULTIMATE ANALYSIS

% COMBUSTIBLES	86.82	% FIXED CARBON	7.92	% CARBON	42.75
% WATER	7.25	% VOLATILES	78.90	% HYDROGEN	6.65
% ASH-INERTS	5.93	% WATER	7.25	% OXYGEN	37.43
		% INERTS	5.93		

GASIFIER

SECONDARY COMBUSTION CHAMBER

HOT BLAST TEMP	1637.00 DEG C	SCC PROCESS AIR	26127.44 NM3/H
HOT BLAST AIR FLOW	2116.53 NM3/H	SCC EXCESS AIR	76, %
FUEL OIL TO TUYERES	0, L/T	FUEL OIL TO SCC	8.97 L/T
FUEL OIL TO SLAG TAP	7.48 L/T		
SLAG OUTPUT	225.01 KG/H		

EFFLUENT CONSTITUENTS
BY VOLUME

OFFGAS

% O2	7,6
% N2	72,1
% CO2	10,0
% H2O	10,4

FLOW 6110.70 NM3/H

TEMPERATURE 577.04 DEG C

EFFLUENT FLOW 31305.90 NM3/H
EFFLUENT TEMP 1260.74 DEG C

HEATING VALUE

REGENERATIVE TOWER

SENSIBLE	242.17 KCAL/NM3
LATENT	26.71 KCAL/NM3
CHEM + PAR	2112.51 KCAL/NM3

EFFICIENCY 80%

TOTAL 2381.38 KCAL/NM3

GAS FLOW	1942.00 NM3/H
GAS TEMP IN	1150.00 DEG C
GAS TEMP OUT	238.27 DEG C

WASTE HEAT BOILER

HOT BLAST FLOW	2116.53 NM3/H
BLAST TEMP IN	37.00 DEG C
BLAST TEMP OUT	1038.00 DEG C

EFFICIENCY 98 %

BLEND AIR 231.52 NM3/H

GAS FLOW	29363.90 NM3/H
GAS TEMP IN	1260.74 DEG C
GAS TEMP OUT	290.00 DEG C

GAS CLEANING EQUIPMENT

ENERGY RECOVERY

ENERGY	1322492.13 KCAL/H
STEAM	17357.56 KG/H
KG STEAM/KG REFUSE	4.58

GAS FLOW	31537.42 NM3/H
PARTICULATE	102.15 KG/H
GAS TEMP IN	286.44 DEG C
GAS TEMP OUT	280.71 DEG C

OVERALL SYSTEM EFFICIENCY 72,97 %

CLIENT : UN OF MINN

RATE : 91, TONS/DAY

REFUSE : LHV = 3751, KCAL/KG, HHV = 4142, KCAL/KG

HEAT AND MASS BALANCE

=====

IN

OUT

KG/H KCAL/H

KG/H KCAL/H

GASIFIER

REFUSE	3792.	14222542.	OFFGAS	6350.	14388749.
HOT BLAST	2737.	735065.	SLAG	202.	66739.
FUEL OIL	25.	250000.	HEAT LOSS		752119.
TOTAL	6553.	15207607.	TOTAL	6553.	15207607.

SECONDARY COMBUSTION CHAMBER

OFFGAS	6350.	14388749.	WASTE GAS	40562.	14517890.
TOTAL AIR	34205.	0.	SLAG	23.	7442.
FUEL OIL	29.	300000.	HEAT LOSS		163417.
TOTAL	40584.	14688749.	TOTAL	40584.	14688749.

WASTE HEAT BOILER

WASTE GAS	38046.	13617301.	WASTE GAS	38046.	2565908.
FEED WATER	17358.	2443945.	STEAM	17358.	13222992.
			HEAT LOSS		272346.
TOTAL	55403.	16061246.	TOTAL	55403.	16061246.

REGENERATIVE TOWERS

WASTE GAS	2516.	900589.	WASTE GAS	2516.	153100.
COLD BLAST	2737.	14594.	HOT BLAST	2737.	735065.
BLEND AIR	299.		HEAT LOSS		27018.
TOTAL	5552.	915183.	TOTAL	5552.	915183.

GAS CLEANING SYSTEM

WASTE GAS	40861.	2719008.	WASTE GAS	40759.	2664628.
			PARTICULATE	102.	
			HEAT LOSS		54380.
TOTAL	40861.	2719008.	TOTAL	40861.	2719008.

CLIENT : UN OF MINN

RATE : 91. TONS/DA:

REFUSE : LHV = 3751. KCAL/KG, HHV = 4142. KCAL/KG

ASSUMPTIONS :

1) SUPPLEMENTAL FUEL TYPE IS FUEL OIL.

2) SUPPLEMENTAL FUEL DATA :

COMPOSITION : 87.20 % CARBON

(BY WEIGHT) 12.50 % HYDROGEN

0.30 % ASH

0. % WATER

SPECIFIC GRAVITY : 0.865 (WATER = 1.0)

LOWER HEATING VALUE : 10196. KCAL/KG

3) BOILER DATA :

STEAM PRESSURE : 34.0 ATMOSPHERES

STEAM TEMPERATURE : 325.0 DEGREES CELCIUS

STEAM ENTHALPY : 761.8 KCAL/KG

FEEDWATER ENTHALPY : 140.8 KCAL/KG

NOTES :

1) AMBIENT TEMPERATURE IS 15.56 DEGREES CELCIUS.

2) AMBIENT PRESSURE IS 1.0 ATMOSPHERE (760 MM HG).

3) GASES AND SOLIDS HAVE ZERO ENTHALPY AT 15.56 DEGREES CELCIUS.

4) WATER AND WATER VAPOR HAVE ZERO ENTHALPY AT 15.56 DEGREES CELCIUS.

5) PROCESS AND COMBUSTION AIR IS DRY.

6) ONE NORMAL CUBIC METER OF GAS IS AT 0.0 DEGREES CELCIUS AND 1.0 ATMOSPHERE.

7) ALL SUPPLEMENTAL FUEL IS COMBUSTED TO CARBON DIOXIDE AND WATER VAPOR WITH 100 % HEAT RELEASE.

8) ANCILLARY EQUIPMENT HEAT LOSSES ARE DETERMINED AS FOLLOWS :

$$LOSS = (1 - \eta) \cdot \text{HOT FLUID SENSIBLE HEAT IN}$$

WHERE η IS THE EQUIPMENT ASSUMED EFFICIENCY.

9) OVERALL SYSTEM EFFICIENCY IS DETERMINED AS FOLLOWS :

$$EFFICIENCY = \frac{(\text{STEAM HEAT OUT} - \text{FEEDWATER HEAT IN})}{\text{REFUSE HEAT IN} + \text{TOTAL FUEL HEAT IN}}$$

WHERE REFUSE AND FUEL HEATS ARE DETERMINED FROM THEIR LOWER HEATING VALUES.

CLIENT : UN OF MINN

RATE : 118, TONS/DA

REFUSE : LHV = 3751, KCAL/KG, HHV = 4142, KCAL/KG

REFUSE ANALYSIS		PROXIMATE ANALYSIS		ULTIMATE ANALYSIS	
% COMBUSTIBLES	86.82	% FIXED CARBON	7.92	% CARBON	42.75
% WATER	7.25	% VOLATILES	78.90	% HYDROGEN	6.65
% ASH-INERTS	5.93	% WATER	7.25	% OXYGEN	37.43
		% INERTS	5.93		

GASIFIER

SECONDARY COMBUSTION CHAMBER

HOT BLAST TEMP	1037.00 DEG C	SCC PROCESS AIR	33987.55 NM3/H
HOT BLAST AIR FLOW	2663.87 NM3/H	SCC EXCESS AIR	77. %
FUEL OIL TO TUYERES	0. L/T	FUEL OIL TO SCC	6.92 L/T
FUEL OIL TO SLAG TAP	5.77 L/T		
SLAG OUTPUT	291.72 KG/H		

EFFLUENT CONSTITUENTS
BY VOLUME

OFFGAS

% O2	7.7
% N2	72.1
% CO2	9.9
% H2O	10.3

FLOW 7838.01 NM3/H

TEMPERATURE 586.73 DEG C

EFFLUENT FLOW 40513.83 NM3/H
EFFLUENT TEMP 1260.52 DEG C

HEATING VALUE

REGENERATIVE TOWER

SENSIBLE 246.95 KCAL/NM3
LATENT 26.43 KCAL/NM3
CHEM + PART 2135.62 KCAL/NM3

EFFICIENCY 80%

TOTAL 2409.00 KCAL/NM3

GAS FLOW 2445.39 NM3/H
GAS TEMP IN 1150.00 DEG C
GAS TEMP OUT 238.24 DEG C

WASTE HEAT BOILER

HOT BLAST FLOW 2663.87 NM3/H
BLAST TEMP IN 37.00 DEG C
BLAST TEMP OUT 1038.00 DEG C

EFFICIENCY 98 %

BLEND AIR 290.83 NM3/H

GAS FLOW 38060.44 NM3/H
GAS TEMP IN 1260.52 DEG C
GAS TEMP OUT 290.00 DEG C

GAS CLEANING EQUIPMENT

ENERGY RECOVERY

ENERGY 17133820.00 KCAL/H
STEAM 22491.23 KG/H
KG STEAM/KG REFUSE 4.57GAS FLOW 40804.66 NM3/H
PARTICULATE 132.17 KG/H
GAS TEMP IN 286.53 DEG C
GAS TEMP OUT 280.80 DEG C

OVERALL SYSTEM EFFICIENCY 73.54 %

CLIENT ; UN OF MINN

RATE ; 118. TONS/DAY

REFUSE ; LHV = 3751. KCAL/KG, HHV = 4142. KCAL/KG

HEAT AND MASS BALANCE

=====

IN		OUT	
KG/H	KCAL/H	KG/H	KCAL/H
GASIFIER			
REFUSE	4917. 18442417.	OFFGAS	8123. 18674578.
HOT BLAST	3444. 925154.	SLAG	262. 86533.
FUEL OIL	25. 250000.	HEAT LOSS	856459.
TOTAL	8386. 19617571.	TOTAL	8386. 19617571.

SECONDARY COMBUSTION CHAMBER			
OFFGAS	8123. 18674578.	WASTE GAS	52491. 18778849.
TOTAL AIR	44368. 0.	SLAG	29. 9641.
FUEL OIL	29. 300000.	HEAT LOSS	186088.
TOTAL	52520. 16974578.	TOTAL	52520. 18974578.

WASTE HEAT BOILER			
WASTE GAS	49323. 17645367.	WASTE GAS	49323. 3325405.
FEED WATER	22491. 3166765.	STEAM	22491. 17133820.
		HEAT LOSS	352907.
TOTAL	71814. 20812132.	TOTAL	71814. 20812132.

REGENERATIVE TOWERS			
WASTE GAS	3168. 1133482.	WASTE GAS	3544. 192692.
COLD BLAST	3444. 18368.	HOT BLAST	3444. 925154.
BLEND AIR	376.	HEAT LOSS	34004.
TOTAL	6989. 1151850.	TOTAL	6989. 1151850.

GAS CLEANING SYSTEM			
WASTE GAS	52867. 3518097.	WASTE GAS	52735. 3447735.
		PARTICULATE	132.
		HEAT LOSS	70362.
TOTAL	52867. 3518097.	TOTAL	52867. 3518097.

CLIENT : UN OF MINN

RATE : 118, TONS/DAY

REFUSE : LHV = 3751, KCAL/KG, HHV = 4142, KCAL/KG

ASSUMPTIONS :

1) SUPPLEMENTAL FUEL TYPE IS FUEL OIL.

2) SUPPLEMENTAL FUEL DATA :

COMPOSITION : 87.20 % CARBON

(BY WEIGHT) 12.50 % HYDROGEN

0.30 % ASH

0. % WATER

SPECIFIC GRAVITY : 0.865 (WATER = 1.0)

LOWER HEATING VALUE : 10196, KCAL/KG

3) BOILER DATA :

STEAM PRESSURE : 34.0 ATMOSPHERES

STEAM TEMPERATURE : 385.0 DEGREES CELCIUS

STEAM ENTHALPY : 761.8 KCAL/KG

FEEDWATER ENTHALPY : 140.8 KCAL/KG

NOTES :

1) AMBIENT TEMPERATURE IS 15.56 DEGREES CELCIUS.

2) AMBIENT PRESSURE IS 1.0 ATMOSPHERE (760 MM HG).

3) GASES AND SOLIDS HAVE ZERO ENTHALPY AT 15.56 DEGREES CELCIUS.

4) WATER AND WATER VAPOR HAVE ZERO ENTHALPY AT 15.56 DEGREES CELCIUS.

5) PROCESS AND COMBUSTION AIR IS DRY.

6) ONE NORMAL CUBIC METER OF GAS IS AT 0.0 DEGREES CELCIUS AND 1.0 ATMOSPHERE.

7) ALL SUPPLEMENTAL FUEL IS COMBUSTED TO CARBON DIOXIDE AND WATER VAPOR WITH 100 % HEAT RELEASE.

8) ANCILLARY EQUIPMENT HEAT LOSSES ARE DETERMINED AS FOLLOWS :

$$\text{LOSS} = (1 - N) \times \text{HOT FLUID SENSIBLE HEAT IN}$$

WHERE -N- IS THE EQUIPMENT ASSUMED EFFICIENCY.

9) OVERALL SYSTEM EFFICIENCY IS DETERMINED AS FOLLOWS :

$$\text{EFFICIENCY} = \frac{(\text{STEAM HEAT OUT} - \text{FEEDWATER HEAT IN})}{(\text{REFUSE HEAT IN} + \text{TOTAL FUEL HEAT IN})}$$

WHERE REFUSE AND FUEL HEATS ARE DETERMINED FROM THEIR LOWER HEATING VALUES.

Vol. 1
9/ CLIENT : UN OF MINN
RATE : 85. TONS/DAY
REFUSE : LHV = 3513. KCAL/KG, HHV = 3885. KCAL/KG

REFUSE ANALYSIS

PROXIMATE ANALYSIS

ULTIMATE ANALYSIS

% COMBUSTIBLES	77.21	% FIXED CARBON	7.29	% CARBON	39.61
% WATER	12.46	% VOLATILES	69.92	% HYDROGEN	5.70
% ASH-INERTS	10.33	% WATER	12.46	% OXYGEN	31.90
		% INERTS	10.33		

GASIFIER

SECONDARY COMBUSTION CHAMBER

HOT BLAST TEMP	1037.00 DEG C	SCC PROCESS AIR	22588.24 NM3/H
HOT BLAST AIR FLOW	1877.93 NM3/H	SCC EXCESS AIR	77. %
FUEL OIL TO TUYERES	0. L/T	FUEL OIL TO SCC	9.60 L/T
FUEL OIL TO SLAG TAP	8.00 L/T		
SLAG OUTPUT	366.02 KG/H		

EFFLUENT CONSTITUENTS
BY VOLUME

OFFGAS

% O2	7.6
% N2	71.9
% CO2	9.9
% H2O	10.6

FLOW 5519.31 NM3/H

TEMPERATURE 492.26 DEG C

EFFLUENT FLOW	27253.91 NM3/H
EFFLUENT TEMP	1260.18 DEG C

HEATING VALUE

REGENERATIVE TOWER

SENSIBLE	203.25 KCAL/NM3
LATENT	45.83 KCAL/NM3
CHEM + PART	2063.09 KCAL/NM3

EFFICIENCY 80%

TOTAL 2312.17 KCAL/NM3

GAS FLOW	1723.11 NM3/H
GAS TEMP IN	1150.00 DEG C
GAS TEMP OUT	238.02 DEG C

WASTE HEAT BOILER

HOT BLAST FLOW	1877.93 NM3/H
BLAST TEMP IN	37.00 DEG C
BLAST TEMP OUT	1038.00 DEG C

EFFICIENCY 98 %

BLEND AIR 204.71 NM3/H

GAS FLOW	25530.79 NM3/H
GAS TEMP IN	1260.18 DEG C
GAS TEMP OUT	290.00 DEG C

GAS CLEANING EQUIPMENT

ENERGY RECOVERY

ENERGY	11495535.25 KCAL/H	GAS FLOW	27458.62 NM3/H
STEAM	15067.34 KG/H	PARTICULATE	88.88 KG/H
KG STEAM/KG REFUSE	4.26	GAS TEMP IN	286.35 DEG C
		GAS TEMP OUT	280.62 DEG C

OVERALL SYSTEM EFFICIENCY 72.12 %

CLIENT : UN OF MINN

RATE : 85, TONS/DAY

REFUSE : LHV = 3513, KCAL/KG, HHV = 3885, KCAL/KG

HEAT AND MASS BALANCE

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IN		OUT	
KG/H	KCAL/H	KG/H	KCAL/H

GASIFIER

REFUSE	3542.	12441875.	OFFGAS	5665.	12508598
HOT BLAST	2428.	652201.	SLAG	329.	108578
FUEL OIL	25.	250000.	HEAT LOSS		726901
TOTAL	5994.	13344076.	TOTAL	5994.	13344076

SECONDARY COMBUSTION CHAMBER

OFFGAS	5665.	12508598.	WASTE GAS	35286.	12638569.
TOTAL AIR	29628.	0.	SLAG	37.	12091.
FUEL OIL	29.	300000.	HEAT LOSS		157938.
TOTAL	35323.	12808598.	TOTAL	35323.	12808598.

WASTE HEAT BOILER

WASTE GAS	33055.	11839504.	WASTE GAS	33055.	2233475.
FEED WATER	15087.	2124297.	STEAM	15087.	11493535.
			HEAT LOSS		236790.
TOTAL	48142.	13963801.	TOTAL	48142.	13963801.

REGENERATIVE TOWERS

WASTE GAS	2231.	799066.	WASTE GAS	2496.	135841.
COLD BLAST	2428.	12949.	HOT BLAST	2428.	652201.
BLEND AIR	265.		HEAT LOSS		23972.
TOTAL	4924.	812015.	TOTAL	4924.	812015.

GAS CLEANING SYSTEM

WASTE GAS	35551.	2369317.	WASTE GAS	35462.	2321930.
			PARTICULATE	89.	
			HEAT LOSS		4738.
TOTAL	35551.	2369317.	TOTAL	35551.	2369317.

CLIENT : UN OF MINN

RATE : 85, TONS/DAI

REFUSE : LHV = 3513, KCAL/KG, HHV = 3885, KCAL/KG

ASSUMPTIONS :

1) SUPPLEMENTAL FUEL TYPE IS FUEL OIL.

2) SUPPLEMENTAL FUEL DATA :

COMPOSITION : 87,20 % CARBON

(BY WEIGHT) 12,50 % HYDROGEN

0,30 % ASH

0, % WATER

SPECIFIC GRAVITY : 0.865 (WATER = 1,0)

LOWER HEATING VALUE : 10196, KCAL/KG

3) BOILER DATA :

STEAM PRESSURE : 34.0 ATMOSPHERES

STEAM TEMPERATURE : 385.0 DEGREES CELCIUS

STEAM ENTHALPY : 761.8 KCAL/KG

FEEDWATER ENTHALPY : 140.8 KCAL/KG

NOTES :

1) AMBIENT TEMPERATURE IS 15,56 DEGREES CELCIUS.

2) AMBIENT PRESSURE IS 1.0 ATMOSPHERE (760 MM HG).

3) GASES AND SOLIDS HAVE ZERO ENTHALPY AT 15.56 DEGREES CELCIUS.

4) WATER AND WATER VAPOR HAVE ZERO ENTHALPY AT 15,56 DEGREES CELCIUS.

5) PROCESS AND COMBUSTION AIR IS DRY.

6) ONE NORMAL CUBIC METER OF GAS IS AT 0.0 DEGREES CELCIUS AND 1.0 ATMOSPHERE.

7) ALL SUPPLEMENTAL FUEL IS COMBUSTED TO CARBON DIOXIDE AND WATER VAPOR WITH 100 % HEAT RELEASE.

8) ANCILLARY EQUIPMENT HEAT LOSSES ARE DETERMINED AS FOLLOWS :

$$LOSS = (1 - N) \times \text{HOT FLUID SENSIBLE HEAT IN}$$

WHERE -N- IS THE EQUIPMENT ASSUMED EFFICIENCY.

9) OVERALL SYSTEM EFFICIENCY IS DETERMINED AS FOLLOWS :

$$EFFICIENCY = \frac{(\text{STEAM HEAT OUT} - \text{FEEDWATER HEAT IN})}{(\text{REFUSE HEAT IN} + \text{TOTAL FUEL HEAT IN})}$$

WHERE REFUSE AND FUEL HEATS ARE DETERMINED FROM THEIR LOWER HEATING VALUES.