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TECHNICAL NOTE

TITLE: PHASE II OF THE WASTE ASSESSMENT METHOD FOR NAVY SHORE ACTIVITIES: PROPOSED SURVEY METHOD

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METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (weight)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2,000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

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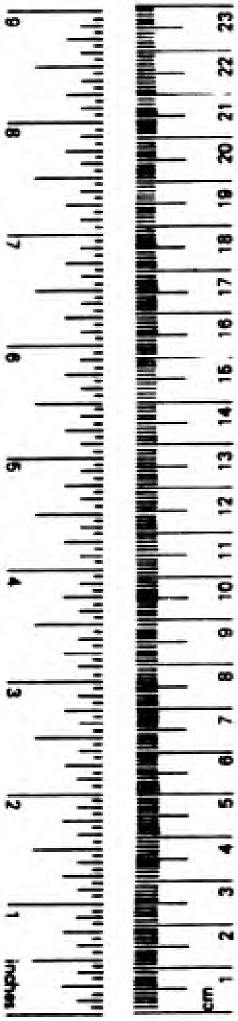
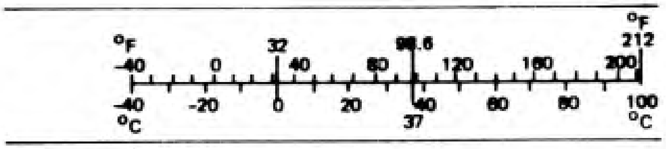
*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (weight)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1,000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (exact)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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This report presents a statistical procedure for determining solid waste characteristics at a Navy activity. The procedure is designed to provide statistically valid data for the design of waste-to-energy facilities. Details are given on how to design a study, how to perform the procedure, and how to analyze the data to obtain valid results in a cost-effective manner.

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This report presents a statistical procedure for determining solid waste characteristics at a Navy activity. The procedure is designed to provide statistically valid data for the design of waste-to-energy facilities. Details are given on how to design a study, how to perform the procedure, and how to analyze the data to obtain valid results in a cost-effective manner.

EXECUTIVE SUMMARY

This report provides details on a waste assessment method for obtaining data on the characteristics and degree of availability of the solid waste generated at a Navy activity. The data will be used in the design of a waste-to-energy facility, such as a heat recovery incinerator (HRI) or a resource recovery facility. The assessment method is conducted on 25 to 30 randomly chosen days over a 1-year period. The use of standard statistical techniques adds validity to the evaluation methodology and ensures that the results can be used with confidence in a waste-to-energy facility design. Statistical data on quantity, composition, and fuel characteristics are generated through the waste assessment method and are expressed in terms of the mean, standard deviation, and the variance of these parameters.

The proposed survey methodology involves three steps:

1. Determine the number of samples required to achieve a specified level of data validity.

2. Develop a sampling schedule, and then use the three sampling techniques to collect data for the statistical analysis.

3. Use the statistical analysis procedure to characterize the Navy activity wastes based on sample results.

The first step, the statistical design of the survey, is discussed in the Technical Results section on sampling survey design (Selection of Number of Samples). Equations for the statistical analyses of the waste quantity mean, standard deviation, and variation confirm the statistical validity of the data and verify the selected sample size.

The techniques discussed in the Technical Results section on waste assessment procedures are used in the second step, which involves data collection. The procedures that can be applied to each sample to quantify and characterize the waste, including fuel characteristics, are detailed. Once the sampling plan has been exercised, the wastes can be analyzed in step three according to the procedures outlined in the Technical Results section on waste assessment analysis procedures.

CONTENTS

INTRODUCTION

The Naval Facilities Engineering Command (NAVFAC) has tasked the Naval Civil Engineering Laboratory (NCEL) to develop alternative methods for determining the quantity and composition of solid wastes at Navy shore activities. Present Navy methods of waste characterization, such as the R^4 method, do not provide adequate data for the design of waste-to-energy facilities. The present methods are conducted over short periods of time, and are too limited in both scope and reliability to support the system design for an energy recovery facility. To correct this problem, NCEL has developed a specific data collection and analysis procedure that provides the degree of data reliability required. The analysis phase includes a computer model that is used as a screening process for predicting which Navy activities are potential candidates for heat recovery incinerator (HRI) sites. The second phase is a detailed waste assessment plan that provides statistically valid data on waste generation rates, composition, and fuel characteristics at a candidate activity for the design of a waste-to-energy system. This document presents details on the second phase of the assessment method.

BACKGROUND

Previous experience both in the government and the private sector has shown that lack of sufficient knowledge of the solid waste generated at an activity often results in an inadequate design of a waste-to-energy facility. Inadequate designs result in facilities that fail to meet expectations, both operationally (rated capacities) and economically (cost savings). Therefore, information concerning the physical composition and quantity of solid wastes is essential in selecting and operating waste-to-energy equipment and facilities, in assessing the feasibility of energy recovery, and in analyzing and designing disposal facilities. Because waste characteristics are an important part of waste-to-energy facility design, many solid waste characterization studies have been developed (Ref 1, 2, and 3).

Most of the Navy sampling plans are structured around the results of municipal waste assessment programs (Ref 4). The problem with using a Navy plan based on municipal waste statistics is that Navy wastes are more variable than typical municipal wastes. This variability is an important parameter in calculating the number of samples needed to achieve valid design information. By using the lower estimates of municipal waste quantity and composition variances, the existing Navy surveys underestimate the number of samples required to achieve a valid result.

To demonstrate the difference in variability between municipal and Navy waste, sample results from a 1981 Navy study at the Naval Air Station (NAS), Jacksonville (Ref 5) were compared with the analyzed waste from the University of California at Berkeley resource recovery facility (Ref 3). The comparison was based on the coefficient of variation (CV) which is a measure of variability. A larger value of CV represents a larger variability. In Table 1 the average compositions by weight and the coefficients of variation for the two studies previously mentioned are compared. For the compositions by weight, an average absolute difference of only 4% was noted between the Navy and municipal wastes. However, the average coefficient of variation for the NAS Jacksonville wastes was 0.32, or 129% larger than the corresponding municipal waste coefficient. In this case, to achieve the same precision and confidence, the number of samples needed for an NAS Jacksonville characterization is 60% greater than the number of samples needed for a municipal waste study.

Recognizing the need for a dedicated Navy activity sampling plan, the Naval Energy and Environmental Support Activity (NEESA) developed a comprehensive program for the recovery and reuse of refuse resources (R^4). The "R^4 Decision Guide" (Ref 6) documents NEESA recommendations for sampling Navy activities and characterizing solid wastes. The recommended 2-week survey period provides information for obtaining crude estimates of waste composition, volume, and weight. However, waste quantity and quality vary continually because of changes in installation activity levels and seasonal changes. The R^4 survey results are only a synoptic view and, therefore, do not reflect the variable nature of the waste.

For this reason, NCEL has adopted an evaluation methodology that spans a 1-year period and can account for these changes in activity levels and seasonal variations. This methodology is part of a two-phase program that is being developed to identify Navy activities that could be economically justified as sites for waste-to-energy facilities. In the first phase, a computer program predicts the quantity of waste and steam demand of specific Navy activities to identify potential HRI sites. If, based on the computer prediction, an activity produces a minimum of 15 tons per day (tpd) of solid waste and has the continuous steam demand required to use the steam produced from this waste, the activity is arbitrarily selected as a potential site for an HRI. The computer program has been tested (Ref 7) and is expected to be completed in September 1984. In the second phase of the program, the proposed survey method is implemented at the prospective sites identified by Phase I. The proposed method is designed to develop the final data necessary to confirm the practical and economic feasibility of the site and to provide statistically valid design information for the facility. This report presents the details of the proposed Phase II method.

TECHNICAL APPROACH

The overall objective of the waste assessment method is to provide valid data for the design of an energy recovery facility. The required data are the mean and variance measurements for the quantity, volume, density, moisture content, energy content, ash content, and composition parameters of the activity solid waste. The mean and variance raw data for these parameters are determined from a series of three procedures.

The procedures are the quantity and volume determination, the waste composition analysis, and the fuel characteristics determination. The procedures will be performed in a sequential order using the entire quantity of solid waste removed from the Naval activity in a day. The collected data will be organized on a set of seven datasheets for easier analysis and reference. Blank datasheets are given in Appendix A. After the three procedures are completed (Datasheets 1 to 5), a statistical analysis procedure will be used to calculate the final parameter results and variance (Datasheets 6 and 7).

Quantity and Volume Determination

The quantity and volume determination procedure will be used to measure the quantity, volume, and density of each truckload of waste which leaves the activity on a given sampling day. This information is organized on Datasheet 1. The final results of this determination will be used in sizing the waste-to-energy facility and specific equipment subsystems. A sample of waste from each truck will be stored for use in the waste composition analysis.

Waste Composition Analysis

The waste composition analysis consists of two procedures that will be used to measure the composition of each truckload of waste on the sampling day. The first procedure measures the composition of the waste, which consists of the 18 components listed in the Technical Discussion/Results section. This information is organized on Datasheet 1. The second procedure is a special waste characterization plan that collects data on the last five components listed in the Technical Discussion/Results section. These components are titled "special wastes" because the incineration of these wastes may create a problem. Early identification of these wastes is necessary so that any appropriate design features can be incorporated. This information is organized on Datasheet 2. The final results from this analysis will be used in the fuel characteristic determination, and in technical design of the processing, combustion, and ash removal subsystems. A sample of each of the 18 components will be stored for later use in the fuel characteristics determination.

Fuel Characteristics Determination

The fuel characteristics determination procedure will be used to calculate the average energy, ash, and moisture contents of activity solid waste for an entire day. These results will be based on an average daily waste composition determined from Datasheet 4, and will be organized on Datasheet 5. The moisture content of the waste will be measured by laboratory analysis of the 18 waste component samples stored during the waste composition analysis. The final results of this analysis will be used in the technical design of the processing, combustion, energy recovery, and ash removal subsystems.

Waste Parameter Statistical Analysis

A waste parameter statistical analysis procedure will be used to determine the number of samples required for statistically valid data, and the mean and variance data for each of the measured parameters. The statistical analysis will use the data contained in Datasheets 2, 4, and 5, and the results will be organized in Datasheets 6 and 7. This procedure will be used after the first ten sampling days and every third sampling day thereafter until the end of the survey. The final results from Datasheets 6 and 7 are the solid waste data needed for the waste-to-energy facility design.

TECHNICAL DISCUSSION/RESULTS

The proposed survey method will be presented in six sections dealing with the physical resources required; the sampling survey design; the three waste assessment procedures -- quantity, composition, and fuel; waste assessment analysis procedures; a datasheet summary; and the survey cost.

Physical Resources Required

The facilities, equipment, and manpower required for the parameter analysis are as follows:

Facilities.

- A well-lit, covered, and level concrete floor--100 by 80 feet
- A calibrated truck scale facility

Equipment.

- Two frontend loaders, one with a clamshell
- 50/100-foot steel tape
- Seventeen 20-gallon trash cans
- Calibrated platform scale, accurate to 200 pounds
- Tarpaulin or plastic sheeting
- Knife, wire cutters, pliers
- Plastic bags, large--150/day
- Screen box (see section on Waste Composition Analysis)
- Safety gear for each crew member
  - Gloves (nonslip, puncture proof)
  - Face masks (model for dust and fine particles, disposable)
  - Eye shields
  - Hats
  - Disposable aprons (paper or plastic)
  - Rubber boots
- First aid kit
- Two shovels, two pitchforks, two rakes, and one broom
- Datasheets

Manpower.

- Five floor men (general labor)
- Two frontend loader operators
- One supervisor

Sampling Survey Design

Selection of Number of Samples. The first step of the survey is to select the number of samples needed to obtain valid results. Previous studies have shown that the estimated minimum needed to ensure that statistically valid results are obtained is 30 samples. Therefore, each survey starts with the assumption that 30 sampling days are needed (Ref 2). However, this number is checked using solid waste weight data after the first 10 samples are completed and every 3 samples thereafter to determine if more or less samples are needed. This allows time to modify the sampling plan accordingly and helps minimize costs. If there is time remaining in the study after the required number of samples has been taken, the sampling program continues at the rate of two previously scheduled sample days per month to collect variance data.

The check on the number of sampling days is performed in two parts. The first part determines the number of samples required; the second part checks the validity of the data. Part 1 of the check determines the number of samples by using (1) Equation B-11 of Appendix B, (2) Table B-1, (3) the mean and standard deviation of the previous samples, (4) the desired precision (maximum of 10%), and (5) the desired confidence in the result (90% minimum). The sample mean ($\bar{X}$) is an estimate of the actual mean (μ). The probability that μ will fall within the boundaries of an interval equal to $\bar{X} \pm h$ is expressed as the confidence. The value h (half-width of the interval) is an indicator of the precision of the interval. The half-width is equal to the precision/100 multiplied by $\bar{X}$. When tighter precisions (<10% of the mean) and higher confidences (>90%) are required, the number of samples needed and the corresponding sampling costs increase. However, the sampling results are improved. Recommended ranges in confidence and precision are 90 to 99% and 1 to 10%, respectively.

Part 1 of the check can be demonstrated as follows. Based on having completed the first 10 samples in the study, a hypothetical activity has a calculated sample mean ($\bar{X}$) of 50 tpd and a standard deviation (S) of 15 tpd. Using a precision of 10% and a confidence of 90%, the new total number of samples required can be determined by using Equation B-11 in Appendix B as follows:

Precision = 10% (chosen)

Confidence = 90% (chosen)

$\bar{X}$ = 50 tpd

S = 15 tpd

$$h = \frac{\text{Precision}}{100} \times \bar{X} = \frac{10}{100} \times 50 \text{ tpd} = 5 \text{ tpd}$$

$$\alpha = 1 - \frac{\alpha}{100} = 1 - \frac{10\%}{100} = 0.90 \times 100 = 90\%$$

$Z(1-\alpha/2)$ = value from Table B-1 at 90% confidence = 1.645

n, number of samples =

$$\frac{[Z(1-\alpha/2)]^2 \cdot S^2}{h^2} = \frac{(1.645)^2 \cdot 15^2}{5^2} = 24.4 \text{ or } 25$$

The new total of samples is 25, which is a 5-sample reduction from the planned 30 samples. If the validity analysis (see Technical Discussion/Results section) is confirmed, the reduction in total samples from 30 to 25 can be used.

Any change in the number of samples is dependent on the standard deviation from the samples previously taken (see example). Also, the difference between the sample standard deviation (S) and the true standard deviation (σ) generally decreases as the number of samples collected increases. Therefore, even though the initial check may indicate a large increase in the number of samples required, future checks may reduce the number as S approaches σ. An additional benefit of the check at 10 samples is that if more than 30 samples are required, the extras can be randomly distributed more easily over the remaining study time. Any reductions indicated by future checks are easily made by removing the already programmed extra days. In any case, the program should have an absolute minimum near 25 sampling days and a maximum near 40 sampling days.

Selection of Random Samples. In the preceding section on the Selection of the Number of Samples, sample sizes were developed for estimating solid waste quantities and composition to a specified precision and confidence. The selection of a sampling day should be random; otherwise, a nonrepresentative selection of samples may result. For example, if the samples are taken only on Monday, the sample mean would yield a higher value than is actually experienced because the quantity of waste collected on Mondays includes the weekend waste. By not sampling the waste generated Tuesday through Friday, the sampling results would not reflect the typical waste generation characteristics.

It is also important that the sampling plan reflect the solid waste characteristics over an extended period of time. If samples are taken every day until the sample size requirement is met, the results will reflect the waste characteristics only for this brief historical period. A 1-year plan that captures the seasonal variations is necessary.

Accounting for these considerations, the random sampling plan should:

(1) Ensure a random sampling of the different days of the week.

(2) Represent seasonal variations over a 1-year period.

Table 2 was developed using a random number generator. This table consists of 250 randomly generated three-digit numbers up to 366. Table 2 can be used to randomly select the days on which samples will be taken. First, the possible sampling days must be identified based on the Julian calendar, which numbers days from the beginning of the year. The number of samples (n) that satisfies confidence and precision restrictions is then determined using the techniques discussed in the section on Selection of Number of Samples. From Table 2, the first n random numbers that represent sampling days are chosen. Numbers may be chosen by row or column. If a random number does not correspond to a working day, or has already been chosen, it is ignored and the next number on the list is selected in its place.

Waste Assessment Procedures

Quantity and Volume Determination.

The quantity of solid waste generated at a Navy activity is measured in terms of average tons generated per day (tpd). This parameter is important to HRI design because the quantity of waste is used to size equipment and facilities, to develop operational procedures, and to assess the economic feasibility of the HRI. The resultant value for waste quantity determined by this method is an average annual value; at any point in time, the actual value will vary from this average depending on the season and level of operation at the activity. This variance is estimated by the survey method so that design changes can be made to ensure effective operation under the varying conditions.

The volume of solid waste is measured in cubic yards per day (yd^3/day). This parameter is used to size tipping floors, storage facilities, and waste feed equipment and to determine the density (lb/yd^3) of the waste. The values for volume must also be examined to account for variance, as described for waste quantity.

The objective of the test procedure is to measure accurately the volume and weight of each truckload of refuse leaving the Navy activity on any given day. These individual truck waste volumes and weights are then totaled to determine the quantity of waste generated on that day. The waste characterization period lasts for about 8 hours, during which time the collection trucks bring the solid waste from various sectors on the Navy activity to the test site. The test plan is designed to evaluate a maximum of 10 truckloads (6 to 8 tons/truck) of refuse. If the solid waste load is occasionally greater than 10 truckloads, crew members will be required to work overtime. If the waste load is frequently higher than 10 truckloads, then two crews, two waste assessment facilities, and two sets of equipment will be required.

The Navy uses two types of waste disposal trucks: tilt frame trucks for large containers (30 to 40 yd^3) and packer trucks for small containers (<10 yd^3). Tilt frame truckloads of waste are easy to sample, as the container is large and open on the top for easy reloading by the frontend loaders. The packer trucks are more difficult to sample because they cannot be easily reloaded. The first reloading option for the packer trucks could be to reload the waste into a large open-top container and use an extra tilt frame truck to remove the waste from the site. Another option would be to load small containers with waste and have the packer truck reload the waste. The first option is preferred since it requires much less time than the second option.

The truck routes should be clearly marked on an activity map. If a large number of small containers are collected, each load of waste should be identified by the packer truck route number. In the case where large roll-off containers are collected, the building number, corresponding to the location of the container, should be used for identification. If the waste along the route is collected more than once a day, the route number should indicate this. This information is used to identify areas with large quantities of special wastes or noncombustibles. These areas may require separate waste collection procedures so that the poor quality waste from these areas is not included with the rest of the higher quality activity waste.

The work area is divided into five sections. The middle section (20 feet wide) is used as the composition sampling area (Figure 1). The two outermost sections (20 feet wide each) are used to store the emptied waste containers before and during the reloading process. The two remaining 20-foot sections are used for dumping the waste from the containers to obtain volume data and a composition sample.

Once the test site, equipment, and crew are assembled, the test procedure outlined below is followed.

(1-1) Truck drivers carrying Navy activity solid waste weigh the truck at a calibrated weigh station.

(1-2) Truck drivers unload the refuse onto the specified spot of the cement floor.

(1-3) After the refuse is unloaded, the driver weighs the empty truck at the weigh station and then returns to the waste characterization site.

(1-4) The weigh station clerk notes the following data:

- Date and time of day
- Fill weight of the truck
- Empty weight of the truck
- Sector of the Navy activity where the waste was picked up (building or route number)

(1-5) The frontend loader operators and the floor men level the dumped refuse within the assigned enclosure to a uniform height, width, and length.

(1-6) The length, width, and height of the pile are determined using a tape measure. Height measurements should be taken at four or more locations and an average height computed. The accuracy of the volume measurements depends upon the care taken when building the rectangular refuse pile. It is very important that the length, width, and height are fairly uniform.

(1-7) The supervisor notes the following on Datasheet 1:

- Date
- Sample number
- Volumetric measurements (length, width, and height)
- Sector of the Navy activity where the waste was picked up (route number)

(1-8) After the measurements are recorded, a clamshell and the floor men obtain a 300-pound random sample for the composition study. Numerous researchers have reported that a 300-pound sample per truckload is optimal for determining waste composition (Ref 1, 8, 9, 10, and 11). To select a random 300-pound sample, the field supervisor schematically represents the spreadout waste on paper with a numbered grid. The supervisor then selects grid numbers at random. The grid squares corresponding to the selected random numbers are transposed to the waste, thus identifying the approximate sample locations. A clamshell and the floor men extract all the sample in the selected locations until about 300 pounds of waste has been collected.

(1-9) Once the sample has been extracted, the frontend loaders reload the waste back into the container for disposal.

Although the random sampling procedure may seem to entail a great deal of work, it is necessary to minimize crew judgment in sample selection. Work crews may select solid waste samples consisting of components that are easy to sort and not objectionable to handle. The random selection method will result in an unbiased sample.

Waste Composition Analysis. Composition components by weight are measured in percentage as the total component weight divided by the total weight generated multiplied by 100. The components are divided into two categories: regular wastes and special wastes. There are 13 regular waste components and 5 special waste components:

1. Paper
2. Cardboard
3. Plastic/rubber
4. Textile/leather
5. Wood
6. Yard wastes
7. Food wastes
8. Ferrous metals
9. Aluminum
10. Other nonferrous metals
11. Inerts
12. Fines and sweepings
13. Glass

14. Special waste--combustible--bulky
15. Special waste--combustible--nonbulky
16. Special waste--noncombustible--bulky
17. Special waste--noncombustible--nonbulky
18. Special waste--restricted

The solid waste composition sampling procedure involves the physical identification of the major components of the samples by hand sorting the "as received" refuse into the components listed above. The sorted wastes are then weighed and the component percentages determined. During the sorting period, the supervisor should ensure that the sorting is accurate and properly done.

To prepare for the solid waste composition sampling procedure, the following steps should be completed.

(2-1) The activity environmental engineer should select a well-lit, covered area close to the concrete floor used in the volume characterization study. The selected location should be away from direct draft through open doors. An area of at least 500 ft^2 (25 feet long by 20 feet wide) is recommended. If an outdoor location is selected, protection from wind and weather should be included (e.g., fences to control litter, temporary roofing or shelter).

(2-2) The activity Public Works officer should contract for or select a team consisting of five crew members and a supervisor. Navy personnel can be used or the working crew can be hired through local temporary help organizations.

(2-3) The field supervisor and activity environmental engineer and safety officer should instruct the working crew on the importance of health and safety in the refuse sorting work. Insist on the use of personal safety equipment during the waste sorting work.

(2-4) The field suprvisor should explain the methods used to identify and correctly classify the waste.

(2-5) The field supervisor should procure the equipment listed in the Physical Resources Required section.

(2-6) The crew should line each can with a plastic bag for step 2-13.

(2-7) The weigher should record the tare weight of each can with a plastic bag.

(2-8) The crew should paint or label each can with the name of the specific classification of refuse that will be deposited in the can during the characterization program. Also label the can with its tare weight.

Paper

Example:

Tare weight - 7.2 lb

Provide two cans for the paper classification and one can for each of the other categories, except for the two bulky categories, for a total of 17 cans. The bulky items will have to be weighed without a can because of their size.

(2-9) The field supervisor should calibrate the platform scale as per manufacturer instructions.

(2-10) The crew should line the floor where the waste characterization program will be conducted with a tarpaulin or heavy-duty, construction-grade, plastic sheet.

(2-11) The crew should position cans and other equipment so that the cans and tarpaulin are easily accessible to the working crews. The platform scale should be located to permit unobstructed weighing and disposal of the wastes. A typical layout of the refuse characterization area is shown in Figure 1.

(2-12) The field supervisor should prepare the data collection sheets. Datasheet 1 (in Appendix A) is the recommended form.

(2-13) The field supervisor should assign four of the crew members as refuse sorters and one crew member as the weigher. The weigher weighs all filled cans and records the waste category, the tare weight of the can, and the total weight of the can. The weigher stores the special waste cans for additional analysis and saves the regular waste components in the individual plastic bags for moisture analysis. When the special waste analysis is complete, the weigher saves the special waste components in a plastic bag with the appropriate regular component.

(2-14) The crew should fabricate one 24- by 18-inch screen box (1-inch mesh) as shown in Figure 2. This box will be used to separate the fines and sweepings from the other wastes.

Once the equipment and sorting crew have been prepared, composition sampling can begin. General guidelines for the hand sorting of refuse are presented here.

(3-1) Spread the refuse sample (300 pounds) thinly over the tarpaulin- or plastic-covered floor by using the shovels and pitchforks.

(3-2) Break open all waste contained in plastic or paper bags and spill their contents over the refuse pile.

(3-3) Separate the wastes by component. Begin with the components of greatest abundance. For example, paper, cardboard, plastic, and wood will be quite visible and should be sorted first. As the major components are taken out, the minor components will be visible for easy sorting. If a component can is completely filled before the sorting is completed, perform steps 3-8 to 3-10, reuse the can for more components, and repeat steps 3-8 to 3-10.

(3-4) Put aside the special wastes for the special waste categorization. Store the two categories of bulky wastes in a corner of the characterization area.

(3-5) Place any waste material that is composed of more than one material into the category where the majority of its weight falls.

(3-6) Treat all brass, zinc, tin, lead, bronze, nickel, and copper materials as "other nonferrous metals." Similarly, treat stones, bricks, and concrete as "inerts."

(3-7) Classify the mixed, fine materials after the larger, distinguishable components of the refuse have been sorted. Use the 1-inch mesh screen shown in Figure 2 to sift out the "fines and sweepings." Categorize all materials that pass through the screen as "fines and sweepings." Sort the items trapped in the screen according to their proper classification. Place the screen over the can for fines and sweepings, then use the broom and shovel to collect the fine material and sort it through the screen.

(3-8) Weigh each can of refuse and note the category, tare weight, and total weight on Datasheet 1.

(3-9) Once the cans have been weighed, store, and set aside each plastic bag for later sampling for moisture content.

(3-10) Reline the cans with plastic bags for the next truckload of waste. Tare weights will remain the same because plastic bags are basically consistent in weight.

The data entry should be carefully and accurately done. The techniques used to summarize the daily composition data are explained on Datasheet 3.

Special Waste Characterization Plan. The special waste characterization procedure is an extension of the characterization program described in the previous section. The objectives of the special waste characterization plan are to determine:

- The percentage (weight) of the total Navy base waste that is special waste.

- The percentages (weight) of the special waste that are combustible and noncombustible, bulky and nonbulky, and restrictive.

- The regular waste component percentages of each of the special waste categories.

- The special handling and processing requirements so that the special waste can be removed or used.

To prepare for the special waste characterization, the testing crews should be instructed how to identify and sort the special wastes from the normal Navy refuse. The characteristics of special wastes should be explained to the crew. A waste is classified as a "special waste" if the collection, handling, containerization, storage, transportation, processing, or disposal of the substance requires careful consideration. Such special wastes may pose a fire, explosion, safety, or health hazard or they may be classified as an environmental pollutant. A representative list of combustible bulky and nonbulky Navy special wastes is included in Appendix C. These wastes may require some special handling and treatment before they can be incinerated. Appendix C also shows the typical Navy noncombustible bulky and nonbulky special wastes and restricted wastes. A bold-face typed copy of this list of possible special wastes should be displayed at the test site.

In sorting out the special wastes along with the total activity waste, it should be understood that all cardboard boxes are not special wastes. Only the bulky fraction of such waste is to be treated as a special waste. This is also true for paper, metals, and other categories. For example, a single copy of a newspaper or a magazine does not become a special waste. However, such wastes, when densely packed in a bundle with wire or rope, are problems. Similarly, a discarded engine block, auto fender, hot water heater, or a kitchen sink, because of their bulky nature, are special wastes.

Notes should be made on the types of special wastes to identify any special handling or processing equipment that will be needed to convert the waste to a usable fuel or to dispose of the waste properly. These notes should be made on Datasheet 2 in the space left for general remarks. The types of information needed are the specific type of special waste and the general dimensions of the material. This type of data should be collected from each truckload of waste. The data should be analyzed to determine any material that is consistently in the waste and what methods are needed to use or dispose of the waste. For example, when the waste stream contains a consistent amount of bulky wood and cardboard, some type of size reduction equipment (shredder, hammermill) or manual labor would be needed to use the waste as a fuel.

Certain wastes should not be burned in an incinerator due to the dangers involved. These wastes are defined as restricted wastes because they may cause hazardous effects, such as corrosion, explosion, or fire, or may act as a toxic agent when burned. For example, polyvinyl chloride (PVC) is not a hazardous material; however, when PVC is burned in large quantities (>2 yd^3) it can produce chlorine gas and hydrochloric acid, which are toxic and corrosive. The restricted wastes are listed in Appendix C.

The procedure for categorizing the special wastes is as follows.

(4-1) Separate the special wastes into five categories: combustibles--bulky and nonbulky; noncombustible--bulky and nonbulky; and restricted items.

(4-2) Provide three separate containers for the nonbulky and restricted items. Prominently mark the containers with the tare weight as shown:

(4-3) Store the bulky wastes in a corner of the hand sorting area.

(4-4) Weigh the three filled containers and the bulky wastes and record the results.

(4-5) Repeat steps 3-1 through 3-8 of the Waste Composition Analysis section for each category using Datasheet 2.

(4-6) Store the special waste components in the same plastic bag as the appropriate regular waste component when the second analysis is completed.

(4-7) Add the results to the components on Datasheet 1 to make a new summary on Datasheet 4. Use the information on this new datasheet in Datasheet 5 to determine accurate fuel characteristics.

Two special waste items in the combustible, nonbulky category--kerosene/petroleum products and paint/paint sludges--do not fit into the 13 normal waste categories on Datasheets 2 and 4. When these special wastes are encountered, the information should be noted in the General Remarks section on Datasheets 2 and 4. For Datasheet 5, the energy, moisture, and ash values of these items can be determined by laboratory analysis at the same time the other components are tested for moisture. The results can be added to the totals on Datasheet 5. It should be noted that if the weight of these items is less than 0.1% of the total day's weight, the impact of these items on the energy and ash values will be negligible and the laboratory analysis will not be required.

Any unidentified liquid, powder, or gel is automatically considered hazardous. Such wastes should be handled with caution. They should be isolated from the other wastes until specifically identified. If the material is hazardous or cannot be identified, the activity hazardous waste office should be notified. The waste can then be properly disposed of by the hazardous waste office. Any further reports, documentation or source identification can be handled by that office.

The special wastes may have health and safety risks. While hand sorting the special wastes, the following precautions and safety measures should be adopted:

(1) All personnel must use the following safety equipment:

- hand gloves
- face mask
- safety eye shield
- full-length, disposable apron
- rubber boots

(2) All pressurized containers must be handled with caution. Explosions can result if such containers are punctured.

(3) Any liquid, powder, or gel that spills on gloves, apron, or boots should be washed off immediately.

(4) All pathological debris, cotton, paper, gauze, cloth, bandages, etc. should be picked up by shovel and deposited into a separate plastic bag. Pathological and dispensary solid wastes may contain hypodermic syringes and infected needles. If such wastes are seen, close contact should be avoided.

(5) All explosive or flammable material should be handled with extreme care.

(6) At the conclusion of the waste characterization, all protective materials, such as gloves, masks, and eye shields, should be disposed of in the regular waste containers. If hazardous wastes were handled, disposal of protective gear should be conducted in accordance with activity regulations.

Fuel Characteristics Determination. There are three fuel characteristics--energy, ash, and moisture content. These parameters are measured in Btu/lb (dry and as received) for energy, percentage weight (dry and as received) for ash, and percentage weight for moisture. They are important in sizing the incinerator and boiler to process the energy input from the waste, in sizing the ash processing subsystem, and in controlling the temperature and combustion air to account for the moisture and energy input. These parameters are also used in the economic assessment of HRI potential.

To determine the moisture content at the end of the day, take the plastic bags containing the stored regular waste components from each 300-pound composition sample. Empty all the bags for one regular waste component onto the plastic sheeting and mix. Remove about a 10-pound sample of the component and seal in a plastic bag. Weigh the sample with the bag and write the weight on a tag and attach the tag to the sample bag. Repeat this procedure for the 13 components. Send the sample bags to a qualified laboratory for moisture analysis according to American Society for Testing Materials (ASTM) procedure E790-81 (Ref 12) for solid waste. Use the moisture data from the laboratory with Datasheet 5 and the values in Table 3 to determine the estimated energy (Btu/lb-dry) and ash content of the waste.

Waste Assessment Analysis Procedures

Validity Analysis. The validity analysis calculates statistical parameters for the weight, volume, density, each of the 18 waste components, and each of the 8 fuel characteristics. These statistical parameters are the sample mean ($\bar{X}$), standard deviation (S), coefficient of variation (CV), coefficient of skewness (a_3), a symmetry check, coefficient of kurtosis (a_4), a peakedness check, and confidence intervals for the 90, 95, and 99% levels. These parameters are defined in Appendix B as Equations B-1 through B-8. The validity analysis uses Datasheet 4 and Equations B-1 through B-7 in Appendix B to check the validity of the data by confirming the normality of the data. When the conditions in Equations B-5 and B-7 in Appendix B are met, the data have a normal distribution and the results are statistically valid. Therefore, any reduction in the number of samples indicated by the analysis in the Selection of Number of Samples section can be made. An example showing how to perform these analyses is included in Appendix D.

Once the required number of samples in the weight category has been collected, the sampling program can be reduced to two samples per month until the year is completed to collect variance information. In a typical 30-sample program, all of the data categories will have statistically valid data, and most of the data categories will have satisfied the minimum sample requirement. The categories that may not meet the minimum sample requirement are glass, yard waste, and restricted special waste (see Appendix D). These categories have small values (less than 1.0%), and even a large difference between the actual and the predicted values is small when compared to the more common waste components. For example, if the difference between the actual and the predicted value for one of these small categories is 20%, the predicted value will range from 0.8 to 1.2%. The ±0.2% difference is insignificant when compared to the 15% values for paper or cardboard. Therefore, the invalid nature of the small components has a negligible effect on the overall validity of the results.

Variance Procedures. Information on waste variance is obtained by conducting the study 25 to 30 times over a 1-year period. This variance is reported as a range of values. The statistical analysis predicts valid high and low values for the year and seasonally. The variance information is needed to design the size of the facility and to determine how the facility will operate.

The datasheets are examined for variance information. This information is important because the HRI can only use a long-term increase of 30% in the quantity of waste. This increase is equivalent to 1 extra day or a 15% increase in operational time on the weekend and a 15% increase (75 to 90% capacity) in incineration rates. Variance information is found by examining every Datasheet 6 and 7 and determining the average values and standard deviations for the parameters in question. The decision on whether the variance is excessive is based on the following criterion:

> With 95% confidence, 90% of the parameter values listed on Datasheets 6 and 7 must fall within 20% of their respective means.

Equation B-13 of Appendix B is used to perform the statistical test for excessive variance for each parameter from Datasheets 6 and 7. Equation B-13 is used to analyze the data from the four seasonal (3-month) and the full-year periods.

For any average value that fails the excessive variance test, special consideration should be given to plant design. For a larger average, a larger processing line or HRI or two smaller processing lines or HRIs may be needed to adjust to the changing generation rates. For minimums, a smaller facility with provisions for removing excess waste may be necessary. The best option will depend on economics (lost fuel value versus increased capital and operating costs) and the variation in generation rates.

Each Datasheet 1 should also be examined for areas on the activity that produce waste with greater than 60% noncombustibles (metals, glass, inerts, noncombustible special wastes). These areas are identified by examining each successive Datasheet 3. Any area that consistantly produces large quantities of noncombustibles should be examined for excessive noncombustible production. If the noncombustibles do not meet the criteria in Equation B-14 of Appendix B, special consideration should be given to providing other means of waste disposal for the containers in that area, special processing equipment, or manual sorting to use the waste. This will reduce operational problems at the HRI or resource recovery facility. The specific determination should be based on the loss of fuel if the waste is removed versus the cost of additional equipment and labor to process the waste to 20% noncombustibles.

Datasheet Summary

The waste assessment method uses seven datasheets to collect and analyze the data. These datasheets are in Appendix A. Each of the datasheets has a different function in the analysis as follows.

Datasheet 1 lists the quantity (pounds), volume (yd^3), density (lb/yd^3), and regular waste components for one truckload of waste. Datasheet 1 is filled out for each truckload of waste that is sampled on a given day and the location of where the waste was collected.

Datasheet 2 lists the results in weight and percentage from the special waste composition analysis conducted on the special waste components listed in Datasheet 1 (combustible, noncombustible, and restricted). Datasheet 2 is also filled out whenever a truckload of waste is sampled.

Datasheet 3 is a summary sheet of the component weight data from every Datasheet 1 filled out on a given sampling day. Datasheet 3 is analyzed by weighted averaging techniques to produce an average percentage by weight for each of the 18 waste components and the total quantity of waste collected on that day.

Datasheet 4 is a summary sheet that sums the "total wet component" weight data in the last column of Datasheet 3 and the summation of the "total actual weights" in the last column of each Datasheet 2 completed during the sampling day.

Datasheet 5 is completed using the total wet component weight in Datasheet 4, the energy and ash contents from Table 3, and the moisture content of the waste components determined by laboratory analysis. Datasheet 5 is used to determine the fuel characteristics of all the wastes that were sampled on a given day.

Datasheet 6 lists the statistical parameters for the weight, volume, and fuel characteristics of the activity. Datasheet 7 lists the statistical parameters for the 18 waste components. These worksheets are used to confirm the validity of the data, as well as to check the number of samples required to provide valid results and the variance of the results. Datasheets 6 and 7 are completed after 10 sampling days and are updated every 3 sampling days thereafter. The data analysis procedures are detailed by the formulas described in Appendix B. The statistical results will provide statistically valid values for the design of HRI facilities. The analysis procedures are also explained by the example in Appendix D.

Survey Cost

The facilities, equipment, and manpower required are listed in the Physical Resources Required section. The cost breakdowns for the waste survey method are shown in Table 4. In determining the estimates, the following assumptions were made:

- The waste characterization program is conducted by a private contractor.
- One crew can sort and measure up to 70 tpd of waste in an 8-hour day.
- The supervisor spends an initial 3 days at the job site preparing for the test program, instructing the laborers, and acquiring the needed materials for the test. The supervisor remains at the test site to supervise the sampling procedure.
- The laborers are hired from the local employment agency on a temporary basis, at an hourly rate of $7.50 per hour per person, including insurance and other fees.
- All data reduction and report writing are done by the supervisor.
- An hourly rate of $15 per hour is used for the supervisor.
- An appropriate concrete covered area is available as a solid waste characterization site at no charge.
- A contingency of 10% on total costs is estimated.
- A 20% cost for general and administrative expenses over direct cost items is charged.
- Overhead and profit is 1.6 times the labor cost.
- The equipment is rented daily.

By regressing total cost (C) of both the volume-weight and the composition sampling with the number of samples (n), the following expression can be derived:

$$C = 1{,}727 + 2{,}596.8n \text{ (for tpd } <70) \qquad (1)$$

When tpd > 70, an estimated $34.10 for each ton above 70 for each sample must be added to the total cost to compensate for the additional manpower needed, based on the workers being paid time-and-a-half for the overtime needed to complete the daily sampling. Thus, Equation 2 is derived:

$$C = 1{,}727 + 2{,}596.8n + 34.1(T-70)n \quad \text{(for tpd >70)} \qquad (2)$$

where T equals tpd of solid waste, and n equals the number of samples.

CONCLUSIONS

The sampling plan developed and described in this report can be used to characterize the volume, weight, composition, and fuel characteristics of Navy activity wastes. This assessment method will provide the best available data, from a statistical and engineering viewpoint, for the design of an HRI or resource recovery facility. The best available data are necessary to ensure the most efficient use of resources and to reduce the problem of inaccurate HRI design.

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Table 1. Percent by Weight Means ($\bar{X}$) and Coefficients of Variation (CV) for Solid Waste Composition Data

Component	Jacksonville		University of California	
	$\bar{X}$ (%)	CV	$\bar{X}$ (%)	CV
Paper and Cardboard	47.9	0.18	47.3	0.11
Metals	6.0	0.75	5.5	0.15
Plastics	11.1	0.60	5.8	0.22
Garbage, Yard Wastes	13.5	1.1	20.8	0.37
Wood	8.8	1.9	0.6	1.5
Glass	9.4	0.56	10.8	0.21
Textiles	3.0	1.0	2.0	1.0
Inerts	0.5	0.70	7.0	0.67

Table 2. Random Three-Digit Numbers

132	349	068	099	171	015	075	296	207	213
212	348	094	248	359	288	359	205	311	366
001	052	113	022	092	364	349	038	243	364
352	365	062	260	334	363	344	249	252	189
107	027	184	274	262	185	063	019	049	245
362	228	265	298	166	311	189	196	352	223
240	287	256	070	074	127	034	324	162	098
355	319	140	177	030	237	173	119	014	107
356	146	236	154	328	043	315	206	198	224
196	120	046	063	217	259	213	324	208	258
119	362	062	162	234	202	045	181	263	090
357	153	133	279	011	298	177	158	204	045
255	047	214	352	138	268	227	282	272	329
179	240	154	306	073	089	361	264	336	135
259	124	199	033	299	220	251	231	128	342
013	001	041	131	211	214	132	109	270	172
252	181	079	268	043	362	258	017	291	077
119	093	220	275	185	282	262	213	113	243
116	105	179	249	135	151	180	215	176	129
063	072	284	295	351	020	343	139	004	266
251	151	001	081	204	085	190	110	255	038
013	361	134	022	145	203	110	305	333	314
205	137	178	362	048	333	185	040	088	035
309	361	283	140	256	041	200	363	051	137
320	156	037	020	109	063	220	096	353	067

Table 3. Typical Ash and Energy Content on a Dry Basis[a] for the Main Waste Components

Component	Ash Content (Btu/lb)	Energy Content (%)
Paper	6	7,660
Cardboard	5	7,370
Plastics/Rubber	10	14,285
Textiles	10	8,330
Wood	1.5	10,000
Yard Waste	4.5	7,000
Food Waste	5	6,670
Ferrous	98	310
Aluminum[b]	96	310
Nonferrous[b]	96	310
Inerts[c]	70	85
Fines and Sweepings	70	3,260
Glass	98	60

[a] Reference 13.

[b] Assumed same as ferrous.

[c] Reference 14.

Table 4. Breakdown of Cost Estimates for the Survey Method

Cost Categories	Cost Estimate ($) for the Following Number of Samples--					
	1	5	10	15	20	30
Nonrecurrent Costs						
1. Refuse sorting cans (17)	200	200	200	200	200	200
2. Construction grade plastic	35	35	35	70	70	70
3. Sifting box	30	30	30	30	30	30
4. Safety supplies	150	150	200	250	250	300
5. Miscellaneous supplies	50	50	75	100	100	125
6. Shovels, steel tape, pitchforks, rakes	80	80	80	80	80	80
7. Rental scale and delivery	90	450	900	1,350	1,800	2,700
8. Test preparation (24 hr)	360	360	360	360	360	360
9. General and administrative expenses over direct costs (0.2 x items 1-7)	127	199	304	416	506	701
10. Overhead and profit (1.6 x item 8)	576	576	576	576	576	576
11. Total Nonrecurrent Costs	1,698	2,130	2,760	3,432	3,972	5,142
Recurrent Costs						
12. Moisture tests	130	650	1,300	1,950	2,600	3,950
13. Bobcat drivers (2) at $12/hr	190	960	1,920	2,880	3,840	5,760
14. Crew (5) at $7.50/hr	300	1,500	3,000	4,500	6,000	9,000
15. Supervisor (1) at $15/hr	120	600	1,200	1,800	2,400	3,600
16. Project management, data analysis	200	1,000	2,000	3,000	4,000	6,000
17. Overhead and profit (1.6 x items 12-15)	1,296	6,496	12,992	19,488	25,984	38,976
18. Total Recurrent Costs	2,236	11,206	22,412	33,618	44,824	67,236
19. Contingency at 10%	396	1,334	2,518	3,705	4,849	7,237
20. Estimated Total Costs	4,330	14,670	27,690	40,755	53,645	79,615

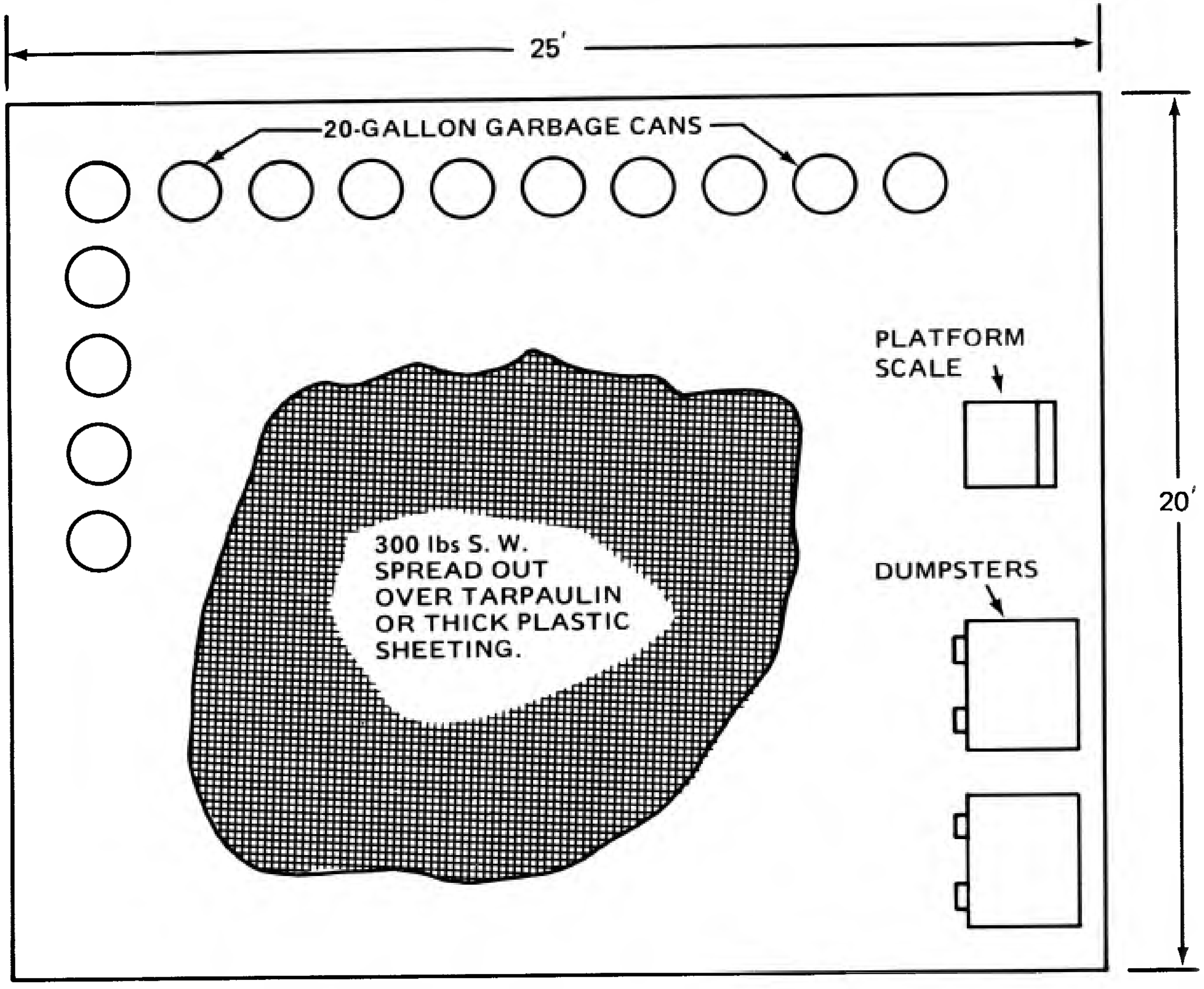


Figure 1. Typical refuse characterization area.

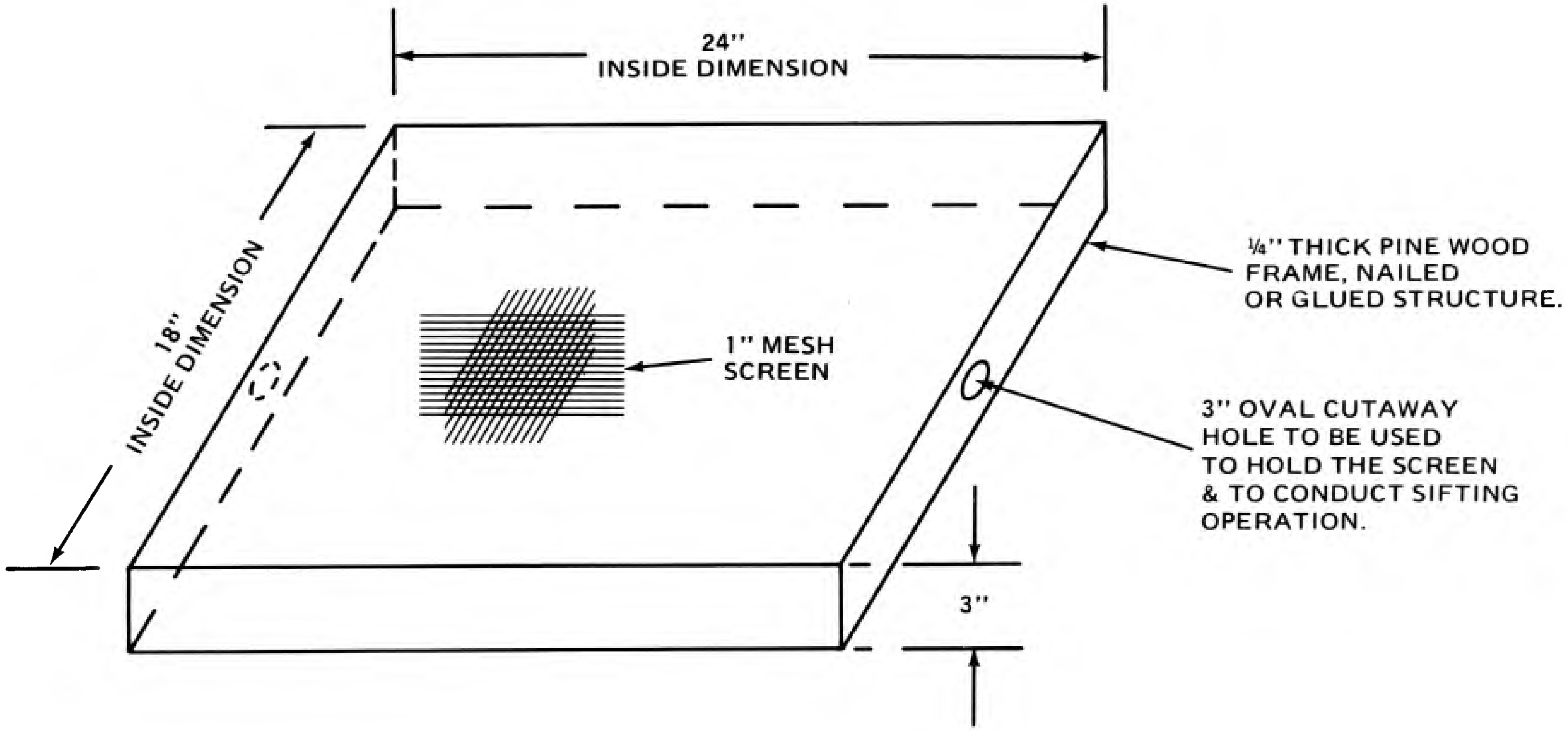


Figure 2. Typical sifting screen box.

Appendix A

SAMPLE DATASHEETS

Datasheet 1. Solid Waste Composition Data Completed for Each Truckload of Waste

Site: ______________________
Sample #: __________________
Waste Received From
(Bldg or Route #): ____________

Date: ______________________
Dumpster Box #: ____________
Truck ID #: ________________

Total Weight (truck and waste, lb): __________________________

Weight of Truck (lb): __________
Tare Weight of Truck (lb): ______
Weight of Waste (lb): __________
Volume of Waste (yd^3): __________

Pile Height (ft): __________
Pile Width (ft): __________
Pile Length (ft): __________
Density of Solid Waste
Sample (lb/yd^3): ____________

Solid Waste Component	Weight of Container and Waste (lb)	Container Tare Weight (lb)	Wet Sample Weight (lb)	Wet Percentage[a] (%)	Component Weight[b] (lb)
Paper					
Cardboard					
Plastic/Rubber					
Textile/Leather					
Wood					
Yard Waste					
Food Waste					
Ferrous					
Aluminum					
Nonferrous					
Inerts					
Fines/Sweepings					
Glass					
Combustible:					
(1) bulky					
(2) nonbulky					
Noncombustible					
(1) bulky					
(2) nonbulky					
Restricted					
Totals:					
General Remarks:					

[a] Wet Percentage $= \frac{\text{wet sample weight (lb)}}{\text{total wet sample weight (lb)}} \times 100$

[b] Component Weight = estimated total weight of each component in the disposal truck based on the wet percentage and the total weight of waste carried by the truck
= weight of waste x wet percentage/100

Datasheet 2. Special Waste Composition Analysis Completed for Each Truckload of Waste

Component	Combustible (lb)						Noncombustible (lb)						Restricted			Total Actual Weight (lb)
	Bulky			Bulky			Bulky			Nonbulky						
	Gross	Tare	Actual	Gross	Tare	Actual	Gross	Tare	Actual	Gross	Tare	Actual	Gross	Tare	Actual	
Paper																
Cardboard																
Plastic/Rubber																
Textile/Leather																
Wood																
Yard Waste																
Food Waste																
Ferrous																
Aluminum																
Nonferrous																
Inerts																
Glass																
Total:																

Note: This datasheet will be completed for each truckload. The results will be added to the appropriate Datasheet 1 to complete Datasheet 4. This new datasheet will be used in Datasheets 5 and 6.

General Remarks:

Datasheet 3. Daily Summary of Measured Results Completed on Each Sampling Day

Item	Summary of Results[a] for Sample No. ______															Total	Total Wet Component[b] (%)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Building No. or Truck Route No.																	
Weight, lb																	
Volume, yd^3																	
Density, lb/yd^3																	
Component, lb																	
Paper																	
Cardboard																	
Plastic/Rubber																	
Textile/Leather																	
Wood																	
Yard Waste																	
Food Waste																	
Ferrous																	
Aluminum																	
Nonferrous																	
Inerts																	
Fines/Sweepings																	
Glass																	
Combustible																	
(1) bulky																	
(2) nonbulky																	
Noncombustible																	
(1) bulky																	
(2) nonbulky																	
Restricted																	
Total																	

[a] Space is provided for up to 15 trucks of waste or 105 to 120 tpd.

[b] $$\text{Total Wet \%} = \frac{\text{total component weight (lb)}}{\text{total weight (lb)}} \times 100$$

Datasheet 4. Daily Summary of Measured Results Incorporating Special Waste Components Completed on Each Sampling Day[a]

Component	Total From Data Sheet 3 (lb)	Total Combustible Weight[b] (lb)		Total Noncombustible Weight[b] (lb)		Restricted Weight[b] (lb)	Total Weight (lb)	Total Wet Component[c] (%)
		Bulky	Nonbulky	Bulky	Nonbulky			
Paper								
Cardboard								
Plastic/Rubber								
Textile/Leather								
Wood								
Yard Waste								
Food Waste								
Ferrous								
Aluminum								
Nonferrous								
Inerts								
Fines/Sweepings								
Glass								
Totals								

[a] Totals to be used in Datasheet 5.

[b] Results from all Datasheet 2s.

[c] $$\text{Total Wet \%} = \frac{\text{total component weight (lb)}}{\text{total weight (lb)}} \times 100$$

Datasheet 5. Energy, Moisture, and Ash Content Completed on Each Sampling Day

Component	Total Wet Weight[a] (lb)	Moisture Content (%)	Dry Weight[b] (lb)	Energy (Dry Basis)[c] (Btu/lb)	Total Energy[d] (Btu)	Ash (Dry Basis)[c] (%)	Total Ash[e] (lb)
Paper							
Cardboard							
Plastic/Rubber							
Textile/Leather							
Wood							
Yard Waste							
Food Waste							
Ferrous							
Aluminum							
Nonferrous							
Inerts							
Fines/Sweepings							
Glass							
Totals:							

Average:[f,g]

1. moisture (%) ____________
2. energy (Btu/lb), dry: ________________ as received: ______________
3. ash (%), dry: ______________________________ as received: ______________

[a] These values are the total wet component % from Datasheet 4 multiplied by a 100-lb sample.

[b] Dry weight (lb) = total weight x (1-moisture %/100).

[c] Energy and ash values from Table 3.

[d] Energy (Btu) = dry weight x energy value.

[e] $$\text{Ash (lb)} = \frac{\text{ash \% x dry weight}}{100}$$

[f] $$\text{Dry average} = \frac{\text{total energy (Btu)}}{\text{total dry weight (lb)}} \text{ or } \frac{\text{total ash (lb)}}{\text{total dry weight (lb)}} \times 100$$

[g] $$\text{Average as received} = \text{(a) } 100 - \text{dry weight or (b)} \left(1 - \frac{\text{dry weight}}{100}\right) \text{x dry energy (Btu/lb)}$$
$$\text{or (c)} \left(1 - \frac{\text{dry weight}}{100}\right) \text{x dry ash (\%)}$$

Datasheet 6. Statistical Analysis, Part 1[a,b]

Sample Number	Sample Date	Total Weight (tons)	Total Volume (yd^3)	Average Density (lb/yd^3)	Average Moisture (%)	Average Energy (Btu/lb)		Average Ash (%)	
						Dry	As Received	Dry	As Received
Mean, $\bar{X}$									
Standard Deviation, S									
Coefficient of Variation, CV									
Coefficient of Skewness, a_3									
Symmetry Check[c]									
Coefficients of Kurtosis, a_4									
Peakness Check[c]									
90% confidence + or -									
95% confidence + or -									
99% confidence + or -									
Total number of samples to be taken at 90% confidence									
Excessive variance[d]									

[a] Equations in Appendix B.

[b] Completed after 10 sampling days and redone for each 3 sampling days thereafter using all the data.

[c] G = good; NG = not good.

[d] Based on Equation B-13; N = No, Y = Yes.

Datasheet 7. Statistical Analysis (%), Part 2[a,b]

Sample Number	Sample Date	Paper	Cardboard	Plastic/ Rubber	Textile/ Leather	Wood	Yard Waste	Food Waste	Ferrous	Aluminum	Nonferrous	Inerts	Fines/ Sweepings	Glass	Combustible		Noncombustible		Restricted
															Bulky	Nonbulky	Bulky	Nonbulky	
Mean, $\bar{X}$																			
Standard Deviation, S																			
Coefficient of Variation, CV																			
Coefficient of Skewness, a_3																			
Symmetry Check[c]																			
Coefficient of Kurtosis, a_4																			
Peakedness Check[c]																			
90% confidence + or -																			
95% confidence + or -																			
99% confidence + or -																			
Total number of samples to be taken at 90% confidence																			
Excessive variance[d]																			

[a] Equations in Appendix B.

[b] Completed after 10 sampling days and redone every 3 sampling days thereafter using all the data.

[c] G = good; NG = not good.

[d] Based on Equation B-13; N = No, Y = Yes

Appendix B

SAMPLE SIZE DETERMINATION

SAMPLE STATISTICS

The sample statistics used to describe solid waste composition and quantity are included in the following list:

a. Mean
b. Standard deviation
c. Coefficient of variation
d. Moment coefficient of skewness
e. Moment coefficient of kurtosis

The mean of a population is a measure of the expected value. It is determined by summing the values of all the items in the population and dividing this sum by the number of items. In the case of an infinite population, it is impossible to determine the mean exactly. Instead, the mean of a sufficiently large sample is used as an estimate of the total population mean. The sample mean ($\bar{X}$) is computed as shown in Equation B-1 by dividing the sum of the individual sample values (X_i) by the number of samples (n).

$$\bar{X} = \left(\sum_{i=1}^{n} X_i \right) / n \qquad \text{(B-1)}$$

Similarly, the standard deviation (S) of the sample, a measure of dispersion or variability in the population, is computed as shown in Equation B-2.

$$S = \sqrt{\frac{\sum_{i=1}^{n} (X_i - \bar{X})^2}{n - 1}} \qquad \text{(B-2)}$$

A small standard deviation indicates that a high percentage of the values of the items in the population lie close to the mean. A large standard deviation indicates that the population is more spread out. The standard deviation is an absolute measure and is influenced by the order of magnitude of the mean. For example, in case 1 a population with a mean of 1,000 has a standard deviation of 100. Another population with a mean of 10 has a standard deviation of 8. Relatively speaking, the variability in the first distribution is less than that in the second. However, the standard deviation for case 1 is more than 10 times greater than for case 2.

The relative variability is measured by the coefficient of variation (CV). The coefficient of variation is the ratio of the standard deviation to the mean.

$$CV = \frac{S}{\bar{X}} \qquad \text{(B-3)}$$

This measure of variability is used to compare the relative variability of two data sets.

The moment coefficient of skewness (a_3) describes the degree of asymmetry of a distribution. It is computed by dividing the third moment about the mean by the product of standard deviation raised to a power of three and the sample size.

$$a_3 = \frac{\sum_{i=1}^{n} (X_i - \bar{X})^3}{nS^3} \qquad \text{(B-4)}$$

For a symmetrical distribution, a_3 is very close to 0. If a_3 is negative, the distribution is skewed to the left. Similarly, positive a_3 values indicate a skewness to the right. Figure B-1 shows the various degrees of skewness. The following condition (Equation B-5) has been suggested for determining if the distribution is skewed (Ref 4). If the condition is met, the distribution is approximately symmetrical.

$$\left| \frac{a_3}{\sqrt{n}} \right| < 0.2 \qquad \text{(B-5)}$$

The peakedness of a distribution is described by the moment coefficient of kurtosis, a_4.

$$a_4 = \frac{\sum_{i=1}^{n} (X_i - \bar{X})^4}{nS^4} \qquad \text{(B-6)}$$

A distribution can range from very peaked to relatively flat. When a_4 is equal to 3, an intermediate degree of kurtosis exists. Equation B-7 determines if the distribution is moderately peaked (Ref 2).

$$\left| \frac{a_4 - 3}{n} \right| < 0.3 \qquad \text{(B-7)}$$

When a_4 << 3, a platykurtic or flat distribution exists. A leptokurtic (very peaked) distribution is suggested when a_4 >> 3. A moderate degree of kurtosis, termed mesokurtic distribution, exists when the condition in Equation B-7 is met. Figure B-2 shows three distributions with varying degrees of kurtosis.

NORMAL DISTRIBUTION ASSUMPTION

The primary objective of the sampling strategy is to estimate volume, weight, percent constituent composition by weight, and fuel characteristics for the solid waste generated at a Navy activity. Therefore, it is important to understand the nature of the distribution of the sample mean, $\bar{X}$.

The Central Limit Theorem in statistics states:

> For almost all populations, the sampling distribution of $\bar{X}$ is approximately normal when the simple random sample size is sufficiently large (Ref 15).

The normal distribution is a moderately peaked, symmetrical distribution. If sample values satisfy the skewness and kurtosis conditions (Equations B-5 and B-7), then the sample size is sufficiently large and the distribution of $\bar{X}$ is approximately normal. It has been shown for municipal wastes that a sample size of 30 will satisfy skewness and kurtosis requirements (Ref 2). If no checks for normality are made, 30 samples will be taken as a lower limit for the number of samples required.

SAMPLE SIZE FORMULA

The formula to use when computing the sample size depends on the characteristics of the population and the requirements of the design engineer. The approach available for computing the sample size is based on the assumption that computing a percent confidence interval for the population mean, μ, is the desired end result. The confidence interval is defined by two parameters: precision (p) and confidence. Precision defines the boundaries of the interval that the true mean will fall within. A measure of precision is h (half-width of the interval), which is calculated by multiplying precision (p)/100 by the mean. Confidence is defined as the probability that the true mean will be within the range specified by the precision, and has a value of 90 to 99% for these studies. Confidence is represented by $(1-\alpha)$ (100). For example, with 90% confidence, there are between 20 and 26 tons per day (tpd) of solid waste generated by a specific Navy activity. In other words, the mean tons per day will be bounded by the 20- to 26-tpd interval with 90% assurance. The equation used to calculate the percent confidence interval for μ is as follows:

$$\bar{X} - \frac{Z\,(1-\alpha/2)\,S}{\sqrt{n}} < \mu < \bar{X} + \frac{Z\,(1-\alpha/2)\,S}{\sqrt{n}} \qquad \text{(B-8)}$$

where: μ = population or true mean

$\bar{X}$ = sample mean

$Z(1-\alpha/2)$ = standard normal variable corresponding to a confidence of $100(1-\alpha)$ percent. Values for this function are given in Table B-1.

S = standard deviation of the sample

n = number of samples, or sample size

The user of a confidence interval would like to specify the required interval width (2h) and confidence interval. Based on such a specification, an appropriate sample size can be determined. The desired confidence interval should have a lower limit $L = \bar{X} - h$ and an upper limit $U = \bar{X} + h$. In other words, with $(1-\alpha)$ (100) confidence:

$$\bar{X} - h < \mu < \bar{X} + h \qquad \text{(B-9)}$$

where $\bar{X}$ is the sample mean. The symbol h denotes the half-width of the confidence interval. The half-width, h, sets the range of values that the mean will be within, with the given percentage probability. The result is expressed as $\mu \pm h$. From Equation B-8:

$$h = Z\,(1-\alpha/2)\; S/\sqrt{n} \qquad \text{(B-10)}$$

By squaring both sides and solving for the sample size n, Equation B-11 is derived:

$$n = \frac{[Z\,(1-\alpha/2)]^2\, S^2}{h^2} \qquad \text{(B-11)}$$

To use this formula, an estimate of the standard deviation is needed. Information about the relative magnitude of S may be obtained from previous samples. The precision (1 to 10%) and the percent confidence (90 to 99%) must be specified. The value of h is obtained through the following equation:

$$h = \frac{\mu \cdot \text{precision}}{100} \qquad \text{(B-12)}$$

The value of $Z\,(1 - \alpha/2)$ is found in Table B-1 for the specified percent confidence.

A test for variance, to determine whether the data lie within an acceptable range of the mean, is shown in Equation B-13.

$$K\,S > 0.2\,\bar{X} \tag{B-13}$$

where: K = constant (Table B-2)

S = sample standard deviation

$\bar{X}$ = sample mean

If this criterion is met, 90% of the values lie within 20% of the mean with 95% confidence. The value of K is taken from Table B-2 and depends only on the number of samples used in the calculation of S and $\bar{X}$.

To determine whether the mean lies below some limit (ℓ) with 95% confidence, the following criterion must be satisfied:

$$\bar{X} \leq \ell + 1.645 \frac{S}{\sqrt{n}} \tag{B-14}$$

In the case in which the noncombustibles must comprise less than 60% of the total, ℓ is equal to 0.6 in Equation B-14. If the criterion is met, then it can be concluded that the mean is less than 60% with 95% confidence.

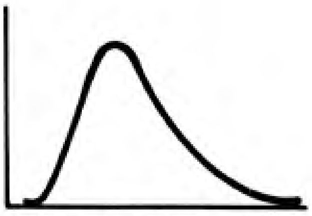
Table B-1. Standard Z Values for Equations B-8 and B-10[a]

Confidence Limit (%)	$Z(1 - \alpha/2)$
90	1.645
91	1.796
92	1.751
93	1.811
94	1.881
95	1.960
96	2.054
97	2.170
98	2.326
99	2.576

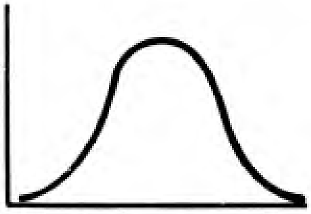
[a] Reference 15.

Table B-2. K Values for Equation B-13

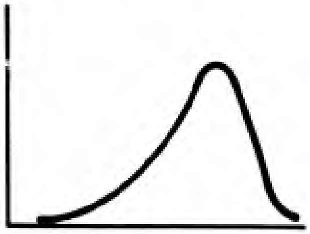
Sample Size, n	K
2	32.019
3	8.380
4	5.369
5	4.275
6	3.712
7	3.369
8	3.136
9	2.967
10	2.839
11	2.737
12	2.655
13	2.587
14	2.529
15	2.480
16	2.437
17	2.400
18	2.366
19	2.337
20	2.310
25	2.208
30	2.140
35	2.090
40	2.052
45	2.021
50	1.996
55	1.976
60	1.958
65	1.943
70	1.929
75	1.917
80	1.907
85	1.897
90	1.889
95	1.881
100	1.874
150	1.825
200	1.798
250	1.780
300	1.767
400	1.749
500	1.737
600	1.729
700	1.722
800	1.717
900	1.712
1,000	1.709
∞	1.645



SKEWED TO THE RIGHT
(POSITIVE SKEWNESS)



SYMMETRICAL OR BELL-SHAPED



SKEWED TO THE LEFT
(NEGATIVE SKEWNESS)

Figure B-1. Skewness in distributions.

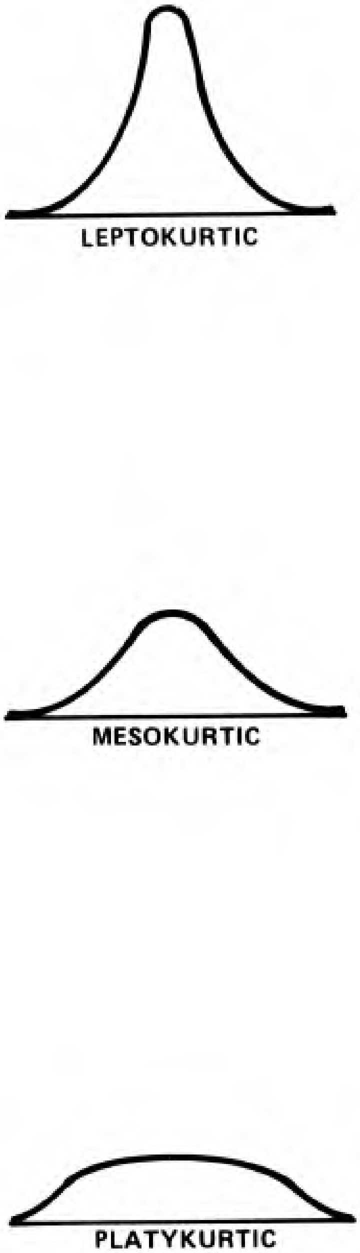


Figure B-2. Kurtosis in distributions.

Appendix C

COMBUSTIBLE, NONCOMBUSTIBLE, AND RESTRICTED SPECIAL WASTES

This appendix contains a list of possible types of special waste that can be found in a Navy waste stream. In parentheses after each type of special waste is the category of normal waste that the type of special waste belongs to on Datasheet 2.

COMBUSTIBLE WASTE COMPONENTS

Bulky (>3 feet in dimension)

- Densely packed newspaper or magazines (paper)
- Large corrugated boxes (cardboard)
- Densely packed corrugated sheets (cardboard)
- Fiber drums (cardboard)
- Auto tires (rubber)
- Long hose (plastic)
- Large floor mats (plastic)
- Styrofoam board (large) (plastic)
- Carpet/padding (plastic)
- Pallets (wood)
- Railroad ties or other large lumber (wood)
- Tree limbs (wood)
- Large volume (>2 yd^3) mess hall garbage or grocery store rejects (food)

Nonbulky

- Fiber rope, coir rope (textile)
- Dispensary wastes (textile, inert, plastic)
- Softwood furniture (wood)
- Crated spoiled vegetables (<2 yd^3) (food)
- Paint and paint sludges (see Special Waste Characterization Plan section)
- Kerosene/petroleum products (see Special Waste Characterization Plan section)

NONCOMBUSTIBLE WASTE COMPONENTS

Bulky (>3 feet in dimension)

- Large wire products (metal)
- Demolition (inert, metals)
- Window air conditioners (metal)
- Metal drums (metal)
- Large glass containers and mirrors (glass)
- Fiberglass drapes, etc. (glass)
- Insulation board/blanket (inert)

Nonbulky

- Electric wire and cords (metal)
- Wire rope (metal)
- Auto parts (metal)
- Bench tools, machine tools (metal)
- Wire dairy cases (metal)
- Metal lawn furniture (metal)
- Plaster (inert)
- Sand and gravel (inert)

RESTRICTED WASTE COMPONENTS

- Munitions (metal)
- Dry and liquid chemicals*
- Corrosive liquids, powders, and gels*
- Pathogenic wastes (textiles, inert, plastics)
- Pesticides (liquid or powder)*
- Plastic film in bulk (PVC, polystyrene, polyethylene, >2 yd^3 or 100 lb) (plastic)
- Pressurized fluid containers (metal)

---

*These wastes should be handled by the activity hazardous waste office and should not be included as part of the normal waste stream.

Appendix D

EXAMPLE STUDY

Using hypothetical data, an example is completed showing how each datasheet should be filled out and how the statistical procedure is used to modify the study and obtain adequate results.

The hypothetical installation is a Navy shipyard producing 70 tpd of solid waste. The waste has a mean density of 300 lb/yd^3 and a composition as listed on Datasheet 7.

Datasheets 1 to 7 are filled out based on having completed the first 10 days of the study. Datasheets 1 and 2 contain the data from one truckload of waste measured during this period. The multiple numbers in the paper and plastic categories on Datasheet 1 represent garbage cans that were filled with sample, weighed, dumped out, and reused for additional sample. The total of these numbers minus the total of the tare weights equals the wet weight.

Datasheets 3 and 4 represent the raw data gathered from 1 sampling day. Datasheet 3 is a complete listing of all the Datasheet 1 data collected that day and provides the waste composition for that day. Datasheet 4 combines the data from Datasheets 2 and 3 to provide information on the waste composition in terms of the 13 main components in Datasheet 5. The general remarks on Datasheet 4 are summaries of the Datasheet 2 remarks and are used to prove the need for any special equipment, handling, or operational procedures, when that part of the waste can be used as a fuel.

Datasheet 5 represents the fuel characteristics for 1 day's sample. The composition data are obtained from Datasheet 4, the energy and ash contents from Table 2, and the moisture content from laboratory analysis.

Datasheets 6 and 7 represent a summary of the first 10 sampling days of the study and are the initial indication of the changes that will be required in the study. Datasheet 6 contains the volume, weight, and fuel characteristic results. The results indicate that adequate information has been collected for the fuel characteristics (i.e., ash--6 samples required versus 10 taken). However, the weight and density results need 14 and 15 samples or 4 and 5 additional samples over the 10 taken. The volume result is not statistically accurate, which indicates that more samples need to be taken to correct the inaccuracy. The volume result can be rechecked as the program continues. From the above information, the sampling program will have adequate statistical data after 6 months or 15 samples. Only 2 samples per month will need to be taken for the next 6 months for variance information, or 27 versus 30 original samples.

Datasheet 7 contains the summarized data and results for the waste composition components. The results indicate that a 27-sample program would provide adequate data for 11 out of 18 components. This should improve as more samples are taken. Therefore, for this case study, 3 sampling days can be removed from the program at a cost saving of about $12,000.

Variance data are readily available from Datasheets 6 and 7. The yearly and seasonal maximums, minimums, and statistical values can be determined by filling out a new set of Datasheets 6 and 7 for the chosen period. The maximums and minimums are found by examining the listed values and recording the respective numbers. By examining the example Datasheet 6, the 3-month minimum for weight data is 45.6 tpd (sample 4) and the maximum is 96.3 tpd (sample 8). It should be noted that these values are only the measured extreme values for this period and may not be the actual extremes for this period. These values just provide an indication of what the range might be.

Using the criteria in the section on Variance Procedures to determine components with significant variance and noncombustibles (Equations B-13 and B-14), and the information on all Datasheet 4s about the types of waste that are consistently present, any special handling, equipment, or operational procedures can be designed if deemed necessary. After 10 samples, only the energy parameters (Datasheet 6) are indicating excessive variance. If this excess persists until the end of the study period, the variance will have to be accounted for in the design of the energy recovery system. The variance can be accounted for by using the lower estimate of energy value, or by using an adjustable fossil fuel burner to alleviate the fluctuation in steam production.

After 10 samples, no areas have been identified as excessive producers of noncombustibles, but three areas are close (30 to 40% noncombustibles). These areas on Datasheet 3 are Buildings 106, 805, and 760, or samples 4, 5, and 9, respectively. The containers from these areas should be monitored on future Datasheet 3s to confirm that noncombustibles are not a potential problem.

The information available from the first 10 samples is a good indication of the types of waste that will be generated at the activity. Unless future samples are consistently different, statistically valid data for design of the HRI will be available from the survey.

Datasheet 1. Solid Waste Composition Data Completed for Each Truckload of Waste (Example)

Site: Naval Shipyard
Sample #: 1
Waste Received From
(Bldg or Route #): Bldg 302

Date: 10/31/83
Dumpster Box #: 306
Truck ID #: 2

Total Weight (truck, dumpster, and waste, lb): 45,320

Weight of Truck (lb): 25,420
Weight of Dumpster (lb): 6,600
Weight of Waste (lb): 13,300

Pile Height (ft): 5.0
Pile Width (ft): 8.0
Pile Length (ft): 30.0

Volume of Waste (yd^3): 44.4

Density of Solid Waste Sample (lb/yd^3): 300

Solid Waste Component	Weight of Container and Waste (lb)	Container Tare Weight (lb)	Wet Sample Weight (lb)	Wet Percentage[a] (%)	Component Weight[b] (lb)
Paper	17.4; 15.3; 15.7; 9.7	5; 5; 5; 5	38.1	12.9	1,716
Cardboard	25.6; 9.3	5; 5	24.9	8.4	1,117
Plastic/Rubber	13.5; 12.6; 11.3	5; 5; 5	22.4	7.6	1,011
Textile/Leather	12.8	5	7.8	2.6	346
Wood	25	5	20	6.8	904
Yard Waste	6.5	5	1.5	0.5	66
Food Waste	19.4	5	14.4	4.9	652
Ferrous	18.6	5	13.6	4.6	612
Aluminum	7.5	5	2.5	0.8	106
Nonferrous	18.3	5	13.3	4.5	598
Inerts	21.2	5	16.2	5.5	732
Fines/Sweepings	10.8	5	5.8	2	266
Glass	5.9	5	0.9	0.3	40
Combustible:					
(1) bulky	20; 65	0; 0	85	28.8	3,831
(2) nonbulky	11	5	6	2	266
Noncombustible					
(1) bulky	17.8	5	12.8	4.3	572
(2) nonbulky	13.1	5	9.2	3.1	412
Restricted	7.2	5	1.1	0.4	53
Totals:	410.5	115	295.5	100.0	13,300

General Remarks:

[a] Wet Percentage $= \dfrac{\text{wet sample weight (lb)}}{\text{total wet sample weight (lb)}} \times 100$

[b] Component Weight = estimated total weight of each component in the disposal truck based on the wet percentage and the total weight of waste carried by the truck
= weight of waste x wet percentage/100

Datasheet 2. Special Waste Composition Analysis Completed for Each Truckload of Waste (Example)

Component	Combustible (lb)						Noncombustible (lb)						Restricted			Total Actual Weight (lb)
	Bulky			Nonbulky			Bulky			Nonbulky						
	Gross	Tare	Actual	Gross	Tare	Actual	Gross	Tare	Actual	Gross	Tare	Actual	Gross	Tare	Actual	
Paper																-
Cardboard	20	0	20													20
Plastic/Rubber																-
Textile/Leather				9.5	5	4.5							6.1	5	1.1	5.6
Wood	40; 25	0; 0	65	6.5	5	1.5										66.5
Yard Waste																-
Food Waste																-
Ferrous							12.8	-	12.8	10.2	5	5.2				18
Aluminum																-
Nonferrous										9	5	4				4
Inerts																-
Glass																-
Total:	85	0	85	16	10	16	12.8	-	12.8	19.2	10	9.2	6.1	5	1.1	114.1

Note: This datasheet will be completed for each truckload. The results will be added to the appropriate Datasheet 1 to complete Datasheet 4. This new datasheet will be used in Datasheets 5 and 6.

General Remarks: Combustible bulky items were 40 lb of pallets, 4 by 4 ft; 25 lb of lumber; and 20 lb of large cardboard boxes, 3 by 5 ft. Combustible nonbulky items were 4.5 lb of coiled fiber rope and 1.5 lb of paint brushes. Noncombustible bulky item was a desk drawer; noncombustible nonbulky items were 5 lb of electrical wire and 4 lb of auto parts. Restricted material was 1.1 lb of cloth bandages from the dispensary.

Datasheet 3. Daily Summary of Measured Results Completed on Each Sampling Day (Example)

Item	Summary of Results[a] for Sample No. ______															Total	Total Wet Component[b] (%)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Building No. or Truck Route No.	Bldg 402	Route 1	Bldg 88	Bldg 106	Bldg 805	Route 2	Bldg 202	Bldg 99	Bldg 760	Route 3							
Weight, lb	13,300	13,800	10,700	17,500	19,100	14,800	14,600	12,600	9,500	14,100						140,000	
Volume, yd³	44.4	60.3	38.4	40	50.6	70.2	35.6	42	19.8	65.4						466.7	
Density, lb/yd³	300	229	279	438	377	211	410	300	480	216						300	
Component, lb																	
Paper	1,716	4,044	521	1,592	1,686	3,048	1,283	1,631	432	2,351						18,304	13.1
Cardboard	1,117	2,834	607	1,641	2,032	2,304	1,419	1,042	225	3,168						16,119	11.5
Plastic/Rubber	1,011	1,283	432	956	841	1,817	965	641	325	1,083						9,354	6.7
Textile/Leather	346	303	168	839	539	625	587	285	-	202						3,894	2.8
Wood	904	821	1,133	1,195	1,405	1,225	1,975	1,119	1,364	406						11,547	8.2
Yard Waste	66	-	125	58	224	-	-	200	-	-						673	0.5
Food Waste	652	838	432	422	850	1,150	1,232	760	-	1,259						7,595	5.4
Ferrous	612	325	771	1,891	1,684	381	1,325	1,184	867	524						9,564	6.8
Aluminum	106	223	58	156	231	207	116	55	17	202						1,371	1.0
Nonferrous	598	355	665	1,587	1,361	584	1,014	621	384	475						7,644	5.5
Inerts	732	505	524	1,224	824	302	921	838	1,280	525						7,675	5.5
Fines/Sweepings	266	561	333	242	402	738	1,102	405	76	631						4,756	3.4
Glass	40	60	10	15	33	54	26	22	-	55						315	0.2
Combustible																	
(1) bulky	3,831	565	2,332	4,172	4,468	1,305	1,875	2,580	2,711	1,121						24,960	17.9
(2) nonbulky	266	150	781	469	532	319	105	560	238	656						4,076	2.9
Noncombustible																	
(1) bulky	572	502	983	832	1,021	589	560	482	1,456	732						7,729	5.5
(2) nonbulky	412	431	725	196	267	422	95	165	125	685						3,523	2.5
Restricted	53	-	100	13	700	-	-	10	-	25						901	0.6
Total	13,300	13,800	10,700	17,500	19,100	14,800	14,600	12,600	9,500	14,100						140,000	100

[a] Space provided for up to 15 trucks of waste or 105 to 120 tpd.

[b]

$$\text{Total Wet \%} = \frac{\text{total component weight (lb)}}{\text{total weight (lb)}} \times 100$$

Datasheet 4. Daily Summary of Measured Results Incorporating Special Waste Components Completed on Each Sampling Day[a] (Example)

Component	Total From Datasheet 3 (lb)	Total Combustible Weight[b] (lb)		Total Noncombustible Weight[b] (lb)		Restricted Weight[b] (lb)	Total Weight (lb)	Total Wet Component[c] (%)
		Bulky	Nonbulky	Bulky	Nonbulky			
Paper	18,304						18,304	13.1
Cardboard	16,119	4,898					21,017	15.0
Plastic/Rubber	9,354	1,531				83	10,968	7.8
Textile/Leather	3,894	-	2,691			763	7,348	5.2
Wood	11,547	17,676	1,160				30,383	21.7
Yard Waste	673	-					673	0.5
Food Waste	7,595	855	225				8,675	6.2
Ferrous	9,564			3,731	1,978		15,273	10.9
Aluminum	1,371			68	26		1,465	1.1
Nonferrous	7,644			1,521	582	55	9,802	7.0
Inerts	7,675			2,353	631		10,659	7.6
Fines/Sweepings	4,756						4,756	3.4
Glass	315			56	306		677	0.5
Totals	98,811	24,960	4,076	7,729	3,523	901	140,000	100

General Remarks: Combustible bulky--4,898 lb large cardboard boxes; 1,531 lb of carpet; 14,628 lb of pallets, 4 by 4 ft; 3,048 lb of lumber; 855 lb of spoiled vegetables. Combustible nonbulky--1,341 lb of coiled rope, 1,350 lb of bundled cloth, 1,160 lb of furniture, 225 lb of crated vegetables. Noncombustible bulky--5,320 lb of metal parts, 2,353 lb of bricks, 56 lb of mirrors. Noncombustible nonbulky--2,586 lb of metal parts; 631 lb of plaster, sand; 306 lb of broken mirrors. Restricted--83 lb of plastic in bulk, 763 lb of dispensary waste, 55 lb of munitions.

[a] Totals to be used in Datasheet 5.

[b] Results from Datasheet 2s.

[c] $$\text{Total Wet \%} = \frac{\text{total component weight (lb)}}{\text{total weight (lb)}} \times 100$$

Datasheet 5. Energy, Moisture, and Ash Content Completed on Each Sampling Day (Example)

Component	Total Wet Weight[a] (lb)	Moisture Content (%)	Dry Weight[b] (lb)	Energy (Dry Basis)[c] (Btu/lb)	Total Energy[d] (Btu)	Ash (Dry Basis)[c] (%)	Total Ash[e] (lb)
Paper	13.1	8	12.05	7,660	92,303	6	0.72
Cardboard	15.0	7	13.95	7,370	102,812	5	0.70
Plastic/Rubber	7.8	3	7.57	14,285	108,137	10	0.76
Textile/Leather	5.2	10	4.68	8,330	38,984	10	0.47
Wood	21.7	20	17.36	10,000	173,600	1.5	0.26
Yard Waste	0.5	60	0.2	7,000	1,400	4.5	0.01
Food Waste	6.2	70	1.86	6,670	12,406	5	0.09
Ferrous	10.9	2	10.68	310	3,311	98	10.47
Aluminum	1.1	2	1.08	310	335	96	1.04
Nonferrous	7.0	2	6.86	310	2,127	96	6.59
Inerts	7.6	3	7.37	85	626	70	5.16
Fines/Sweepings	3.4	10	3.06	3,260	9,976	70	2.14
Glass	0.5	2	0.49	60	29	98	0.48
Totals:	100	-	87.21	-	546,046	-	28.89

Average:[f,g]

1. moisture (%) 12.8
2. energy (Btu/lb), dry: 6,261 as received: 5,460
3. ash (%), dry: 33.1 as received: 28.9

[a] These values are the total wet component % from Datasheet 4 multiplied by a 100-lb sample.

[b] Dry weight (lb) = total weight x (1-moisture %/100).

[c] Energy and ash values from Table 3.

[d] Energy (Btu) = dry weight x energy value.

[e] Ash (lb) = $\frac{\text{ash \% x dry weight}}{100}$

[f] Dry average = $\frac{\text{total energy (Btu)}}{\text{total dry weight (lb)}}$ or $\frac{\text{total ash (lb)}}{\text{total dry weight (lb)}}$ x 100

[g] Average as received = (a) 100 - dry weight or (b) $\left(1 - \frac{\text{dry weight}}{100}\right)$x dry energy (Btu/lb) or (c) $\left(1 - \frac{\text{dry weight}}{100}\right)$x dry ash (%)

Datasheet 6. Statistical Analysis, Part 1[a,b] (Example)

Sample Number	Sample Date	Total Weight (tons)	Total Volume (yd^3)	Average Density (lb/yd^3)	Average Moisture (%)	Average Energy (Btu/lb)		Average Ash (%)	
						Dry	As Received	Dry	As Received
1	10/31/83	70	466.7	300	12.8	6,113	5,331	33.1	28.9
2	11/4/83	64.9	511	254	15.3	6,085	5,154	28.5	24.1
3	11/15/83	88	457.1	385	17.8	6,321	5,196	27.6	22.7
4	11/28/83	45.6	460.6	198	16.7	6,255	5,210	32.4	27
5	12/1/83	78	559.1	279	15.2	5,840	4,952	30.8	26.1
6	12/27/83	55.3	415.8	266	14.3	5,532	4,741	25.3	21.7
7	1/6/83	66.4	413.7	321	13.8	5,791	4,992	22.1	19
8	1/14/83	96.3	464.1	415	12.3	5,925	5,196	27.6	24.2
9	2/12/83	77.7	444	350	14.9	6,432	5,474	32.8	27.9
10	2/14/83	57.8	498.3	232	16.1	6,607	5,543	36.7	30.8
Mean, $\bar{X}$		70.0	469.04	300	14.92	6,090	5,179	29.69	25.24
Standard Deviation, S		15.414	44.09	68.42	1.702	325.9	241.1	4.295	3.583
Coefficient of Variation, CV		0.22	0.094	0.228	0.114	0.054	0.0466	0.145	7.044
Coefficient of Skewness, a_3		0.169	0.671	0.273	0.05	-0.087	-0.206	-0.157	-0.154
Symmetry Check[c]		G	NG	G	G	G	G	G	G
Coefficients of Kurtosis, a_4		2.22	2.857	2.08	2.204	2.17	2.424	2.332	2.183
Peakedness Check[c]		G	G	G	G	G	G	G	G
90% confidence + or -		8	-	35.6	0.9	170	125	2.2	1.9
95% confidence + or -		9.6	-	42.4	1.1	202	149	2.7	2.2
99% confidence + or -		12.6	-	55.7	1.4	265	196	3.5	2.9
Total number of samples to be taken at 90% confidence		14	-	15	4	1	1	6	6
Excessive variance[d]		N	N	N	N	Y	Y	N	N

[a] Equations in Appendix B.

[b] Completed after 10 sampling days and redone for each 3 sampling days thereafter using all the data.

[c] G = good; NG = not good.

[d] Based on Equation B-13; N = No, Y = Yes.

Datasheet 7. Statistical Analysis (%), Part 2[a,b] (Example)

Sample Number	Sample Date	Paper	Cardboard	Plastic/ Rubber	Textile/ Leather	Wood	Yard Waste	Food Waste	Ferrous	Aluminum	Nonferrous	Inerts	Fines/ Sweepings	Glass	Combustible		Noncombustible		Restricted
															Bulky	Nonbulky	Bulky	Nonbulky	
1	10/31/83	13.1	11.5	6.7	2.8	8.2	0.5	5.4	6.8	1.0	5.5	5.5	3.4	0.2	17.9	2.9	5.5	2.5	0.6
2	11/4/83	11.5	8.3	4.3	1.2	11.3	0.2	4.8	8.3	0.7	6.8	5.0	3.0	0.1	23.6	1.6	7.6	1.2	0.5
3	11/15/83	11.4	7.7	3.8	0.9	10.4	0.3	6.3	9.2	0.6	6.3	6.2	4.2	0.0	21.9	2.2	6.0	2.3	0.3
4	11/28/83	14.6	9.6	5.5	1.8	9.8	0.1	7.1	10.5	1.2	4.2	4.4	2.4	0.3	19.0	2.5	5.0	1.8	0.2
5	12/1/83	12.3	12.5	6.2	3.2	8.8	0.2	5.8	8.6	1.4	5.2	5.0	5.0	0.3	17.0	1.8	4.2	1.7	0.8
6	12/27/83	12.5	13.6	7.9	2.6	7.6	0.1	6.6	7.3	0.8	5.8	6.0	4.0	0.2	15.5	3.5	3.2	2.1	0.7
7	1/6/83	11.8	10.3	7.6	1.5	7.8	0.4	4.3	5.4	1.0	6.7	6.5	4.5	0.4	20.2	3.7	4.7	2.8	0.4
8	1/14/83	17.3	11.2	4.8	2.9	6.5	0.6	3.9	6.2	1.3	4.5	4.7	2.7	0.1	20.5	4.2	5.3	3.0	0.3
9	2/12/83	14.7	12.4	5.8	2.0	6.3	0.7	5.1	4.9	0.9	4.9	5.1	2.1	0.1	24.7	1.9	5.7	2.5	0.2
10	2/14/83	16.2	11.8	6.4	3.4	7.2	0.8	4.4	6.5	0.5	5.3	5.5	3.5	0.0	16.4	2.7	7.2	1.9	0.3
Mean, $\bar{X}$		13.54	10.89	5.90	2.23	8.39	0.39	5.37	7.37	0.94	5.52	5.39	3.48	0.17	19.67	2.70	5.44	2.18	0.43
Standard Deviation, S		2.062	1.898	1.342	0.871	1.668	0.251	1.065	1.763	0.299	0.884	0.677	0.946	0.134	3.082	0.874	1.311	0.547	0.211
Coefficient of Variation, CV		0.152	0.174	0.227	0.390	0.199	0.644	0.198	0.239	0.318	0.160	0.126	0.272	0.788	0.157	0.324	0.241	0.251	0.491
Coefficient of Skewness, a_3		0.642	-0.406	-0.057	-0.155	0.439	0.340	0.233	0.306	0.092	0.101	0.259	0.085	0.282	0.270	0.384	0.108	-0.194	0.556
Symmetry Check[c]		NG	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
Coefficient of Kurtosis, a_4		2.077	2.077	1.989	1.646	2.017	1.742	1.826	2.111	1.867	1.874	1.952	1.876	1.973	1.891	1.916	2.482	2.234	1.951
Peakedness Check[c]		G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G	G
90% confidence + or -		--	1.0	0.7	0.4	0.9	0.13	0.6	0.9	0.16	0.46	0.35	0.49	0.07	1.6	0.45	0.7	0.28	0.11
95% confidence + or -		--	1.2	0.8	0.5	1.0	0.16	0.7	1.1	0.19	0.55	0.42	0.59	0.08	1.9	0.54	0.8	0.34	0.13
99% confidence + or		--	1.6	1.1	0.8	1.4	0.20	0.9	1.4	0.24	0.7	0.55	0.77	0.11	2.5	0.71	1.1	0.45	0.17
Total number of samples to be taken at 90% confidence		--	9	14	42	11	113	11	16	28	7	5	20	168	7	29	16	18	66
Excessive variance[d]		N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N

[a] Equations in Appendix B.

[b] Completed after 10 sampling days and redone every 3 sampling days thereafter using all the data.

[c] G = good; NG = not good.

[d] Based on Equation B-13; N = No, Y = Yes.

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