NBSIR 78-1500

Application of Life Cycle Costing to Hand-Held Hair Dryers: A Field Demonstration for Small Appliances

S. Wayne Stiefel
P. Clare Goodman
William B. Beine

Consumer Sciences Division
Center for Consumer Product Technology
National Engineering Laboratory
National Bureau of Standards
Washington, D.C. 20234

May 1978

Final Report

Prepared for
National Bureau of Standards
Department of Commerce
Washington, D.C. 20234

NBSIR 78-1500

APPLICATION OF LIFE CYCLE COSTING TO HAND-HELD HAIR DRYERS: A FIELD DEMONSTRATION FOR SMALL APPLIANCES

S. Wayne Stiefel
P. Clare Goodman
William B. Beine

Consumer Sciences Division
Center for Consumer Product Technology
National Engineering Laboratory
National Bureau of Standards
Washington, D.C. 20234

May 1978

Final Report

Prepared for
National Bureau of Standards
Department of Commerce
Washington, D.C. 20234

Acknowledgments

The writers gratefully acknowledge the contribution of Elizabeth Robertson, who structured and conducted the survey of small appliance repair firms. Ruth Warnock also deserves thanks for her conscientious secretarial assistance in the preparation of this manuscript.

Contents

List of Tables

List of Figures

1.2 Objective

The objective of this study was to collect information on hair dryers, aid development of life cycle performance test methods and characterize costs as a function of time. The project was a demonstration study on hair dryers to provide insights into the processes and techniques which can be used in the application of the LCC technique for a small appliance where the consumer is a significant factor in its usage.

1.3 Approach

Two parallel approaches were utilized during this project. Field data collection methods, intended to develop information on usage, repair and cost information, constituted the efforts which are documented in this report. Laboratory test method development efforts will be documented in a forthcoming NBS report.

The field data collection included a pilot field experiment to collect usage and repair data from consumer participants provided with specially instrumented hair dryers. Repair incidence and repair cost data were also collected by two other methods. First, used hair dryers were collected from volunteers for failure mode analysis. Second, repair agencies were surveyed for repair and service cost data.

2. HAIR DRYER FIELD EXPERIMENT

2.1 Purpose

A hair dryer field study experiment was designed for three reasons: (1) to ascertain energy consumption, usage information and failure data from hand-held hair dryers; (2) to provide field data to compare with data obtained from a laboratory test procedure; and (3) to demonstrate the procedures for field monitoring of hand-held and other small appliances.

In addition to the instruments provided to record usage, a questionnaire was designed to obtain two types of information: namely, usage patterns and personal user characteristics. Information on usage patterns was sought for two reasons. First, since many previous studies have relied entirely on user recall as a means for obtaining usage data, it was desired to observe the correspondence between measured data and user estimated data. Second, the measuring instruments could not supply certain types of usage data, such as the temperature setting which affects energy consumption.

Personal data were collected to determine the composition of the participant group for possible comparison with other studies. Additionally, this information would facilitate any future analysis of failure characteristics, such as the correlation between length of hair and time to failure. The sample was not originally intended to be a statistical representation since families with more than one user were favored over single users, especially single users with low usage rates.

2.2 Methodology

2.2.1 Selection of Hair Dryers

A preliminary laboratory study was conducted involving 15 brands of hand-held blow hair dryers. Based on the preliminary tests, a model with a fairly high rate of laboratory failures was selected for further laboratory test method development and use in the field experiment.

The sample size required for the field study was determined by following a statistically based estimation procedure.[2] The preliminary laboratory study of dryers was used as an initial sample to calculate a mean failure time and a standard deviation that were needed to estimate the total required sample size for the second laboratory study and the field study. Equations and detailed calculations are given in Appendix A.

2.2.2 Selection of Participants

Sixty hair dryers were distributed equally among two sets of participants:

(1) Families of NBS employees providing "normal" use.

(2) Local hair cutting salons providing "heavy" use.

---

[2]Mary Natrella, Experimental Statistics, National Bureau of Standards, Handbook 91, October 1966, pp. 2-10.

The two sets of participants were selected with distinctly different purposes in mind. Family participants provided data on dryer usage (frequency of use and duration for each use). Hair salons were selected to provide data on failures (time to failure and failure modes) within a relatively short period of time.

The family participants were selected from volunteers responding to several notices placed in the weekly NBS Technical Calendar. Prescreening information was obtained from those volunteers who indicated interest in participating in the study.

The prescreening information included the following:

- NBS office location and number. All contacts were made at NBS.

- Type of hair dryer presently being used. This was asked in order that dryers be distributed only to persons who were already using a hand-held blow hair dryer.

- Number of persons in the family who would use the dryer and probable frequency of use. From these questions an estimate was made for the total amount of use the dryer might receive. Families who would use dryers less than two times per week were not selected.

- The outlet location for the hair dryer. Families who did not plug their dryer into a standard size outlet could not participate. The instrument box located at the end of the power cord was too large to fit into most medicine cabinet outlets.

Prescreening information was collected for 50 volunteer families. From these volunteers a sample of 30 participants and 5 alternates were selected. Acknowledgements of appreciation were mailed to all volunteers who were not selected. Those selected were mailed a letter describing the study and informing them about Participant Agreement forms that had to be signed by all potential study participants. During the following week these forms were collected. For privacy, a folder for each participant family was numbered and names were matched to numbers on a separate list located in a different office. The preliminary information as well as the participant agreement forms were kept in these folders.

A demonstration of the operation of the hair dryer, including the location of the control settings, was given when each NBS employee picked up a study dryer. At this time participants were also asked to read the instruction booklet and insure that each user of the dryer in their family also read the booklet and understood the operation of the hair dryer.

The second set of participants were beauty salon operators who use hair dryers several times per day. Locating hair salons willing to participate using the hair dryer selected proved to be unproductive. Few salons were willing to use 1000 watt dryers. Most of them wanted something that would produce more heat, such as a 1200 or 1500 watt dryer. Even beauty salons that used 1000 watt dryers on a regular basis found the study dryers to be unbalanced or too bulky for continuous use. The following list summarizes the type of complaints that were heard from beauty salons, about the study dryers:

- Doesn't dry fast enough.
- Not hot enough.
- Hard to handle.
- Heavy and bulky.
- Could not find a place to plug in the black box.

A number of hair cutting places tried the dryers, but none appeared to be satisfied enough with their operation to continue using them. Consequently no use data was obtained from this set of participants.

2.2.3 Data Collection Procedures (NBS Families)

The instrument box, containing the elapsed time and frequency count meters, also served as the dryer's electrical plug and was attached to the plug at the end of the hair dryer power cord. The box's dimensions necessitated use of a wall outlet as opposed to a medicine cabinet outlet. The purpose of the time meter was to measure the total cumulative time the dryer was in operation. The purpose of the counter was to measure the number of times the dryer was turned on. The number of counts obtained should not be taken to represent the number of times the dryer was used since a dryer is typically turned off and on again several times during a single drying process. An interruption, such as answering a telephone, or a routine practice, such as putting in hair curlers, results in more than one on-off count during a single drying period. Therefore, it is important to note that the meter used for this field study measures the number of times the dryer was turned on.

In addition to meter results, users were asked to estimate their usage based upon personal recall. The information obtained from the two approaches complement one another and allows for the comparison of recalled versus metered responses.

During August 1977 each study participant completed the questionnaire concerning their usage patterns. Table 1 is a copy of the first questionnaire. In September 1977 it was discovered that an additional question should be asked; it is shown in table 2. The results of these questionnaires are reported in Appendix B of this document. The results reported are representative of 9 to 11 weeks of use attained during FY 77. The study is continuing and participants have retained the dryers to accumulate additional use and failure data.

In compliance with requirements of the Privacy Act, a system was established to protect against the disclosure of the personal information collected.

2.3 Participant Description

The number of persons using a dryer in a single household ranged from one to four. A total of 68 people were using the 30 dryers. This translated to an average of 2.26 users per dryer. Three families chose to stop participating at the end of the fiscal year 1977, the remaining families all agreed to continue. One new family was added and assigned one of the dryers from a family no longer participating.

For each participant, the following personal data were collected and tabulated: age, sex, thickness of hair, length of hair, and room most often used to dry hair.

Table 1. Usage pattern survey instrument #1.

Dryer # ________

We would appreciate each person using the study hair dryers taking a few minutes to answer the following questions.

Sex

Male	Female

Age

under 10	10-15	16-21	over 21

How would you describe your hair?

- ☐ Thick
- ☐ Medium
- ☐ Thin

How long is your hair?

- ☐ Short
- ☐ Collar length
- ☐ Shoulder length
- ☐ Longer than shoulder

Do you routinely use hair spray before you finish using the hair dryer?

- ☐ Yes
- ☐ No

Approximately, how many times per week do you use the hair dryer?

________ times

About how many minutes do you spend each time drying your hair with the dryer?

________ minutes

Estimate the percentage of time you use the dryer at each temperature setting.

High ______ %

Medium _____ %

Low ______ %

Cool ______ %

Above entries should total 100%

In which room do you most often dry your hair?

- ☐ Bathroom
- ☐ Bedroom
- ☐ Kitchen
- ☐ Living room
- ☐ Other (Please describe)

____

Did you find the attached black box inconvenient?

- ☐ No
- ☐ Yes--Explain ________________________

____

Did the dryer perform abnormally at any time? For example, stopped and started by itself while drying, did not produce heat, smoked, etc.

Please explain ________________________

____

Table 2. Usage pattern survey instrument #2.

Is the hair dryer normally turned on and off more than once during each drying use?

- ☐ Yes ⟶ How often? _____
- ☐ No

Sex

Male	Female

Age

under 10	10-15	16-21	over 21

Excellent cooperation was received from all questionnaire recipients, with a 100 percent response rate. Appendix B contains tables summarizing these data.

The participants included 43 females and 25 males. Approximately half of the participants were over 21 years of age. The younger participants (21 or under) were much more likely to be female while the older participants were equally divided among males and females. Most participants had either short or collar length hair, which tended to be of medium thickness, with only a few thin-haired participants.

2.3.1 Questionnaire Usage Results

The bathroom was the room most often used to dry hair by 65 percent of the participants. The bedroom was most used by 32 percent (see Appendix B, table B-4). A 1975 national market survey on hand-held styler/dryers reported that 59.6 percent of the dryers were used in the bathroom most of the time, and 27.6 percent were used in the bedroom.[3]

Each participant was asked to estimate the following: (1) average frequency of dryer usage per week; (2) minutes per use; (3) on and off's per use; and (4) percentage of time at each temperature setting. Together, (1) and (2) yield "accumulated hours per dryer"; (1) and (3) yield "on-off cycles per dryer"; and (1), (2), and (3) yield "minutes per on-off cycle."[4] These calculated values can be compared to the measured data obtained from the instrument box.

Average frequency of dryer usage per week as estimated by this study can be compared to other studies. Among NBS families the average number of uses per week was 4.35. Comparison of the distribution of frequency data (table 3)

---

[3] Proprietary report.

[4] See Appendix C for histograms of each of the three categories of data described above.

by NBS families and a 1975 national market survey on hand-held dryers reveals that roughly similar percentages of people use the dryer 1-2 and 3-4 times per week. Among frequent users of hair dryers, the sum of the 5-6, once a day, and more than 7 times per week categories are comparable. Many more people in the national study claimed use of the dryer once a day, rather than slightly more or slightly less.

Table 3. Comparison of market survey frequency of use to field study results.

Frequency of use	Field results	National survey
More than 7 times per week	10%	1.5%
Once a day	13%	38.3%
5-6 times per week	16%	1.8%
3-4 times per week	34%	29.3%
1-2 times per week	27%	27.3%
Less than 1 time per week		1.7%

The questionnaire also solicited other information, such as hair spray use, convenience of instrument box and perceived performance problems.

It is possible that hair dryer failures could result from use of hair sprays. Only one person in this study reported routinely using hair spray before finishing use of the dryer. Since this represents only one percent, a substantial number of failures due to hair spray is unlikely.

The instrument box or "black box," located at the end of the power cord, was judged to be inconvenient by 26 percent of the users. Table 4 lists the reasons given by these people.

Table 4. Instrument box convenience assessment.

Did you find the black box inconvenient?

No	50 or 74%
Yes	18 or 26%

Following were the reasons given (more than one reason was given on a few occasions):

4	Furniture had to be kept away from the wall, due to the size of the box.
5	Box would not fit in certain outlets (bathroom).
3	Box was too large/bulky.
2	Had to use an extension cord.
2	Box was inconvenient for storage.
1	Box would not stay in wall socket.
1	Box caused power cord to become twisted.
1	Box was ugly.
1	Box would not fit in a wall socket that already had a plug in the bottom position.

Only a few dryer performance problems were reported. Table 5 lists the problems cited by participants. All of the problems with the 30 dryers were reported by four families.

Table 5. Hair dryer performance problems.

Did you experience any performance problems?	
No	62 individuals (91%)
Yes	6 individuals (9%)
Following are the problems given:	
2	"Not powerful enough."
1	"A couple of times the dryer sounded like it was going to stop."
1	"Once when only one switch was pushed to high and the other one on "off" there was no air and the coils inside turned bright red."
1	"A few times it would produce a smoky smell like burning hair."
1	"Slowed down briefly--then up to speed."
1	"Slowed down for 2-5 seconds during drying, but it resumed normal operation by itself--may be line voltage fluctuation."

2.3.2 Comparison of Recalled Estimates with Measured Values

During 1975, an experimental study[5] on hair dryer usage was conducted in the NBS Human Factors Laboratory. Twenty subjects were requested to dry their hair using their own dryer while their activities were monitored and videotaped. The average drying time of these 20 laboratory sessions was seven minutes. The subjects were also requested to complete a brief questionnaire concerning their home use of the dryer. The average reported drying time at home was 12 minutes. A large difference between the self-estimated use time and the laboratory use time is evident. It could be postulated that the difference in location and the experimental circumstances influenced the use period. The measuring of use cycles in home environments would provide additional indications if an overestimation pattern by users should be expected.

---

[5] Stefl, Mary, Electrical Appliances: Hand-Held Hair Dryers, Interim Report CPSC Project No. 132, Unpublished draft, May 10, 1976.

Many studies have relied upon consumer estimates as the means for obtaining usage data on appliances. In this study it was possible to contrast recalled results with measured values to evaluate their comparability. The raw usage data from both the metered values as well as the recalled survey responses obtained from the individual users have been tabulated in Appendix B. The hair dryers were used approximately nine weeks prior to reading the instruments (which provided estimates of total hours of operation and on-off counts for each of the dryers). Comparable recalled values have been computed for each hair dryer using appropriate weighting factors for each of the dryer users. These values and their methods of computation are shown in Appendix C. Comparisons were made between the recalled survey and metered estimates for the total hours of operation, total on-off cycles and minutes per on-off cycle.

Figure 1 compares the total estimated hours of operation for each hair dryer as read from the meter and as calculated from the recalled survey. A perfect correspondence would result in all points lying on the "45 degree line." In only two cases, which occurred at low usage values and within the measurement error, was the recalled estimate lower than the meter reading, and in two more cases the recalled estimate and meter reading were the same. All the remaining cases involved recalled estimates exceeding metered estimates. In many cases the survey estimate is several times that of the meter reading. A least squares fit of the points is also shown in figure 1. The average estimated hours of operation was 13.8 for recalled and 4.1 for metered values.

Figure 2 illustrates graphically a comparison of the two estimates for total on-off counts. The recalled values were summed for each user for comparison with the meter values. Again, perfect correspondence would result in all points falling on the "45 degree line." As in the case of hours of operation, recalled values far exceed metered values for the vast majority of dryers.

Figure 3 provides the data on minutes per on-off cycle. The pattern of recalled exceeding metered values is once again repeated.

An important conclusion can be drawn from observing the scatter shown in figures 2 and 3 when comparing the metered and estimated values. No adequate relationship between the recalled and metered values can be established, because of

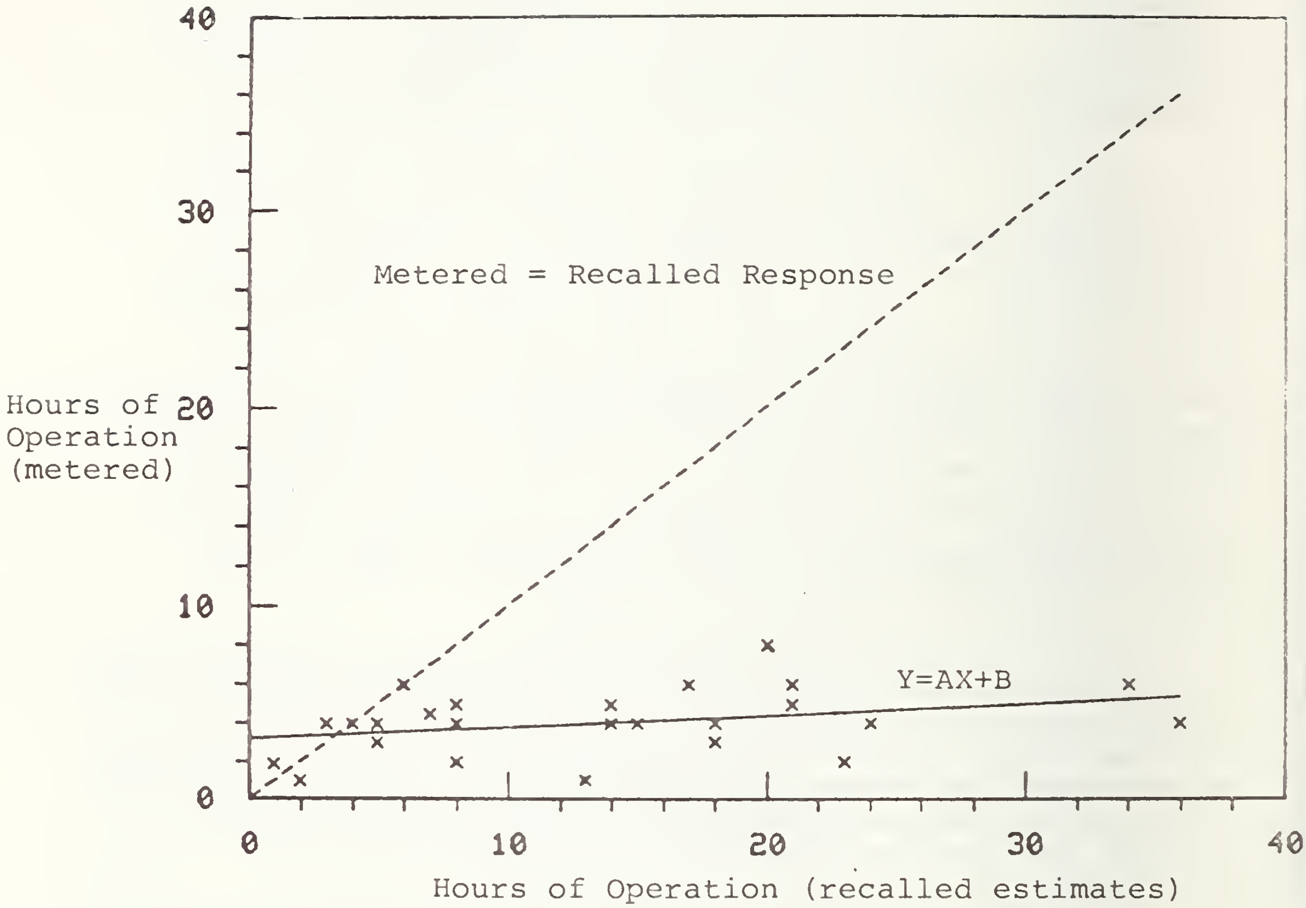


Figure 1. Total hours of hair dryer operation: comparison of metered versus recalled estimates during approximately 9 weeks of field use.

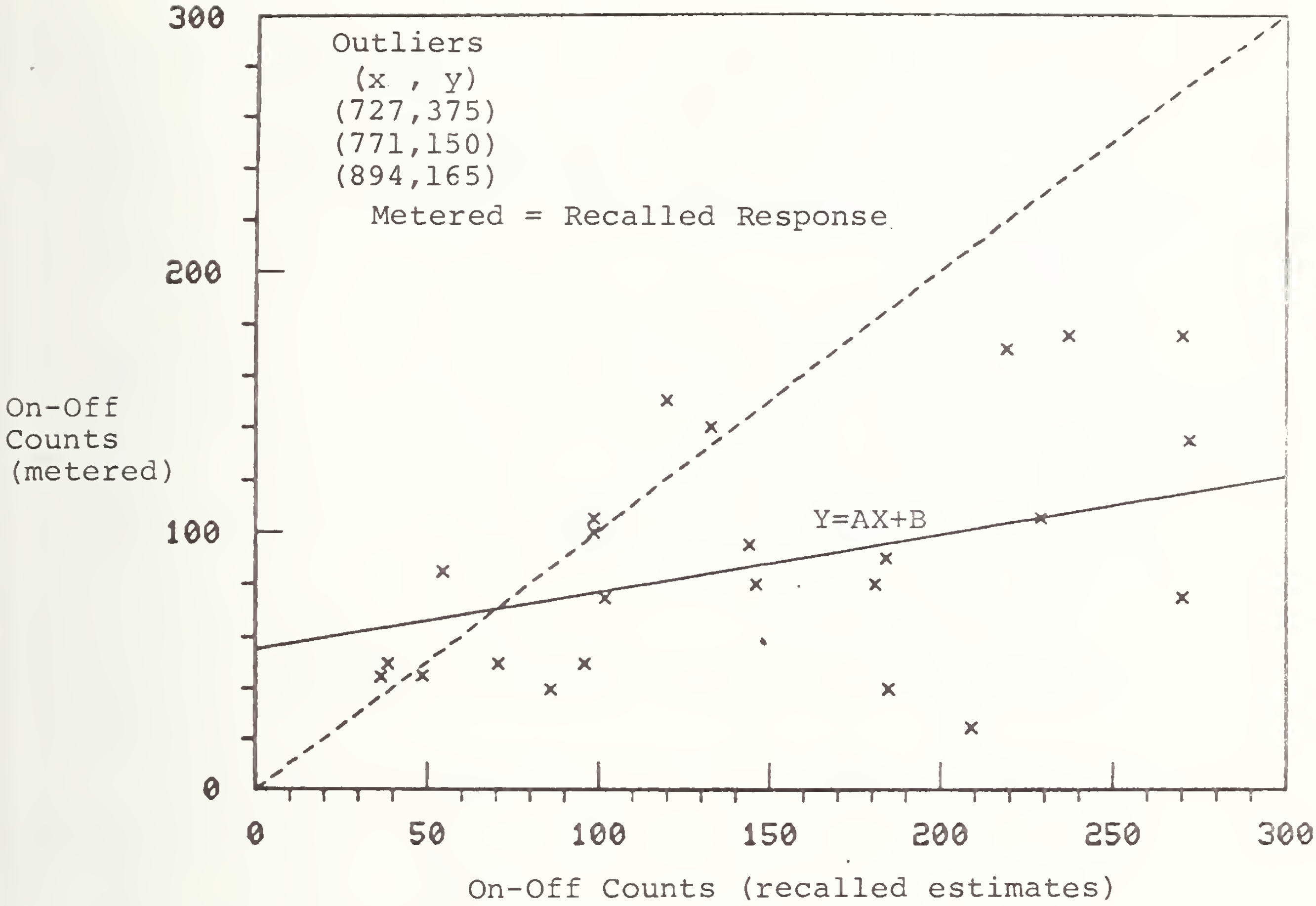


Figure 2. Total on-off counts: comparison of metered versus recalled estimates during approximately 9 weeks of field use.

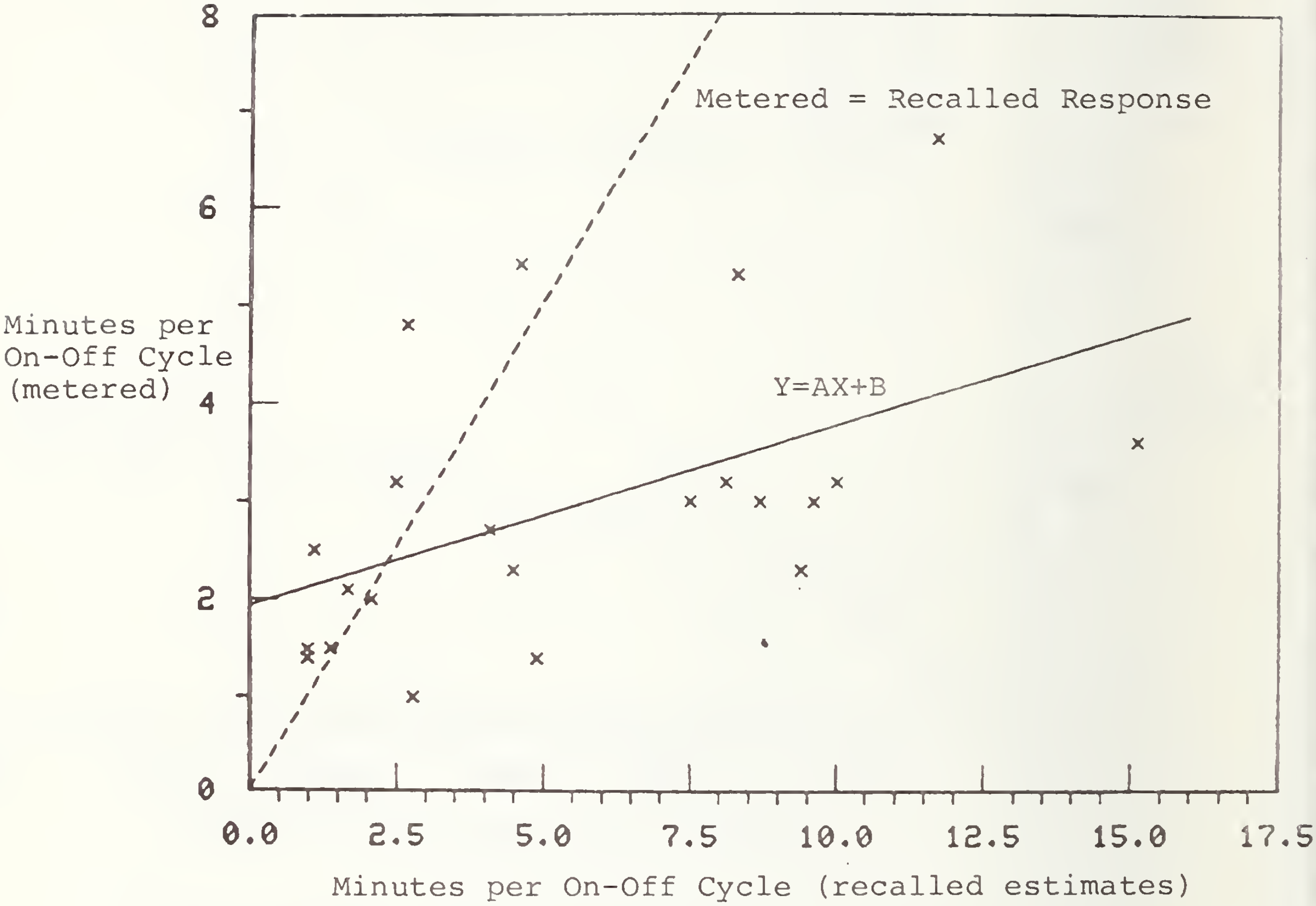


Figure 3. Minutes per on-off cycle: comparison of metered versus recalled estimates during approximately 9 weeks of field use.

the poor correlation between the data and the fitted curve. Furthermore, the discrepancy between the line representing exact correspondence and the best fitted line points out the need for good measured data to draw accurate and reliable conclusions about usage.

3. REPAIR AGENCY SURVEY

3.1 Survey Process

The objective of this survey was to examine the use of repair agencies as a source for repair cost data and as a means to identify the most frequent hand-held blow hair dryer failures. To expedite the data collection, firms specializing in the repair of small electric appliances were sought. Several firms across the country were willing and capable of estimating repair costs and identifying the most frequent repairs performed.

This pilot survey was designed to investigate interviews and questionnaires as methods for acquiring information and data on small appliance failures, particularly hand-held blow hair dryers. Since it was a pilot survey, the number of interviews was limited, in this case to nine respondents. Because of the limited numbers, the survey can not be assumed to be statistically representative of repair agencies.

Respondents included:

1. Four local appliance repair firms listed in the yellow pages.

2. Four members of the National Appliance Service Association (NASA).

3. One manufacturer.

NASA, located in Kansas City, Missouri, is a group of 125 firms who are owners of factory-authorized appliance centers servicing small electrical appliances. The four members interviewed were scattered throughout the U.S.

The interviews were conducted using the telephone. The persons being interviewed were assured that no identifiers would be associated with the information collected. Although a schedule of questions was used to guide the conversation, the interviewer was free to pursue areas the repair expert believed to be pertinent. In this way all questions on the schedule were addressed in each interview and additional information was collected which could not have been obtained from a set format of questions.

The schedule covered items referring to the problems consumers experience with dryers and with their repair, as well as costs for repair. In addition, the service agency was asked about their problems in providing service. The schedule used was:

> What kind of problems do people have with hand-held blow dryers? What is the most frequent problem you see coming into your shop? About how many dryers do you see (come in for repair) in an average week? How much time is involved in the repair? Does your shop perform the repairs? How much does it cost, on the average?
>
> How old are the dryers which come in for repair? Are some dryers, because of design, either difficult or impossible to repair (for example, sealed units)? In that case, how does the customer get his dryer repaired? Do you have any difficulty getting parts for some brands? How much do the parts cost?

3.2 Results of the Interviews

3.2.1 Most Frequent Repairs

Table 6 gives the number of times each repair was mentioned and how many times the repair was ranked as being the most frequent. Included in these data are results from five earlier contacts with manufacturers made in a preliminary investigation.

Table 6. Ranking of most frequent repairs.

Repair Problem	No. of times mentioned	No. of times ranked 1st
Heating element	10	4
Cords	7	6
Cleaning	7	1
Fuse	6	2
Switches	5	-
Fans	3	-
Motor	3	-
Thermostat	2	-

3.2.2 Cost for Service (labor and parts)

The average cost including labor and parts to repair a dryer in general was $7.78. The lowest recorded cost was $3.50; the highest was $11. Table 7 lists the repair fees typically charged represented by the average cost and the highest and lowest cost reported for particular repairs. These figures are inclusive of labor and parts as the repair firms tended to discuss a "flat price" rather than to calculate time and material costs separately.

Table 7. Repair fee estimates.

Repair of ...	Average cost	Lowest cost reported	Highest cost reported
Cords	$5.63	$3.50	$ 7.00
Heating element	9.50	8.00	11.00
Fuse	5.71	6.00	7.85
Switch	5.93	3.50	7.85
Fan	5.68	3.50	7.85
Thermostat	5.68	3.50	7.85
Clean	6.93	3.50	7.85

3.2.3 Parts Cost

Only a few of the respondents reported the costs of particular parts. Table 8 shows the part, the average cost and the lowest and highest cost reported.

Table 8. Parts cost estimates.

Part	Average cost	Lowest cost reported	Highest cost reported
Cords	$2.25	$1.50	$3.00
Fuses	1.33	.65	2.00
Elements	3.24	2.95	4.95
Switches	1.45	.95	1.95
Motor brushes	1.00	1.00	1.00

3.2.4 Causes for Failure

Many different causes for failure were mentioned during the interviews. One of the most frequently mentioned causes was the impeding of air flow thereby causing overheating. Blocking of air flow can result from build up of dirt, lint or hair; or from laying the dryer down while in operation in a manner that blocks the air intake. Another common cause of failure was the dropping of dryers resulting in damage to elements, switches and fans. One firm claimed the majority of dryers brought to it are not operating due to strain relief failure in line cords. Other failures result from dirt or hair lodged in bimetallic contacts and hair wrapped around motor shafts.

3.2.5 Repair versus Replacement

The decision to repair or to replace a blow hair dryer appears to be dependent upon parts accessibility and the cost for repair. Repair agencies generally do not stock parts for all hair dryers and obtaining parts sometimes results in lengthy delays. Two repair firms stated that if the cost for repairs exceeded eight or nine dollars it is better for the customer and the repair agency to offer a replacement dryer at a few dollars above their cost. Motor replacement costs are not listed in table 7 because the repair firms surveyed felt this cost to be prohibitive for most customers.

4. USED HAIR DRYER ANALYSIS

4.1 Collection Process

Used hair dryers (blow-type and stylers) were collected from NBS and other government personnel for a general analysis of hair dryer condition and failures as a function of construction and age. The procedure for this collection involved placing several notices in the NBS Technical Calendar requesting hand-held blow hair dryers that were no longer in use, whether operative or non-operative. At the time the dryers were collected, the following information was recorded:

1. Brand name.
2. Rated wattage.
3. Age of hair dryer.
4. Number of users.
5. Uses per week for each user.
6. Time per use for each user.
7. Reason for donation, if known.

The condition of collected dryers was analyzed and an attempt was made to determine the reason for failure if the unit was inoperative.

4.2 Results

A total of 54 hand-held hair dryers were collected; 17 were hand-held blowers and 37 were hand-held stylers. The blowers were of more interest to this study since blowers were being used for the field study and in the laboratory evaluation.

The age of the hair dryers collected varied but the majority of the dryers were either fairly new or relatively old and out-of-date. The oldest styler was five years, with the vast majority between one and two years. The blowers more clearly divided into two groups with 35 percent two years or younger and the remaining 65 percent six years or older. Table 9 shows the age distribution for all the units collected.

Because the survey cannot be assumed to be statistically representative, the results of the interviews can only be used to suggest the types of failures which might occur--not the frequency expected in the field.

Table 9. Age of hair dryers collected.

		Less than 1 year	1-2 years	3-4 years	5-9 years	Old or 10 years or more
All Dryers	No.	9	28	5	3	9
	%	17	52	9	6	17
Blowers Only	No.	2	4	0	2	9
	%	12	24	0	12	53
Stylers Only	No.	7	24	5	1	0
	%	19	65	14	3	0

Even though stylers were collected, blowers were analyzed more carefully for condition status and cause of failure. Of the 17 blowers, 11 operated, at least to some degree, and were divided into one of the following three categories:

1. Running poorly overall, or motor running slower than it should.

2. Operating acceptably with nothing apparently wrong.

3. Old enough to be considered out-of-date.

The remaining six were clearly broken or involved some type of failure. The six problems were as follows: loose fan blade, bent shaft, bad thermal element, shorted coil, broken wire and broken heater. Table 10 gives the data on the blowers that were collected.

Table 10. Evaluation of hand-held blowers collected.

No.	Watts	App. age* (years)	App. run time (hrs.)	Condition status*
1	950	1	100	Motor runs slower than it should
2	400	old	numerous	Appears to run o.k.
3	440	old	numerous	Burning smell, heater not working
4	440	old	numerous	Broken wire
5	275	old	numerous	Poor performance
6	215	15	780	Old
7	215	15	520	Old
8	215	6	150	Old
9	365	25	over 2000	Motor runs slow
10	200	7	150	Old
11	215	10	520	Excellent condition
12	215	old	unknown	Old
13	1000	2	70	Shorted coil
14	1000	1 1/2	60	Bad thermal element
15	1000	1/2	30	Bent shaft
16	?	1	1	Fan blade loose
17	?	3/4	65	Operating o.k.

*Old - indicates owner could not estimate age, however, unit appeared to be over six years old.

Of the 17 hand-held blowers the wattage was recorded for 15 of them. The average wattage was 452 and their wattage could be broken down as follows.

Wattage	Low 215 or less	Medium 275-440	High 950 or higher
Number of units	6	5	4

Because of the limited sample size the information can only be used for guidance and should not be generalized for the hair dryer population.

5. COMPUTATION OF LIFE CYCLE OWNERSHIP COSTS

The cost elements for hair dryers consist of purchase price, energy cost and repair costs during the retention period. A life cycle cost equation[6] for hair dryers follows:

$$LCC = P + \sum_{t=1}^{N} \frac{1}{(1+i)^t} \left[(EC)_t + (RC)_t\right] \frac{1}{(1+i)^N} (DC)$$

where,

LCC = present value of costs incurred during N years,

P = initial purchase price,

N = retention period,

i = discount rate (per year),

EC = energy cost,

RC = repair cost, and

DC = disposal cost. (This item becomes negative if a consumer received money when disposing of an old product.)

Purchase price information is readily available to consumers at point of sale. For the cost analysis a purchase price of $20 was selected as a representative value for a 1000 watt blow hair dryer.

Energy costs depend upon the input wattage and the intensity of use for the dryers. The magnitude of the energy cost expenditure would influence the importance in providing consumers a means for estimating its value. Because the recall survey responses exceeded the metered values for each use intensity measure, the recalled responses have been used to give an upper bound to the energy cost values. Table 11 shows the average use intensity values for the hair dryer users in this study.

---

[6] Stiefel, S. W., S. J. Kim and H. Hung, Life Cycle Costing: An Assessment of Practicability for Consumer Products, NBSIR 77-1212, December 1976, p. 15.

The values were derived from the recall survey data in Appendix B, table B-1. The estimated annual power consumption, also shown in table 14, was approximately 30 kWh. The calculated electricity cost is $1.19 or $2.38 at respective rate charges of $0.04/kWh and $0.08/kWh.

For this analysis the disposal cost (or salvage value) was assumed negligible. This is reasonable considering the ease for disposing of a small appliance and also the difficulty in finding a purchaser for a used hair dryer.

Table 11. Computation of cost of energy.

	Dryer Setting				
	High	Medium	Low	Cool	Total
Average # of hours per dryer per year	20.4	9.9	2.8	1.3	
Power input* (watts)	1021.5	733.2	484.2	187.9	
Annual kWh used	20.9	7.3	1.4	0.2	29.8
Annual cost ($) @ $0.04/kWh	0.84	0.29	0.06	0.01	$1.19
Annual cost ($) @ $0.08/kWh	1.67	0.58	0.11	0.02	$2.38

*Based on observations obtained from laboratory measurements on 60 units at a supply voltage of 120 volts A.C.

Discussions with the repair agencies in the survey indicated their approach in many instances was to offer new units at a few dollars above cost when repairs exceeded eight or nine dollars. Although many thousands of hair dryers are repaired annually, there is evidence that the vast majority of hair dryers are thrown away rather than repaired. A yet to be published survey, sponsored by the National Science Foundation at UCLA, dealing with small appliance disposal, indicated that 78 percent of blow hair dryers were replaced rather than repaired after failure.

More than half of the respondents said "that they would not hesitate to throw away a product costing less than $20 if it broke down."[7]

One approach is to assume that hair dryers essentially reach the end of their useful lives as soon as repairs are required. Under this assumption no repair costs are incurred during the hair dryer's useful life. A life cycle performance test method which could predict mean time to first failure would under this assumption also provide a useful life estimate.

If repairs and disposal cost are not included then the ownership cost equation consists only of purchase price and energy cost. It is possible to predict LCC values for many different retention periods. In the absence of objective results providing a useful life value, a series of LCC values were computed for energy rates of $0.04/kWh and $0.08/kWh and using discount rates of 0, 5 and 10 percent to illustrate their effect on cost. These values have been graphed in figure 4 for retention periods up to ten years.

Using the upper bounds of usage and energy cost, figure 4 indicates it takes approximately nine years for the energy cost to equal the $20 initial purchase price. Of course, using lower usage and energy rates and discounting future costs further lowers the influence of energy costs. On the other hand, doubling usage frequency would have the same effect as doubling energy costs.

The value of figure 4 is in making comparisons with alternative products to assess relative ownership costs. Energy cost estimates for other blow hair dryers can be derived from a combination of laboratory energy measurement, field usage data and energy rate data similar to that demonstrated by this project. To compare total ownership cost for an extended period of time the "useful life" estimate is needed. Dramatic differences in "useful life" estimates for dryers of nearly equal purchase price would result in a substantial difference in ownership costs. It is possible to translate the cost data to an average annual cost for the period corresponding to the useful life. The average annual cost basis provides the means for comparing products with different useful lives.

---

[7]W. David Conn, "Factors Affecting Product Lifetime," 27th Mechanical Failures Prevention Group Meeting, November 1977.

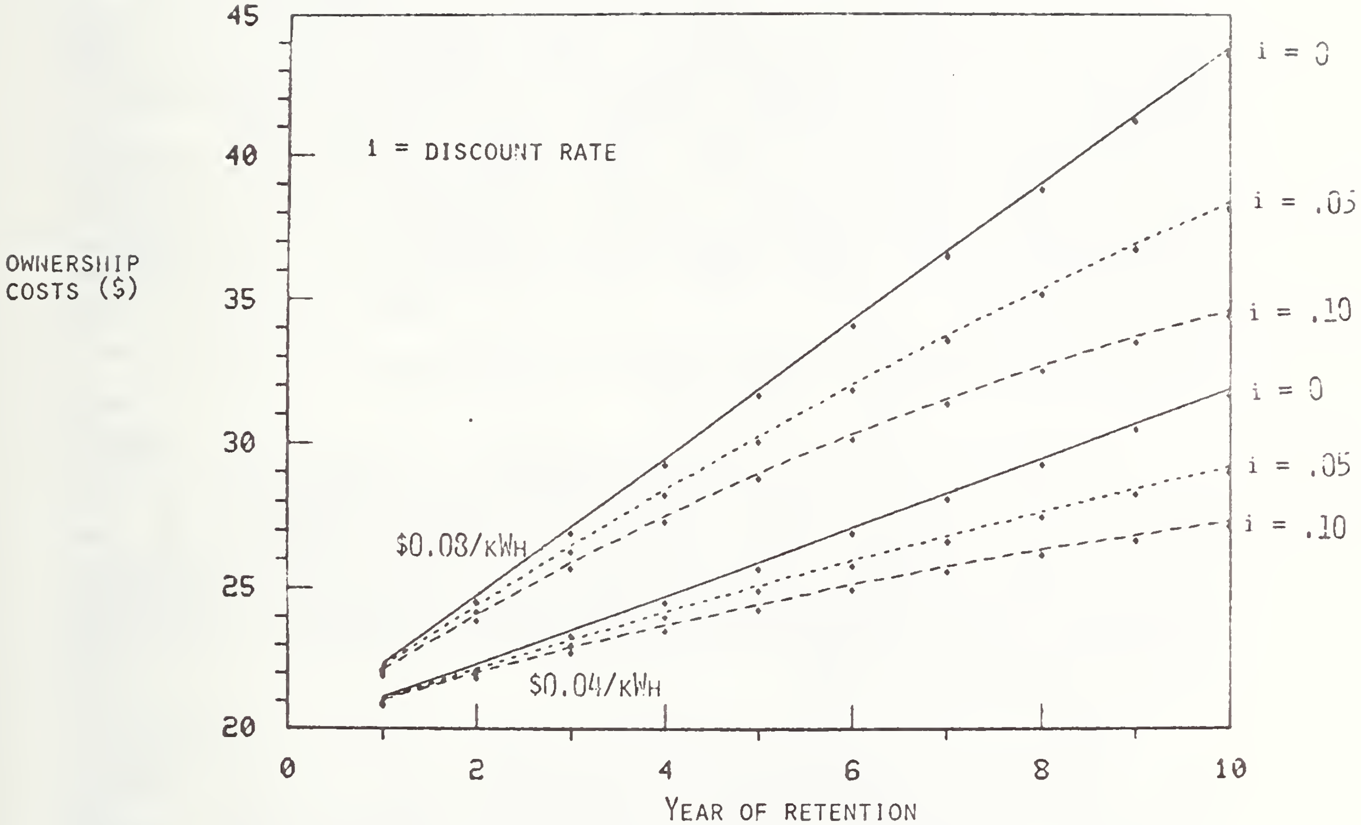


Figure 4. Average ownership cost for a 1000 watt blow hair dryer (excluding repairs) versus year of retention.

6. CONCLUSIONS

This project provided the opportunity to test various techniques to obtain information necessary for the development of life cycle performance test methods and the characterization of life cycle costs for a small appliance. Appendix D summarizes the organizational structure used for this project and the lessons learned which are applicable to similar field studies.

A primary element of life cycle cost information is usage data. Efforts to collect usage data involved both the recall survey and instrumentation techniques. The comparison of the results indicated a discrepancy between results obtained by these methods. Therefore for an accurate assessment of usage, data should be collected by means of instruments (e.g., timers, counters, etc.). However, since failures were found for several instruments and feedback from users indicated inconvenience, specific design and test criteria need to be addressed. Instrumentation should be designed for and tested under actual use conditions and should be configured to minimize their effect on usage patterns.

Efforts to locate repair incidence, failure mode and repair cost data involved a survey of repair firms, the collection of used (usable and broken) dryers and field testing under "normal" use conditions. The repair firm survey results indicated that the most frequently repaired components were heating elements, cords, fuses and switches. Cleaning was also indicated as a frequent activity for restoring units to use.

Collection of used hair dryers for analysis of hair dryer condition and failures as a function of construction and age provides some useful information, that allows engineers to evaluate functioning and non-functioning units and to collect through examination information on failed components.

The field testing experience indicated that extensive monitoring time would be required to obtain repair incidence and failure mode data under "normal" usage conditions. Heavy commercial users could speed up the process. However, they were not satisfied enough with the performance of the study hair dryer to continue its use. Future experiments, employing commercial firms to provide a heavy use test, should select products which satisfy the requirements of the commercial user.

Failure incidence data for small appliances are scarce, difficult to obtain and may be misleading. Preliminary data indicate that for inexpensive appliances, such as the hand-held hair dryer, most units are discarded when they need repair. Therefore, repair data obtained from repair firms and even from manufacturers would underestimate failure rates and may not be representative of failure modes. Because of the implications of this finding additional research to confirm the "throw away" approach to relatively inexpensive appliances is warranted. If products are generally not repaired then a laboratory test which succeeds in predicting mean time to first failure would also provide a reasonable useful life estimate. The laboratory test must stress all components likely to fail. To translate the laboratory result into a meaningful value for consumers requires the integration of usage information. This is necessary both to guide in the selection of the laboratory usage cycle and to relate mean operating usage cycles to mean calendar time.

Life cycle costing analyses were performed using the usage patterns derived from this study. Under the assumption that hair dryers essentially reach the end of their useful lives as soon as repairs are required, no repair costs were included in the analyses. Disposal cost was also considered to be negligible. The two cost elements remaining were initial purchase price and energy cost. In the absence of objective results providing useful life estimates, a series of ownership cost values were computed for energy rates of $0.04/kWh and $0.08/kWh and using discount rates of 0, 5 and 10 percent to indicate their influence on cost. Using the upper bounds of usage and energy cost, it takes approximately nine years for the energy cost to equal a $20 initial purchase price. Of course, using lower energy rates and discounting future costs further lowers the influence of energy costs. The value of LCC is in making comparisons among alternative products to assess their relative ownership costs. LCC comparisons for hair dryers would include factors for useful life, purchase price and energy costs in making comparisons on an annualized basis. Annualizing costs permits comparison of products with different useful life values over a similar time period.

APPENDIX A. ANALYSIS OF SAMPLE SIZE FOR HAIR DRYER EXPERIMENT

Problem: Compute the sample size required to ascertain the mean (m) failure time for the field study of hair dryers with a risk (α) that the estimate of m is off by d or more hours.

Preliminary laboratory tests on 15 hair dryers yielded estimates for time to failure. The mean failure time was 178.6 hours with a standard deviation of 41.6 hours. In order to determine sample size, estimates of the population standard deviation (σ) are required. Assuming the laboratory data provides a best guess concerning results expected in field testing, the standard deviation of 41.6 hours can be used to estimate σ.

Let $d = 10$ hours
$\alpha = .05$

According to NBS Handbook 91,* the first estimate of the total sample size required (n') can be computed as follows:

$$n' = \left[\frac{z_{(1-\alpha/2)}\sigma}{d}\right]^2$$

where, z = the z statistic from tables

$$n' = \left[\frac{(1.960)\ (41.6)}{10}\right]^2$$

$$= 66.5 .$$

A rough rule, according to NBS Handbook 91, is to make the first sample greater than or equal to 30 unless the computed sample size is less than 60. An initial sample size (n_1) of 30 units was selected for the field study.

The 30 units are undergoing field use. Once the failure data are obtained, the estimate of the population standard deviation (s_1) computed from these units can be used to determine how large the second sample should be. The second sample (n_2) is computed as follows:

---

*Mary Natrella, Experimental Statistics, National Bureau of Standards, Handbook 91, October 1966, p. 2-11.

$$n = \left[\frac{t_{(1-\alpha/2)}\ s_1}{d}\right]^2$$

where, t = student's t statistic from tables for n_1-1 degrees of freedom

n = the total sample size for the first and second samples combined

therefore, $n_2 = n - n_1$.

APPENDIX B. USAGE DATA SUMMARY

The tables in this appendix consist of summary data obtained from responses to the recall survey and obtained from each dryer's instrument readings for use hours and on-off counts. Table B-1 provides the recall usage data by participant for each hair dryer. Tables B-2, B-3 and B-4 summarize personal information pertaining to age, hair characteristics and room of use. Table B-5 contains instrument readings for hours used and on-off counts.

Table B-1. Questionnaire raw usage data.

Dryer no.	Days dryer used	User #1 No. times per week	User #1 Min. per use	User #1 On-off cycles per use	User #1 Temp. setting percent H	M	L	C	User #2 No. times per week	User #2 Min. per use	User #2 On-off cycles per use	User #2 Temp. setting percent H	M	L	C	User #3 No. times per week	User #3 Min. per use	User #3 On-off cycles per use	User #3 Temp. setting per cent H	M	L	C	User #4 No. times per week	User #4 Min. per use	User #4 On-off cycles per use	User #4 Temp. setting percent H	M	L	C
21	65	3	5	2.5	80	5	5	10	3	10	3	50	0	30	20	3	2	2	0	100	0	0							
22	64	6	1	1	0	0	4	96																					
23	57	3	5	3.5	75	0	0	25																					
24	70	10	5-10	1		25	75		7-10	5-10	1		25	75															
25	64	2	10	2	0	75	25	0	3	4	3	100				3	10	2	5	90	5		6	5	1		100		
26	68	3	5-8	1	80	20			2	15	1	100																	
27	66	7-10	10-15	2.5	10	10	30	50	2	3-5	1	90	10																
28	64	10	15	5.5		100			7	10	3.5		100																
29	62	2	20	5	100				7	15	11	100																	
30	64	2	10	1	90	10			2	5	1	90	10																
31	65	7	15	1		100			3	10	1		100																
32	69	1-2	15-20	2	100				5	8-10	1		100			2	10-12	1				100							
33	63	3 1/2	5	3	75	15	5	5	5	5	2		1	98	1														
34	65	3	12-15	1.5	100				1	20	1	98			2	3	10-45	2	100				4	15	2	100			
35	65	8-9	5	3	100																								
36	65	4	3	1	90	5		5	7	2	1	99			1														
37	63	3	5	1	100				4	20	6.5	20	75	5		1	15	1	100										
38	70	5	5	1	100				2	3-4	no resp.	50	50																
39	81	3-4	5	1		70	30		3	3-5	1	100				4	10-15	3	100				5	2	1	100			
40	63	6	10	1	100				6	30	4	100																	
41	62	7	5-8	10	95	1	1	3	1	5	1		100			1	5-8	30		100									
42	67	7	5	1			80	20	3	2	1		100																
43	58	7	5-10	1	100				5	10	1	100																	
44	62	7	7	1		100			7	4	1	90	10			1	10	1		100									
45	46	3	15	1	100				8	8-10	1		100																
46	62	3	20-30	1.5	95	5			3-4	10-15	1	100																	
47	67	5	2	2	100				1	3	2	100				1	5	3	100										
48	60	6-7	15	2	95	4		1	4	8	1	100																	
49	61	2-3	6	1	10	50	40		2	3	1	100																	
50	60	14	10	1	100																								

Table B-2. Sex and age of NBS hair dryer participants.

	Under 10 years	10-15 years	16-21 years	Over 21 years	Totals	Percentage
Male	0	2	5	18	25	37%
Female	2	8	15	18	43	63%
Totals	2	10	20	36	68	
Percentage	3%	15%	29%	53%		

Table B-3. Hair length and thickness of NBS hair dryer participants.*

	Short	Collar length	Shoulder length	Longer than shoulder	Totals
Thick	7	12	3	1	23
Medium	15	14	4	3	36
Thin	4	3	1	1	9
Totals	26	29	8	5	68

*Participants used their own perceptions for describing hair characteristics.

Table B-4. Room most often used to dry hair by NBS hair dryer participants.

	Number	Percentage
Bathroom	44	65
Bedroom	22	32
Living room	1	1
Family room	1	1
Totals	68	

Table B-5. Meter readings raw data.

Dryer no.	Days used	Hours used	On-off counts
21	65	2	25
22	64	2	85
23	57	1	40
24	70	2	40
25	64	4	105
26	68	5	45
27	66	4	170
28	64	6	375
29	62	5	150
30	64	4	45
31	65	6	no reading
32	69	4	105
33	63	no reading*	90
34	65	4	80
35	65	6	175
36	65	4	75
37	63	no reading	175
38	70	3	50
39	81	6	135
40	63	4	75
41	62	4	165
42	67	4.5	50
43	58	5	100
44	62	no reading	140
45	46	1	no reading
46	62	3	50
47	67	4	95
48	60	no reading	80
49	61	no reading	50
50	60	8	150

*No reading indicates meter readings could not be taken due to damaged instruments.

APPENDIX C. COMPARISON OF USAGE VALUES FOR SURVEY RESPONSE AND METER ESTIMATES

Comparison of the recall survey response with the metered values required computation of compatible values. Comparisons were made between survey and metered estimates for the hours of operation, total on-off cycles and minutes per on-off cycle. Distributions for estimates of accumulated hours per dryer, on-off cycles per dryer and minutes per on-off cycle comparing the metered and questionnaire survey responses are shown in figures C-1, C-2 and C-3. Values were either taken directly from the raw data or calculated as shown in table C. An explanation of how each of the calculated values in table C were derived, identified by column number, follows.

<u>Column 2 - Recall hours of operation</u>

$$\text{Hours of operation} = \text{days used} \times \frac{\text{hours}}{60\ \text{min}} \times \frac{\text{week}}{7\ \text{days}} \times \sum_{\text{User } i=1}^{N} \frac{\text{uses}}{\text{week}}(i) \times \frac{\text{min}}{\text{use}}(i)$$

<u>Column 3 - Recall on-off counts</u>

$$\text{On-off counts} = \text{days used} \times \frac{\text{week}}{\text{days}} \times \sum_{\text{user } i=1}^{N} \frac{\text{uses}}{\text{week}}(i) \times \frac{\text{on-off cycles}}{\text{use}}(i)$$

<u>Column 4 - Recall minutes per on-off cycle</u>

$$\text{Minutes per on-off cycle} = \frac{\displaystyle\sum_{\text{user } i=1}^{N} \left[\frac{\frac{\text{min}}{\text{use}}(i)}{\frac{\text{on-off cycles}(i)}{\text{use}}} \times \frac{\text{uses}}{\text{week}}(i) \times \frac{\text{min}}{\text{use}}(i) \right]}{\displaystyle\sum_{\text{user } i=1}^{N} \left[\frac{\text{uses}}{\text{week}}(i) \times \frac{\text{min}}{\text{use}}(i) \right]}$$

<u>Column 5 - Metered minutes per on-off cycle</u>

$$\text{Minutes per on-off cycle} = \frac{\text{hours used}}{\text{on-off counts}} \times \frac{60\ \text{min}}{\text{hour}}$$

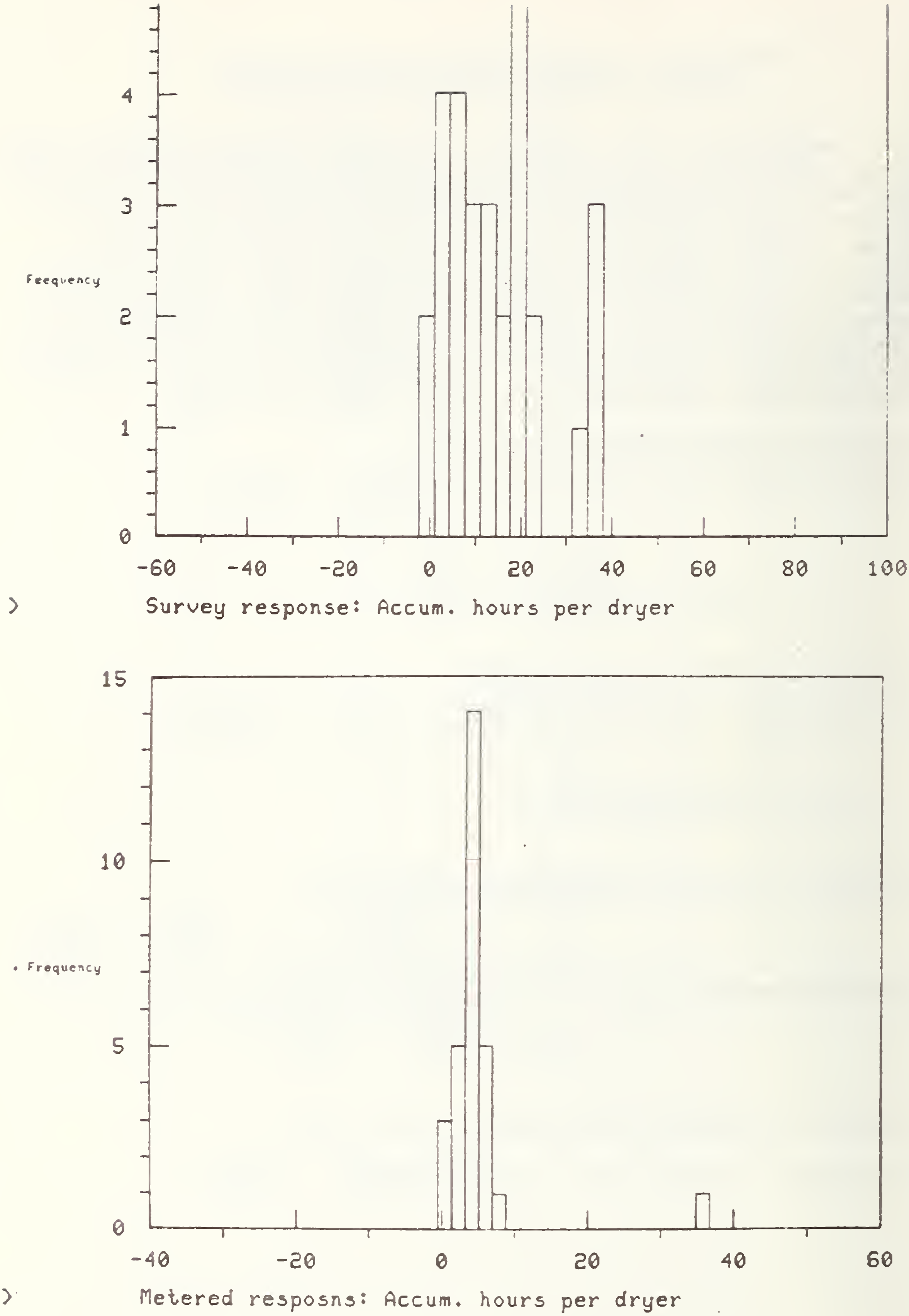
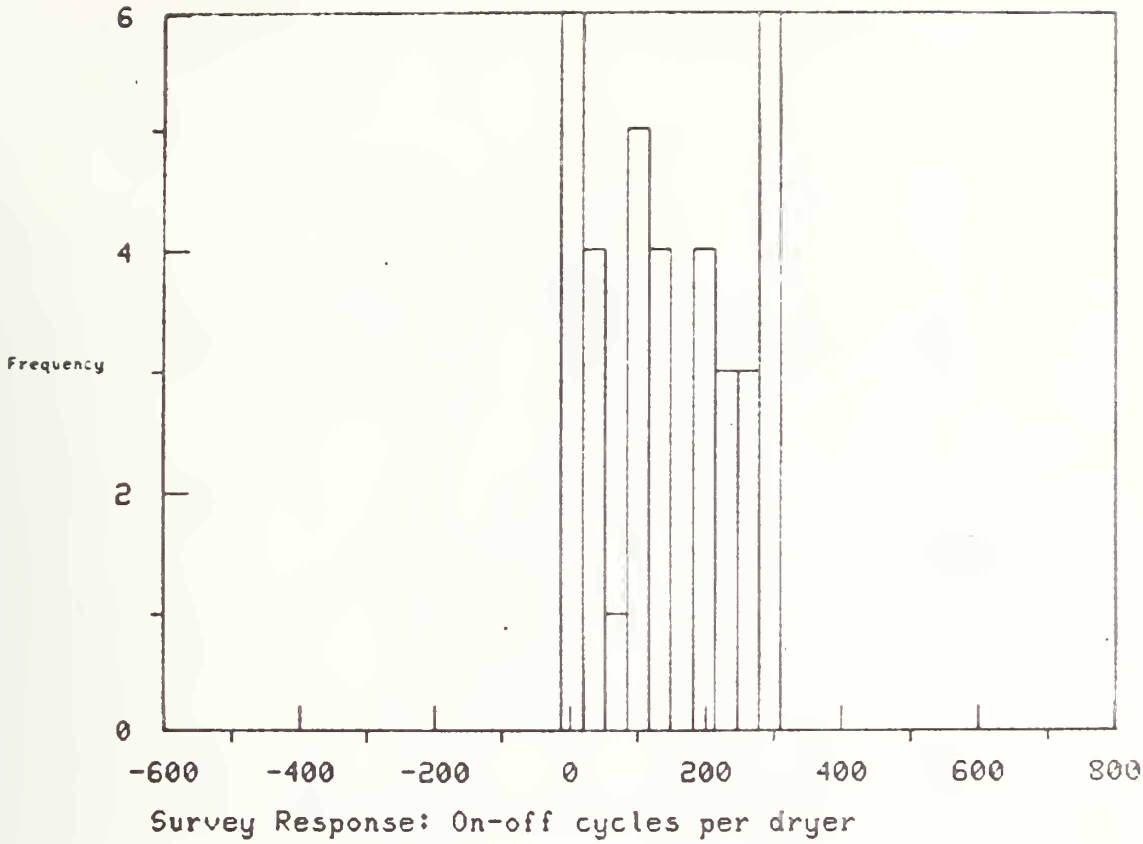


Figure C-1. Accumulated hours per dryer.



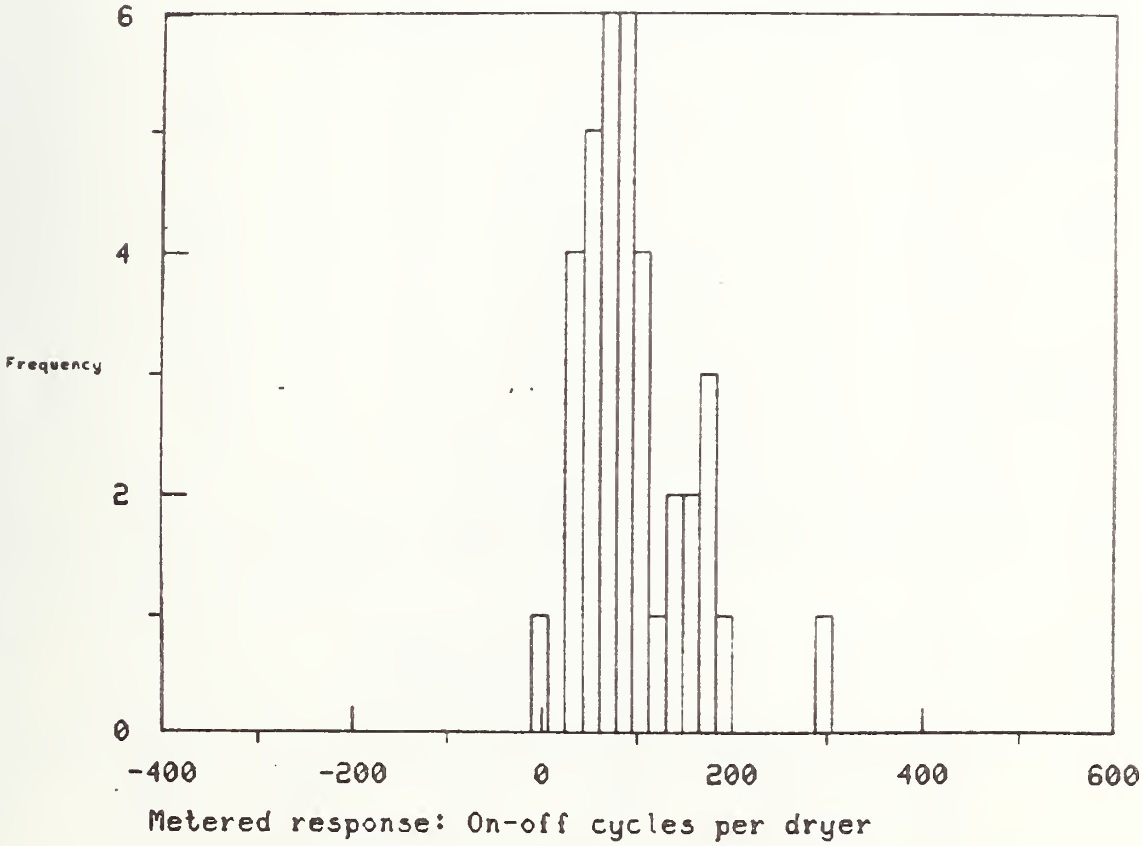
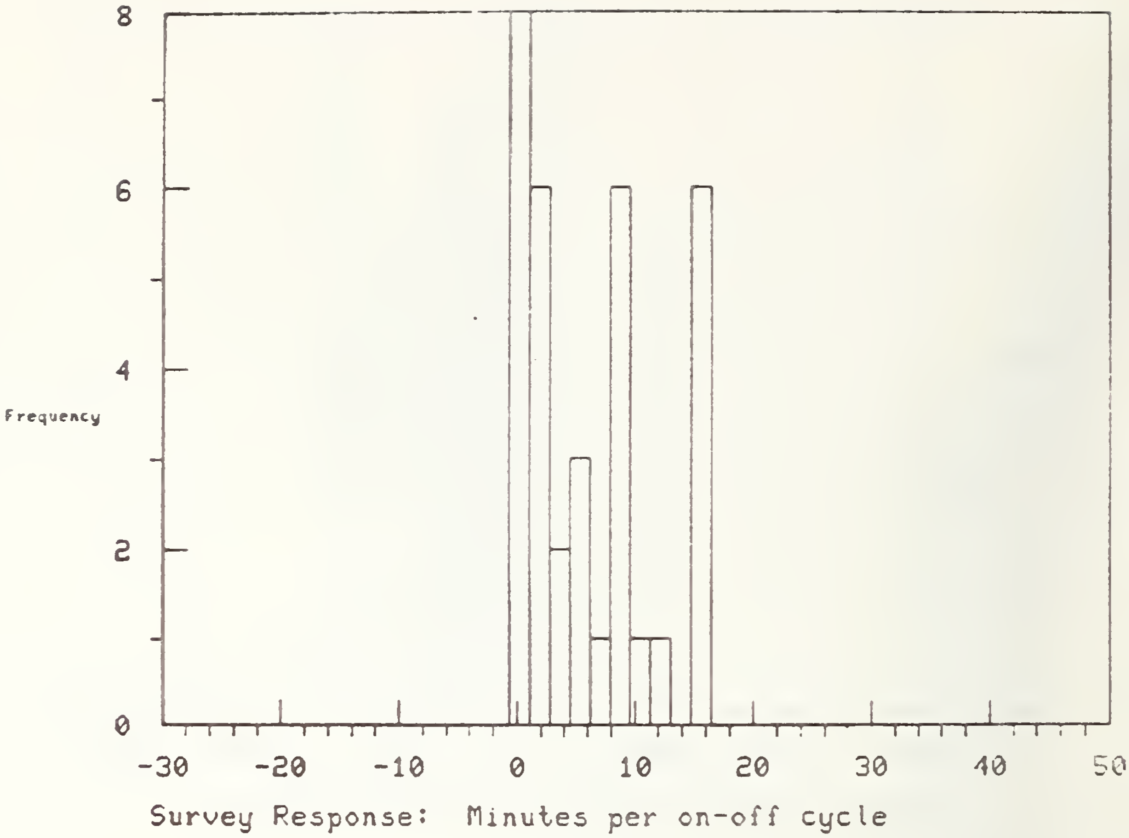


Figure C-2. On-off cycles per dryer.



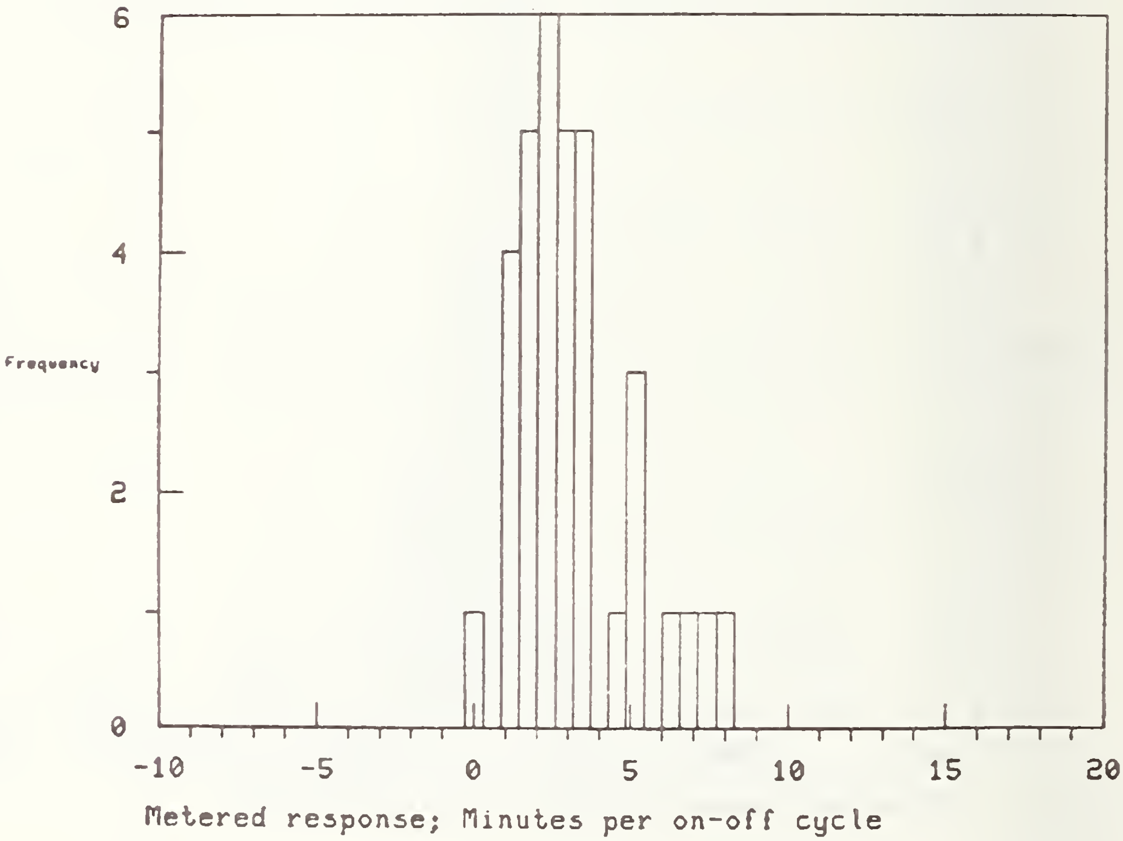


Figure C-3. Minutes per on-off cycle.

Table C. Calculated usage values.

Dryer no.	Recalled Estimates			Metered minutes per on-off cycle
	Hours of operation	On-off counts	Minutes per on-off cycle	
21	8	209	2.7	4.8
22	1	55	1.0	1.4
23	2	86	1.4	1.5
24	23	185	7.5	3.0
25	14	229	4.5	2.3
26	8	49	11.7	6.7
27	18	219	4.9	1.4
28	34	727	2.8	1.0
29	21	771	2.1	2.0
30	5	37	8.3	5.3
31	21	93	13.9	---*
32	15	99	9.4	2.3
33	6	184	2.2	---
34	24	181	9.6	3.0
35	6	237	1.7	2.1
36	4	102	2.5	3.2
37	17	270	5.0	---
38	5	no response	---	3.6
39	17	272	4.1	2.7
40	36	270	8.1	3.2
41	8	894	1.0	1.5
42	7	96	4.6	5.4
43	14	99	8.7	3.0
44	13	133	6.4	---
45	13	72	11.3	---
46	18	71	15.1	3.6
47	3	144	1.1	2.5
48	18	146	7.6	---
49	3	39	5.1	---
50	20	120	10.0	3.2

*Dashed lines indicate meter readings could not be taken due to damaged instruments.

APPENDIX D. IMPLICATIONS FOR FUTURE FIELD STUDIES

D.1 Organizational Structure

Designing, planning and implementing field studies requires organization. The organizational structure used in this field study is depicted by the flow diagram shown in figure D. Of course, every individual study may vary but the sequence and stages will be similar. Phase I involves translation from a set of objectives for a given consumer product through the planning of a field study design. Phase II incorporates the processes of obtaining approvals, instrumentation development, functional and safety testing, participant location, etc., required prior to Phase III implementation of the field experiment. Phase III includes pilot and pretesting of measurement instruments and questionnaires to insure any unforeseen problems are solved prior to implementation of the field study followed by the experimental part of the study. Phase IV involves analysis of data collected in order to translate it into the informational elements required and identified by the original project objectives.

D.2 Lessons Learned

D.2.1 Allocation of Time

Field studies are time consuming. Lead time must be allotted to allow for the various approvals, e.g., the NBS Human Research Ethics Committee and/or OMB, or to design, produce and test necessary measurement instrumentation.

The hair dryers remain in field use, although the data shown in this report constituted use periods of only 8 to 11 weeks. The expected usage pattern of the product under study and the project objectives should control the period allotted for deployment of products in the field. Usage data can be obtained with shorter deployment times than failure data. The combination of usage data with failure data is the ideal and is not available without monitoring field use experience.

D.2.2 Participant Selection

Finding willing participants can be a difficult and tedious process. Several advertising campaigns should be planned and attempted. More volunteers than eventually are needed should be solicited so a choice of participants is

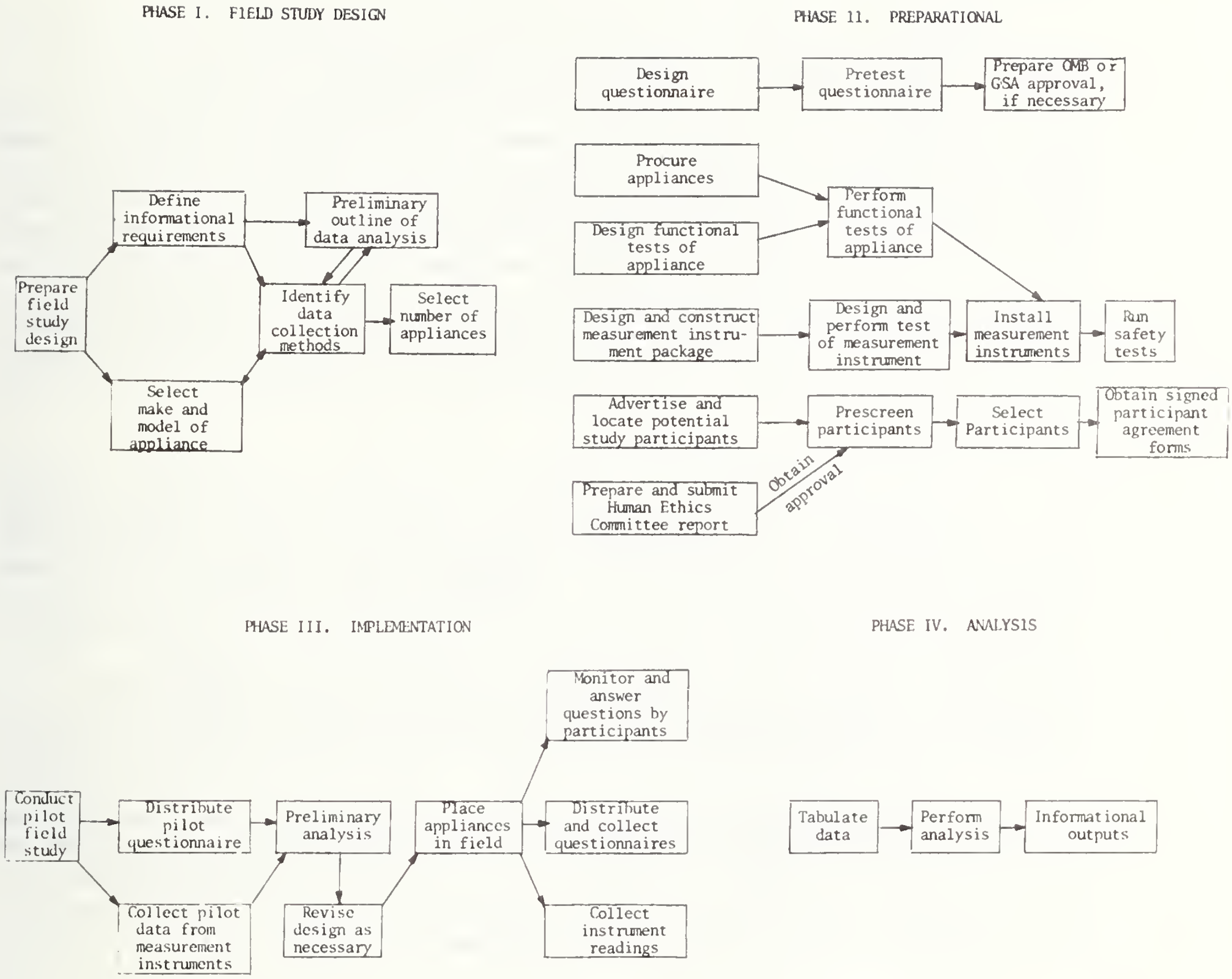


Figure D. Organizational structure for conducting field studies.

available at the time of selection. If a statistically representative sample is required the preliminary questionnaire designed for this field study should be expanded to include more in-depth information so participant selection can be made smoothly.

Attempts to utilize "heavy" users in order to shorten the expected time to failure proved unproductive. In our field study the hair dryers were rejected by hair cutting salons, following a trial period, because their heat output was inadequate and the measurement instruments inconvenient. Therefore, if the product being tested, which is suitable for a typical consumer, does not meet the requirements of the commercial "heavy" user, participants will be difficult to find. A second consideration when utilizing "heavy" users involves the type of use. If usage is substantially similar, only more frequent, higher failure rates can be translated to "normal" use. Failures caused by additional abuse or overloading, however, must be avoided.

D.2.3 Instrumentation for Data Collection

The comparison of the results from the recalled survey with the results from instruments measuring time and on-off counts pointed out a large deviation. Reliance on recalled estimates may be misleading. In addition to accuracy questions, volunteers are usually not willing to spend extensive periods of time answering questions about appliance usage; therefore the questionnaire should be limited to significant questions that can be answered quickly and easily.

No relationship between the metered and recalled values could be established. This lack of agreement points out the importance of using reliable instruments to draw valid conclusions. As much as possible of the data should be collected by means of timers, counters, etc.

Questionnaire development is one of the most intricate parts of the data collection. Before questions are written it is necessary to decide exactly what information is required. Wording of the questions also demands great care. The large discrepancies between the recalled data and measured values leaves some unanswered questions. Since both are estimates of the actual usage, it is highly desirable to be able to place confidence limits around them.

Internal instrumentation of the hair dryer circuitry was considered as an alternative to the external package attached to the power cord. Several considerations resulted in elimination of the internal instrumentation option including possible invalidation of the manufacturer's liability and modification of the hair dryer configuration which could result in changed performance.

Measurement instruments should be designed and tested with the field environment in mind. Five out of the 30 measurement units were damaged and could not be read. Although participants were asked to report dropping or other damage of the instruments, only one such case was reported. The measurement instruments should be tested for their accuracy, reliability and resistance to expected environmental effects, such as shock. If possible a set of products should be designated for control, equipped with both the measurement instruments and a control device such as a conventional timer and counter.

A secondary effect was observed for the measurement boxes attached to the hair dryers. During this study it was discovered that several participants considered the measurement boxes inconvenient, therefore it is possible that use patterns were changed. It would be difficult to determine to what extent these complaints affected dryer usage.

The hair salons were a particularly interesting case. They not only found the black box inconvenient, but they stated that they did not have the space to plug in the dryer because of the box size. Space was often very tight in beauty salon outlets because so many other appliances such as curling irons were also plugged in the same wall sockets as the hair dryers.

D.2.4 Failure Data Collection

The identification of failure modes was accomplished using both collection of used hair dryers and survey of repair agencies. The field study has only resulted in a single failure during the few months it has been in progress. Failure rate data, however, was not found during the course of this study.

Some of the individuals, which contributed failed hair dryers still under warranty, did not want to be troubled by the nuisance, delay and expense involved with getting a repair. If such an attitude is pervasive, feedback of failure rate data to manufacturers may be incomplete even during warranty periods. Many persons view the hair dryer as a relatively inexpensive appliance which they perceive as economically unrepairable. It is expected that although many thousand hair dryers are repaired, the majority are discarded. Small inexpensive (less than $25) products like the hair dryer probably follow a similar pattern. This implies failure rate data from user experience or repair agencies will be very difficult to obtain, or may be misleading. Laboratory test methods, based upon controlled field experiments, may be the only means for obtaining useful life estimates for these small appliances.

NBS-114A (REV. 11-77)

U.S. DEPT. OF COMM. BIBLIOGRAPHIC DATA SHEET	1. PUBLICATION OR REPORT NO. NBSIR 78-1500	2. Gov't Accession No.	3. Recipient's Accession No.
4. TITLE AND SUBTITLE Application of Life Cycle Costing to Hand-Held Hair Dryers: A Field Demonstration for Small Appliances			5. Publication Date 6. Performing Organization Code
7. AUTHOR(S) S. Wayne Stiefel, P. Clare Goodman and William B. Beine			8. Performing Organ. Report No.
9. PERFORMING ORGANIZATION NAME AND ADDRESS NATIONAL BUREAU OF STANDARDS DEPARTMENT OF COMMERCE WASHINGTON, D.C. 20234			10. Project/Task/Work Unit No. 4411135 11. Contract/Grant No.
12. Sponsoring Organization Name and Complete Address *(Street, City, State, ZIP)* Same as item 9			13. Type of Report & Period Covered Final 14. Sponsoring Agency Code

15. SUPPLEMENTARY NOTES

16. ABSTRACT *(A 200-word or less factual summary of most significant information. If document includes a significant bibliography or literature survey, mention it here.)*

This report describes a demonstration project on hair dryers which applied the life cycle costing technique to a small appliance where the consumer is a significant factor in its usage. Described are the field data collection techniques: including an experiment to collect use, energy consumption and repair data from participants provided with specially instrumented hair dryers. Repair and repair cost data were also obtained from collecting used hair dryers for failure mode analysis and from repair agency surveys.

The lessons learned provide insights into the application of the life cycle costing technique to other small appliances. This study indicated individuals' recalled estimates for usage significantly exceed the metered values. It is important, therefore, that measurement instruments be used as much as possible to collect usage data. The importance of developing test methods based upon controlled field use experience was in part substantiated by the inability to obtain failure rate data. Some of the individuals who contributed failed hair dryers still under warranty did not want to be troubled by the nuisance, delay and expense involved with obtaining a repair. If such an attitude is pervasive, feedback of failure rate data for inexpensive appliances may be incomplete even during warranty periods.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Field data collection techniques; hair dryers; instrumented usage data; life cycle costing; repair data; small appliances.

18. AVAILABILITY	19. SECURITY CLASS (THIS REPORT)	21. NO. OF PAGES
[XX] Unlimited [ ] For Official Distribution. Do Not Release to NTIS	UNCLASSIFIED	52
[ ] Order From Sup. of Doc., U.S. Government Printing Office Washington, D.C. 20402, SD Stock No. SN003-003 [X] Order From National Technical Information Service (NTIS) Springfield, Virginia 22151	20. SECURITY CLASS (THIS PAGE) UNCLASSIFIED	22. Price $5.25

USCOMM-DC 66035-P78