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Field Test Results on the Performance of A Refrigerator-Freezer in A Single-Family Residence

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
National Engineering Laboratory
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Washington, DC 20234

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U.S. DEPARTMENT OF COMMERCE, Malcolm Baldrige, *Secretary*
NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Director*

ABSTRACT

The operation of a side-by-side 623 L (22 cubic foot) refrigerator-freezer in use in a single family residence was continuously monitored for over two years. During this time, the daily cumulative number of freezer and fresh-food door openings, ice-maker operations, defrost cycles, and compressor cycles were recorded. In addition, the lengths of time the doors were open, the length of defrost heater "on" time, and the watt-hours energy use were recorded. On a weekly basis the amount of accumulated defrost water was measured. All information was entered into a computer file and analyzed to determine the magnitudes, variations, and trends of the data. The effects of such variables as the season of the year, number of people using the test unit, and a slow refrigerant leak were evaluated.

Graphic representations of many of the variables vs. time and vs.each other are included in the report. The small effect that ambient or variable use conditions had on long term cumulative energy use and the great variation found in the use conditions on both a daily and weekly basis are typical observations. Averaged over the entire data collection period, the fresh food compartment door was opened 32.5 times per day for a total of 3.8 minutes per day. The freezer compartment door was opened seven times per day for a total of 1 minute per day, and the ice-maker operated 2.4 times per day producing 14 ice cubes.

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PREFACE

The data for this project were developed as an unfunded after-hours personal activity to satisfy the author's curiosity. DoE funding was provided to NBS for the analysis of the data and preparation of this report.

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1.0 INTRODUCTION

This field test was undertaken to develop in-home use data on variables other than room air temperature that could affect the energy consumption of a side-by-side refrigerator-freezer. Door openings combined with food loads and load removals, defrost operations and the amount of frost removed, and ice-maker operations and ice cube usage could effect energy use. The Department of Energy (DoE) test procedure for refrigerators [1] measures energy consumption with the doors closed but in an ambient temperature of 32.2 C (90 F). The elevated temperature causes the unit under test to use more energy than in a more typical room ambient of 22.2 C (72 F). The increase is believed to be equivalent to the energy used to cool the interior of the unit after door openings and added food loads under average household use conditions. The results and conclusions of the analysis of the home test data can provide some of the information that would be needed for consideration of possible changes in the test procedure simulation to make it better correlate with national average "typical" home use conditions. All of the data values were recorded daily except for defrost water. The defrost water was measured weekly. Data were taken from July 1,1978, to November 2, 1980 in Gaithersburg, Maryland.

2.0 TEST PROCEDURE

The unit tested was a side-by-side, two-door 623 L (22 cubic foot) refrigerator-freezer (hereafter called the "refrigerator") with an automatic icemaker. The refrigerator was purchased new in 1966 and over the years was moved to homes in three different cities along with other household goods. The refrigerator had been modified in a previous test at NBS by adding access valves to the suction and discharge lines of the compressor, and the system had been recharged several times. For this test, electrical connections were made to the wiring underneath the food compartments across the compartment lights, the icemaker water solenoid, and the compressor motor and the wires were brought out to a terminal strip on the back of the refrigerator. A hidden electrical wire was connected to the defrost heater and brought out alongside the defrost drain tube to the terminal strip. Electrical power from these connections was used to operate counters and clock motors. The defrost water hose that ordinarily drained into an evaporation pan in the condenser cooling hot air discharge passage was rerouted to the back of the refrigerator. The water collection pan was left in its customary position. The refrigerator was installed in the authors home in the location provided for a refrigerator in the kitchen of the detached single-floor, three-bedroom, full-basement home near Gaithersburg, Maryland. The home heating system was a hot air oil furnace with central air conditioning in the summer. There was a hot-air (cold in the summer) vent directly above the refrigerator but there were no windows or return air vents nearby. The sink, range, and dishwasher were about 1.4 meters (4.5 feet) away from the refrigerator.

In order not to affect the results of the test, no instrumentation was visible to the users. The wires to the instruments and the plastic defrost water tube were passed through holes made in the floor behind the refrigerator and down to a high shelf in a room in the basement below. Energy consumption was measured with a small electronic watt-hour integrator that utilized a mercury tube coulomb gage calibrated in tens of kilowatt-hours on its scale. Since full scale was 100 kilowatt-hours, the gage was reversed each time it neared its limit. This instrument was about 50 X 75 X 100 mm (2 X 3 X 4 inches) in size and had a 900 mm (3 ft) power supply cord and a three-wire outlet mounted on it. It was located behind the refrigerator and was not readily visible to the users of the refrigerator but was accessible for nightly readings. The defrost water was collected in a 1.8 liter (61 oz.) loosely covered coffee carafe.

During most of the test period, there were three people in the home, two adults and one young adult. For a five month and a two month period, only the two adults were in residence.

Three times during the test period the refrigerator needed servicing to add refrigerant and once to replace the condenser cooling fan motor which was running slowly causing the motor thermal protector to operate frequently.

All of the accumulated data were entered into a computer file and are available for further use if needed. During the test period of 857 days, 78 days of readings were missed. Of these, 56 were periods of one week or more and they occurred because of vacations. The remaining 22 missed readings were for three or fewer days at a time and were for various reasons. They were scattered fairly uniformly throughout the test period. Near the end of the test period, from September 15 to November 2, 1980, data readings were taken weekly rather than daily. Due to the failure of the watt-hour meter, no watt-hour readings were taken during this period.

Prior to using the raw data in the computer file, the data were manually reviewed to find any data points that were widely divergent from the usual value for that particular recorded value. When such points were obviously either misread or misrecorded they were replaced with values interpolated from the adjacent recorded cumulative data values.

3.0 RESULTS

A comprehensive diary of the user family's activities during the test period was not kept, so only some notes on the data records are available to correlate the variations in the recorded variables with the activities and events that may have affected them. When correlations with the notes are observed, they are mentioned in the following discussion.

Figures 1 and 2 show the cumulative values of the variables over the entire data collection period. Before plotting these curves, the daily data were cumulated into 122 weekly values. The numbers at the ends of the curves are the final cumulated values. The watt-hours final value was at the end of week #144 since watt-hour readings were discontinued that week. Week #0 was the first week in July 1978, week #52 was July 1, 1979, etc. The position of the week numbers on the time axis roughly correspond to the start of the seasons of the year. For instance, weeks #0, #52, and #104 represent the summers of 1978, 1979, and 1980. Figures 1A, 1B, 2A, and 2B are plotted with the data of the first two years of the test period. They are the same as Figures 1 and 2 but with a time scale of only one year.

3.1 Door operations

The straight dashed line manually drawn over the fresh food door openings curve of Figure 1 shows an interesting trend in that the plotted door openings curve seems to be slightly but constantly rising. There is no logical explanation for this so one might conclude that, as the years go by, the use of the fresh food compartment is increasing. This trend is better evaluated with the curves of Figures 1A and 1B. The fresh food door opening curve of Figure 1A is very nearly a straight line that results in a 31.3 openings-per-day rate. The effect of a vacation during the last two weeks in August 1978, is just noticeable on this curve. The fresh food door openings curve of Figure 1B deviates from a straight line from October 1, 1979, to January 1, 1980, but is nearly a straight line otherwise. The flat section of the curve from late September to early October 1979, was a vacation period when the refrigerator was turned off. There is no explanation of the increase in door openings for the next three months. The overall door opening rate for the second year, Figure 1B, was 33.6 openings-per-day. The difference between the first and second years fresh food door opening rate is inexplicable. The average fresh food door opening rate over the entire test period was 32.5 openings-per-day, obtained by dividing the 27,782 openings by the total days of 854.

The curve of fresh food door open hours on Figure 1 and 1B shows abrupt rises at about weeks #58 and #84 (August 1979, and February 1980). The rise at week #84, late February 1980, was during the time of repairs on the refrigerator. No notes recorded with the data explain the other sharp rise, but it was probably caused by accidentally leaving the door open for a long period of time. By dividing the 54.52 total hours of fresh food door-open hours by 122 weeks and by 7 days per week, the door open time per day is calculated as 3.8 minutes. This, when divided by the door openings per day, results in an open time of 7.1 seconds per opening.

Freezer door operation curves on Figures 1, 1A, and 1B also show the effects of vacations and repairs on the freezer door openings and open time. The two discontinuities in the freezer door cumulative open time were due to the freezer door having twice been left in a slightly open position for several hours. Notes on the data records were made when this was observed. On Figure 1, an extension of a straight line has been drawn beyond the first portion of this curve. This dashed line shows that the average door open time per week or month did not change after the door was left open. The slopes of the curve sections after the accidental open periods are the same as before these periods. The accidents cannot be construed to be normal door open hours so the freezer door open time can best be calculated using the slope of the straight line drawn over the first part of the curve on Figure 1. Using this method, the freezer door was found to be open 0.9 minutes per day. It was opened nearly 7 times per day and open an average of 7.9 seconds each time.

Figure 3 was plotted to show the weekly values of door openings and open time. These curves would show even greater variations when plotted on a daily rather than a weekly average basis. One might expect that, although the openings and length of time vary widely, the length of open time per door opening would remain relatively constant. As shown by the dotted line of Figure 3, this is not the case and all three variables showed erratic and unpredictable variations. Rough plots of door opening variables and ratios were made of the fresh food compartment data and of the data using different time axis periods but are not included with this report because insufficient additional information was gained; the other curves were all similar to the curves of Figure 3.

An observation from the analysis of the door operation data of both compartments is that no correlation with either the season of the year or the number of people in the household could be found.

The door operations information generated by this test can be compared to two earlier publications containing similar information. The first was a NBS report [2] on data taken on ten units in use in a town-house complex in Twin Rivers, N.J. The data were collected on one single-door refrigerator and nine automatic defrost refrigerator-freezers. One of the latter was a side-by-side model. The family sizes ranged from three to five, one to three children, and the data collection period was for about six months in 1976. The second source is contained in an Arthur D. Little report [3] that uses usage values obtained from an NBS preliminary draft report [4] and an NBS interim memorandum [5]. The usage figures in this report were used to analyze potential reductions in the energy consumption of household appliances. The results of the report were used by the Department of Energy to develop minimum energy consumption standards published in the Federal Register [6] and later a revised proposal for no minimum standards [7]. Table 1 lists the usage values from these references and from this Home Use Test.

TABLE 1 - DOOR OPENING DATA
Door Opening Frequency and Time

Source	Fresh-food Compartment			Freezer Compartment		
	No./ Day	Sec./ Open	Min./ Day	No./ Day	Sec./ Open	Min./ Day
A.D.Little	50	12.5	10.4	25	12.5	5.2
Town-house	48	21.2	17.0	10	20.0	3.3
Home use	33	7.1	3.8	7	7.9	0.9

The table shows that the usage of the refrigerator in this test was less than the usage reported in earlier publications. The door opening values were much lower than those given in the Arthur D. Little report but closer to the town-house data. The reverse is true of the seconds-per-opening column. The factor that probably has most effect on energy consumption is the length of time the doors are open per day. The "Home Use" results were much lower than either of the previously published values. It would be interesting to determine whether the side-by-side door configuration permits faster access to foods stored in the compartments, and perhaps to more orderly storage that allows faster loading and retreival. Certainly the range of values in the table indicates that test results of one family's usage is not sufficient to generalize conclusions for all users. It is possible that the family usage and the results of this test are atypical.

3.2 Ice maker operations

Icemaker operations, plotted on Figures 1, 1A, and 1B, show the frequency of operation of this device to be remarkably uniform. The average overall frequency was 2.37 operations per day which equates to 14.2 ice cubes per day. The 14.2 cubes per day rate is surprising since the high estimate of ice cube usage by the family is nine ice cubes per day. Part of the high final value may be attributed to occasional extra high usage periods. On each of the one year curves, Figures 1A and 1B, there are two noticable increases. For instance in early November 1980, on Figure 1B. These rises represent extra icemaker operations and, although not noted on the data sheets, the rises are probably due to the emptying, clean-out, and remaking of a full container of ice cubes. A full container holds about 144 ice cubes which requires 24 icemaker operations per refill. If it is assumed that there were two clean outs per year, the ice cube usage would become 13.4 ice cubes per day. If the extra usage is doubled to account for a few parties and/or additional clean outs, the daily ice cube usage would still be roughly three ice cubes per day higher than the estimate of family usage. Thus, it appears that the sublimation of ice cubes in this "Home Test" ice-maker refrigerator- freezer ~~is~~ about three ice cubes per day. ^could be

3.3 Defrost water

The curves of the cumulative amount of defrost water collected weekly are on Figures 2, 2A, and 2B. These curves show that this variable was not as constant as the variables already discussed. The total amount of water collected during the 122 week test period was 130.2 liters (4404 fluid oz.). Thus, 1.07 liters of water per week (36.1 oz.) or 152.5 ml per day (5.16 oz.) was collected. The total volume of water can be divided by the total number of defrosts (2001) to find the water collected per defrost was 65.1 cubic centimeters (2.2 oz.). From inspection of the Figure 2 curve , it appears that the defrost water volume is cyclic. Figure 4 was plotted to evaluate this possibility. The zero values at weeks #8 and #66 were vacation weeks with the refrigerator turned off. Because defrost water was not collected the same day each week and twice a week occasionally, the origional data were modified for some weeks to correct for these data collection variations. The "x" marks on the time axis indicate changed values. Most of the changes were to eliminate zero water collection points. In most cases, the change made was to duplicate the previous weeks value. Although the water volume values are somewhat erratic, it can be seen that the defrost water accumulation in the refrigerator was cyclic and at a maximum in July - August and minimum in January - February.

The defrost heater is turned off by a thermostat when the frost has melted and the evaporator warmed up to the cut-off temperature value of the thermostat. Thus, the length of time the heater is on should vary proportionally with the amount of frost melted (i.e. defrost water collected); and the energy consumption of the defrost feature should be dependent on the amount of frost to be removed. To investigate this factor, two other curves are plotted on Figure 4. The curve of defrost heater "on" hours per week (dotted line) seems to follow the defrost water trend after week #66, but before that a reverse trend is noted. At weeks #15, #57, and #88 repairs were made to the refrigerator. It is possible that, inadvertently, the defrost control thermostat was not positioned firmly against the evaporator structure. This would tend to increase the heater hours and make the length of on time less dependent on the amount of frost accumulated. The plot of ounces of water collected per hour of defrost heater heating should be a constant value plus a variable proportional to the amount of frost to be melted. This trend is shown on Figure 4 by the points plotted as individual small circles. In the previous section it was noted that the sublimation of ice cubes might be as much as three ice cubes per day. This sublimated water must deposit as frost onto the evaporator. Since one ice cube weighs about 31 grams, three would equal 93 grams (3.1 fluid ounces) of water. Thus, it is possible that, of the 152.5 grams (5.16 oz.) of defrost water per day, 93 grams (3.1 oz.) could be from ice cubes and the remaining 59.5 grams (2.1 oz.) from other sources.

3.4 Energy consumption

From the curves of Figures 1 and 2, the energy consumption (kilowatt-hours) appears to show a slightly cyclic characteristic with the lower energy consumption periods about 52 weeks apart at weeks #26 and #78 which represent January 1, 1978 and 1979. To better show the energy use data, Figure 5 was plotted. Kilowatt-hours per day, defrosts per day and compressor cycles per day were plotted. Since the defrost timer on the refrigerator requires eight hours of compressor running time to initiate a defrost cycle, the number of defrost cycles is a measure of the running time of the compressor. The compressor cycles per day indicate the capacity of the cooling system, since the greater the capacity in BTU's per hour of the system the less running time it needs to provide the needed cooling. Assuming reasonably constant loading conditions, the system should have shorter compressor run times and cycle more frequently with a high capacity system.

Figure 5 shows that if there is a seasonal effect on energy consumption it is small and masked by other factors. The compressor cycles per day is an interesting curve because it shows the effect of a slow refrigerant leak in the cooling system. The repairs noted in the previous section occured in weeks #15, #57, and #88. The curve shows that the system was losing capacity during the months prior to the repairs since the number of compressor cycles was falling. The repairs consisted of charging the system which caused the number of cycles per day to rise to their normal level. Strangely enough, there appears to be no clear correlation between the system capacity and the kilowatt-hours energy consumption of the refrigerator. The average energy consumption per day calculated by dividing the total cumulative kilowatt-hours by 798 days (only 114 weeks of data were taken on this variable) is 6.8 kilowatt-hours per day. No reliable energy consumption value obtained by use of an elevated temperature - no door opening test procedure could be obtained from the manufacturer for the vintage 1966 unit used in these tests. However, an AHAM 1975 Directory [8] lists the energy consumption of refrigerators in a table of costs of energy vs. rated total volume. This table shows that the range of daily energy use of refrigerator-freezers having volumes of from 21.5 to 22.5 cubic feet (609 to 637 L) was from 3.95 to 7.89 kWh per day in 1976. Considering the range of energy-use of typical units manufactured nine years later, the results obtained from the data taken for this test are on the high end of the range but reasonable.

A relatively high energy consumption is expected for the unit in this test because the family prefers to keep the freezer compartment very cold. The temperature in the freezer was usually at about -20.5 to -17.7 C (-5 to 0 F). The energy consumption determined by the DoE test assumes a freezer temperature of -15 C (5 F). Other factors that might contribute to a high energy consumption are normal manufacturing tolerance, age, modification of the cooling system, etc. Plans are underway to bring the refrigerator in to the NBS laboratory test facility to perform the DoE standard test. The results will be compared with actual use field data of this report.

4.0 CONCLUSIONS

The results of this study, relating to refrigerator-freezer compartment door openings, show them to be quite variable on a day-to-day, week-to-week, or even a month-to-month basis but that cumulative values are fairly linear on a yearly basis. Comparison with previously published usage values shows that while the family usage studied in this test may be representative of normal usage, it cannot necessarily be considered typical or average. The large difference in usage between published values and these test results shows that there will be a broad range of usage among "typical" users. Thus, the use of door openings as a test procedure method would have to be correlated with an average value of number of openings, duration of the openings, and ambient temperatures. Very extensive field tests extending over a number of years would be required to develop such averages for correlative purposes. This test indicated that there may be differences between types of refrigerators, ie. side-by-side vs. top-mount. The effects of other features such as ice makers, water dispencers, etc. would also have to be evaluated.

The conclusions regarding door operations also apply to ice maker operations and defrost water collection. The 14 ice cubes per day and the 65 ml (2.2 ounce) of defrost water per defrost cycle may establish the order of magnitude of the variables but cannot be considered as typical or average. The test results indicate that exposed ice cubes may be a source of defrost water and thus a contributer to defrost energy consumption.

The energy consumption of the tested refrigerator under actual use conditions was on the high side of the range of energy use values of similar units manufactured nine years later that were tested using a procedure quite like the present DoE test method. Considering the fewer door openings and low door open time per opening of this home test unit when compared to previously published values, the energy consumption should be further investigated by testing it using the DoE method to determine the correlation between the two energy use values.

5.0 REFERENCES

1. Federal Register / Vol.47, No.154 / Thursday, August 10, 1982, Rules and Regulations, pp 34517-34529.

2. Y-M. Chang and R.A.Grot, Field Performance of Residential Refrigerators and Refrigerator-Freezers, National Bureau of Standards, Washington D.C.,20234, NBSIR 79-1781.

3. Arthur D. Little, Inc., Study of Energy-Savings Options for Refrigerators and Water Heaters, Vol.1: Refrigerators, prepared for The Office of Transportation and Appliance Programs, Federal Energy Administration, May 1977, pp 15-18.

4. Mulroy,J. and J.Grimes, "Factors Affecting the In-Use Energy Consumption of Household Refrigerators and Freezers," National Bureau of Standards, Preliminary draft report.

5. "Refrigeration Appliances" Field Tests, National Bureau of Standards interim memorandum, provided by Bernard McGuire, Appliance labelling Section.

6. Federal Register / Vol.45, No.127 / Monday, June 30, 1980 Proposed Rules, pp 43976-44087.

7. Federal Register / Vol.47, No.64 / Friday, April 2, 1982 Proposed Rules, pp 14424-14461.

8. Association of Home Appliance Manufacturers, AHAM 1975 Directory of Certified Refrigerator/Freezers, September 1975 - Second Special Edition.

HOME USE DATA, 1978–1980

REFRIGERATOR–FREEZER, SIDE–BY–SIDE
Cumulative Weekly Average Values

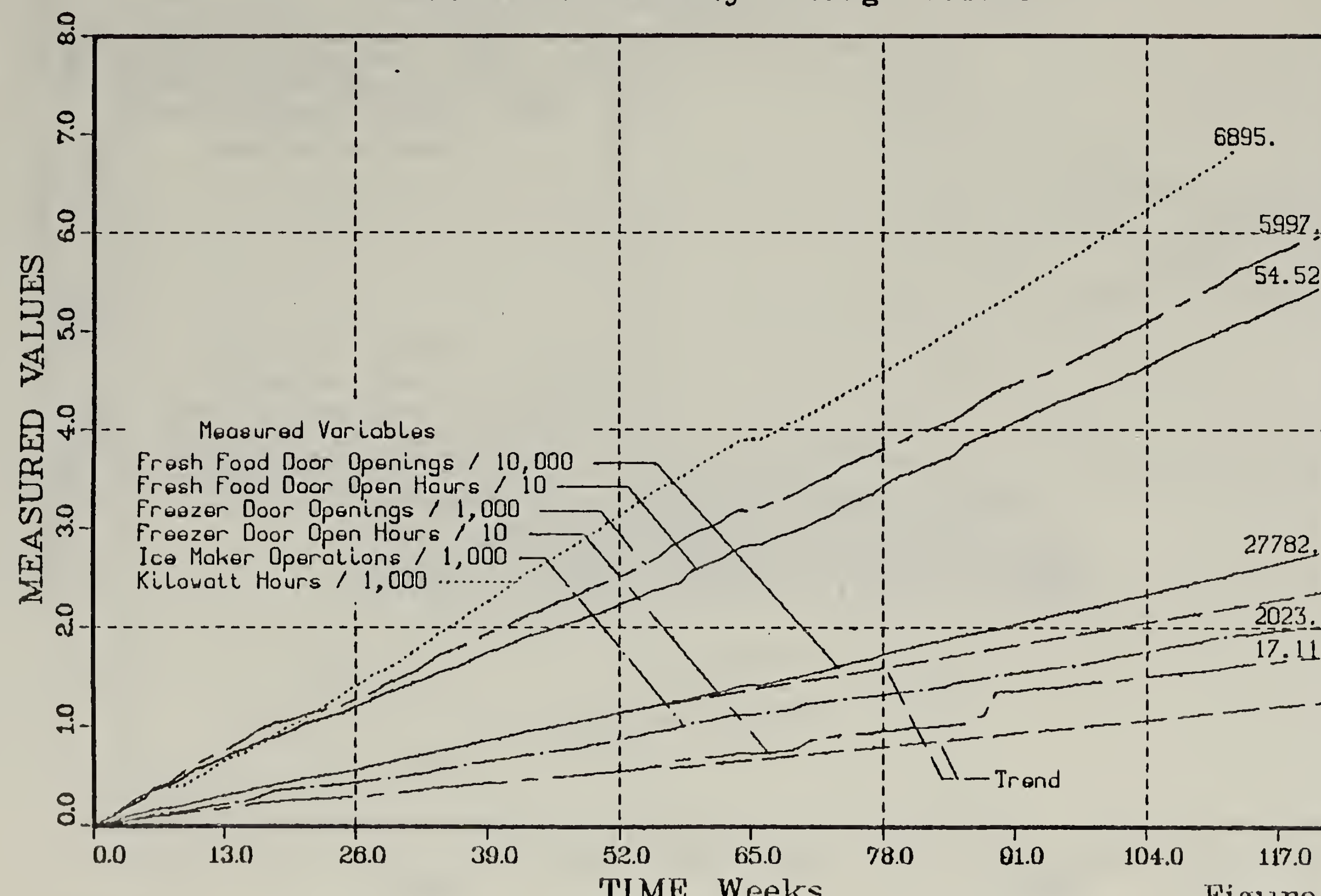


Figure 1

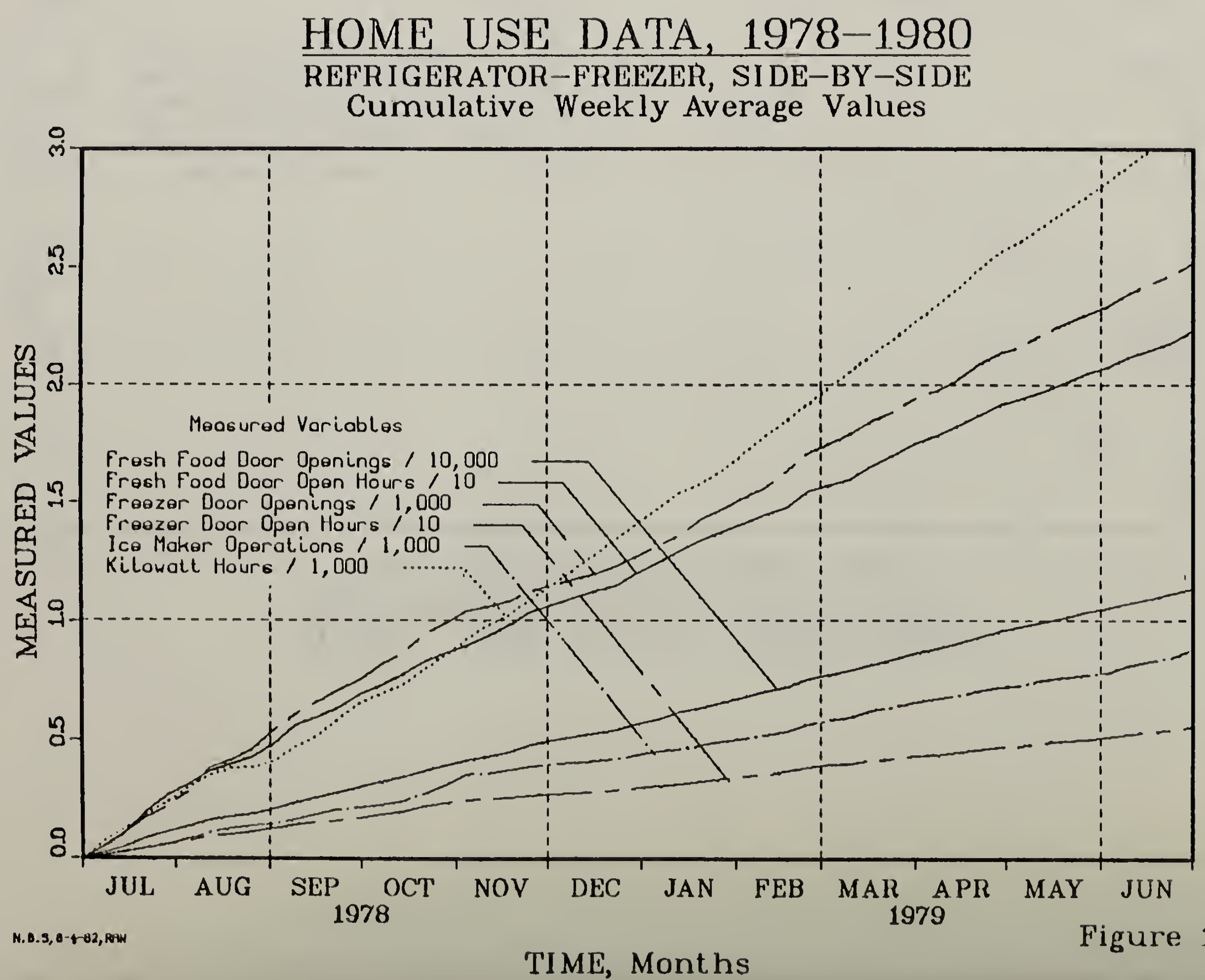
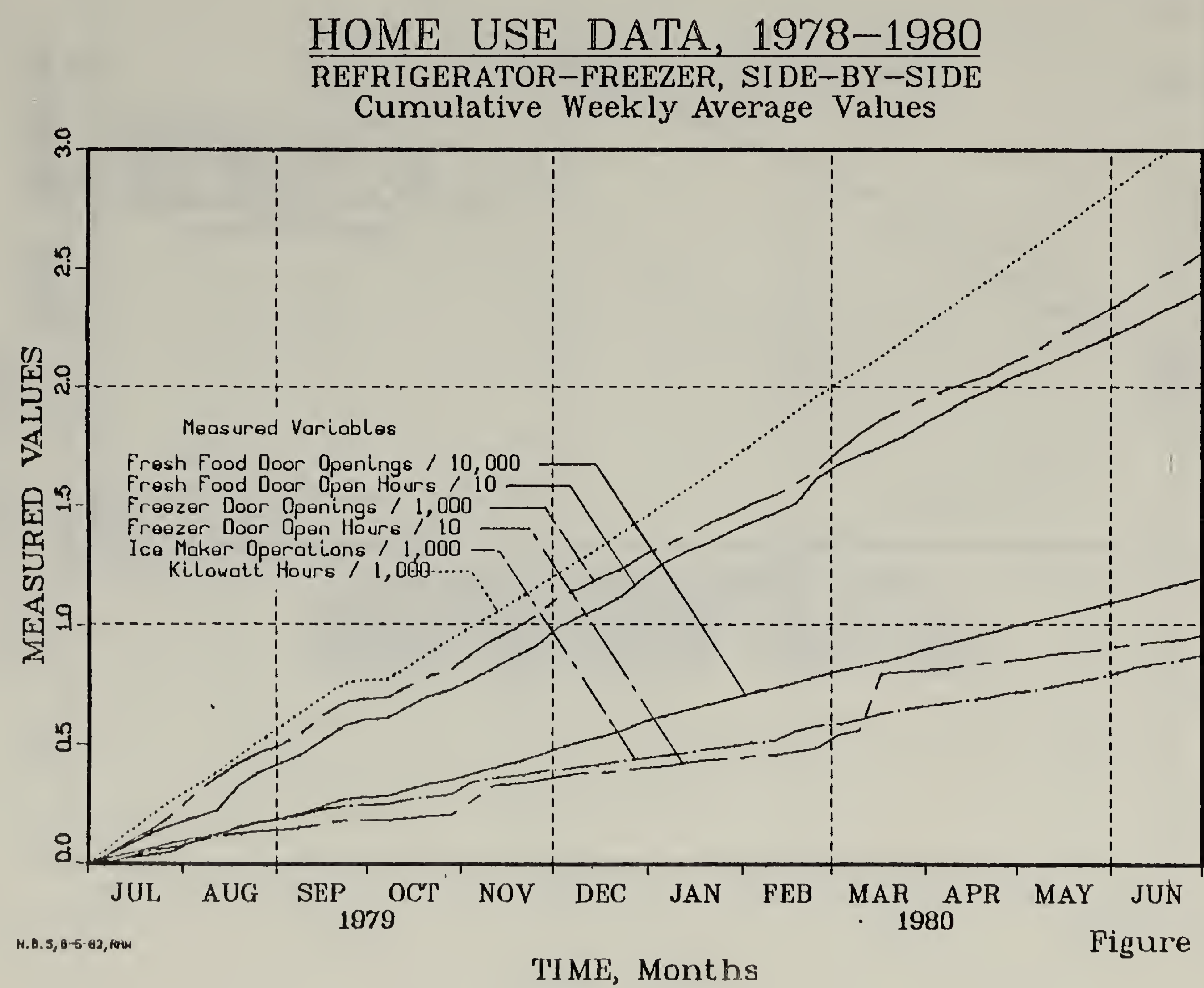

HOME USE DATA, 1978–1980
REFRIGERATOR–FREEZER, SIDE–BY–SIDE
Cumulative Weekly Average Values
MEASURED VALUES
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Measured Variables
Fresh Food Door Openings / 10,000
Fresh Food Door Open Hours / 10
Freezer Door Openings / 1,000
Freezer Door Open Hours / 10
Ice Maker Operations / 1,000
Kilowatt Hours / 1,000
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
1978
1979
TIME, Months
N.B.S, 8-4-82, RAW

Figure 1A



HOME USE DATA, 1978–1980
REFRIGERATOR–FREEZER, SIDE–BY–SIDE
Cumulative Weekly Average Values
MEASURED VALUES
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Measured Variables
Fresh Food Door Openings / 10,000
Fresh Food Door Open Hours / 10
Freezer Door Openings / 1,000
Freezer Door Open Hours / 10
Ice Maker Operations / 1,000
Kilowatt Hours / 1,000
JUL
AUG
SEP
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
JUN
1979
1980
TIME, Months
N.B.S, 8-5-82, RHW

Figure 1B

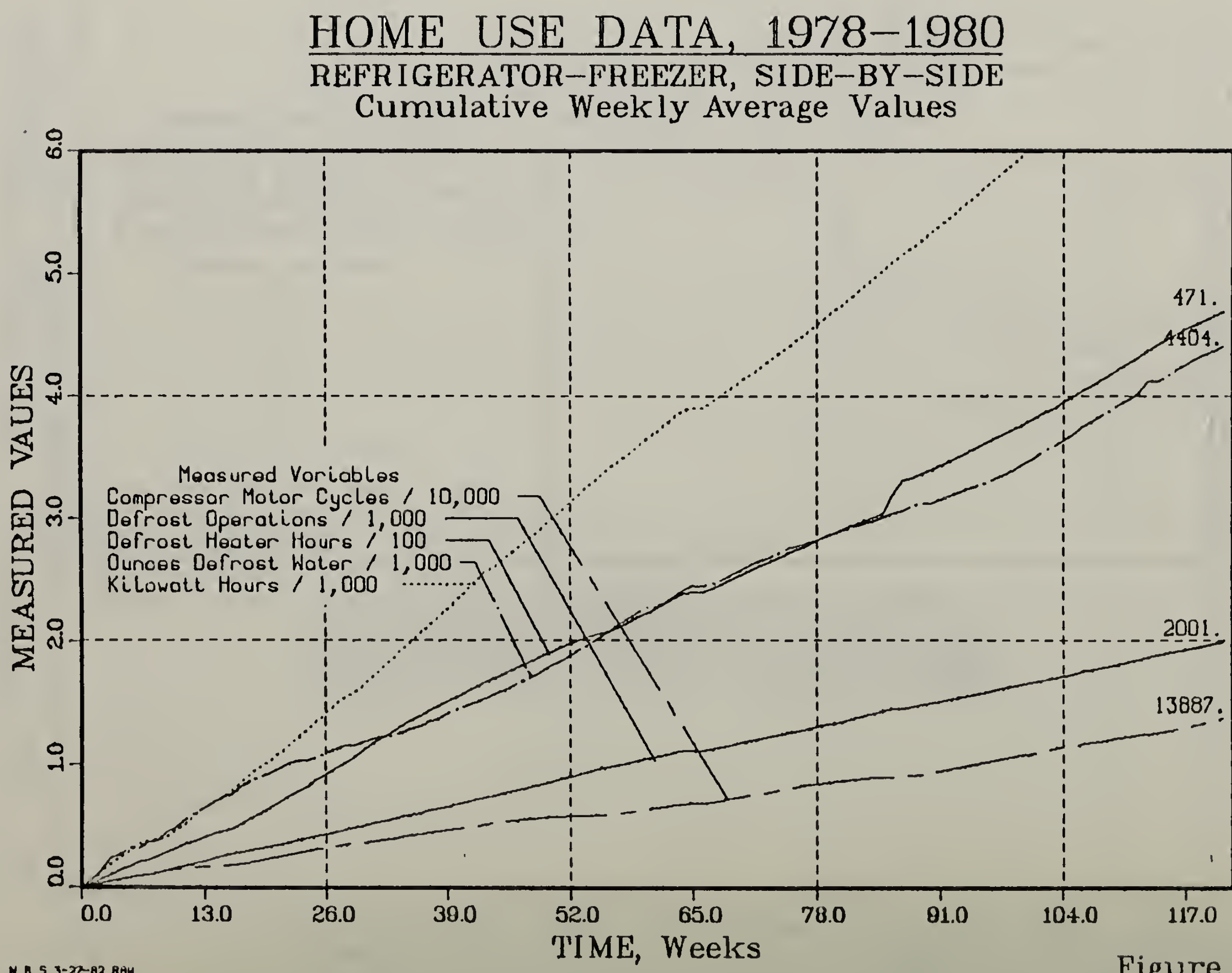

HOME USE DATA, 1978–1980
REFRIGERATOR–FREEZER, SIDE–BY–SIDE
Cumulative Weekly Average Values
MEASURED VALUES
0.0
1.0
2.0
3.0
4.0
5.0
6.0
Measured Variables
Compressor Motor Cycles / 10,000
Defrost Operations / 1,000
Defrost Heater Hours / 100
Ounces Defrost Water / 1,000
Kilowatt Hours / 1,000
471.
4404.
2001.
13887.
0.0
13.0
26.0
39.0
52.0
65.0
78.0
91.0
104.0
117.0
TIME, Weeks
N.B.S, 3-27-82, RAW

Figure 2

HOME USE DATA, 1978–1980

REFRIGERATOR–FREEZER, SIDE–BY–SIDE
Cumulative Weekly Average Values

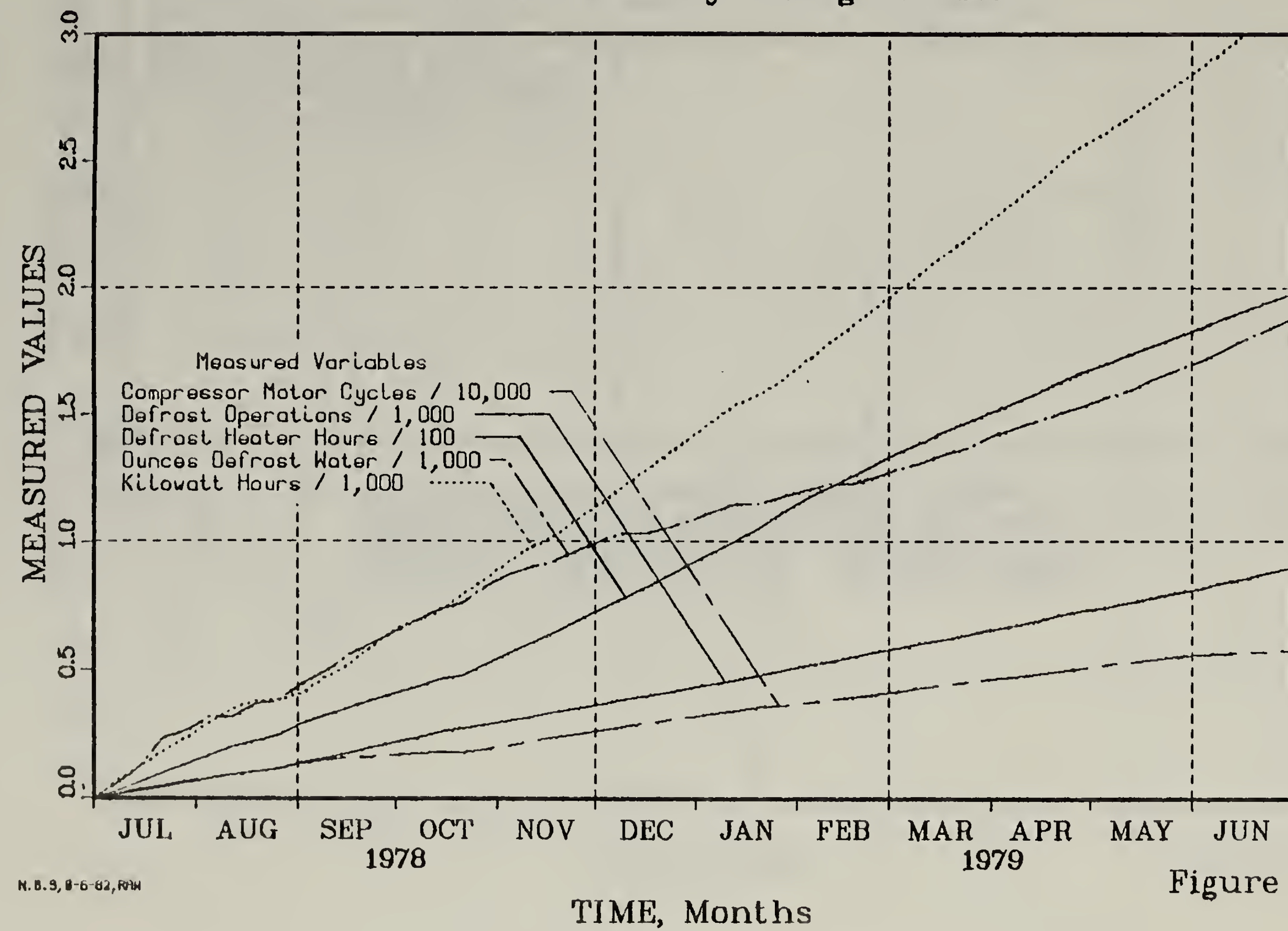


Figure 2A

HOME USE DATA, 1978–1980

REFRIGERATOR–FREEZER, SIDE–BY–SIDE

Cumulative Weekly Average Values

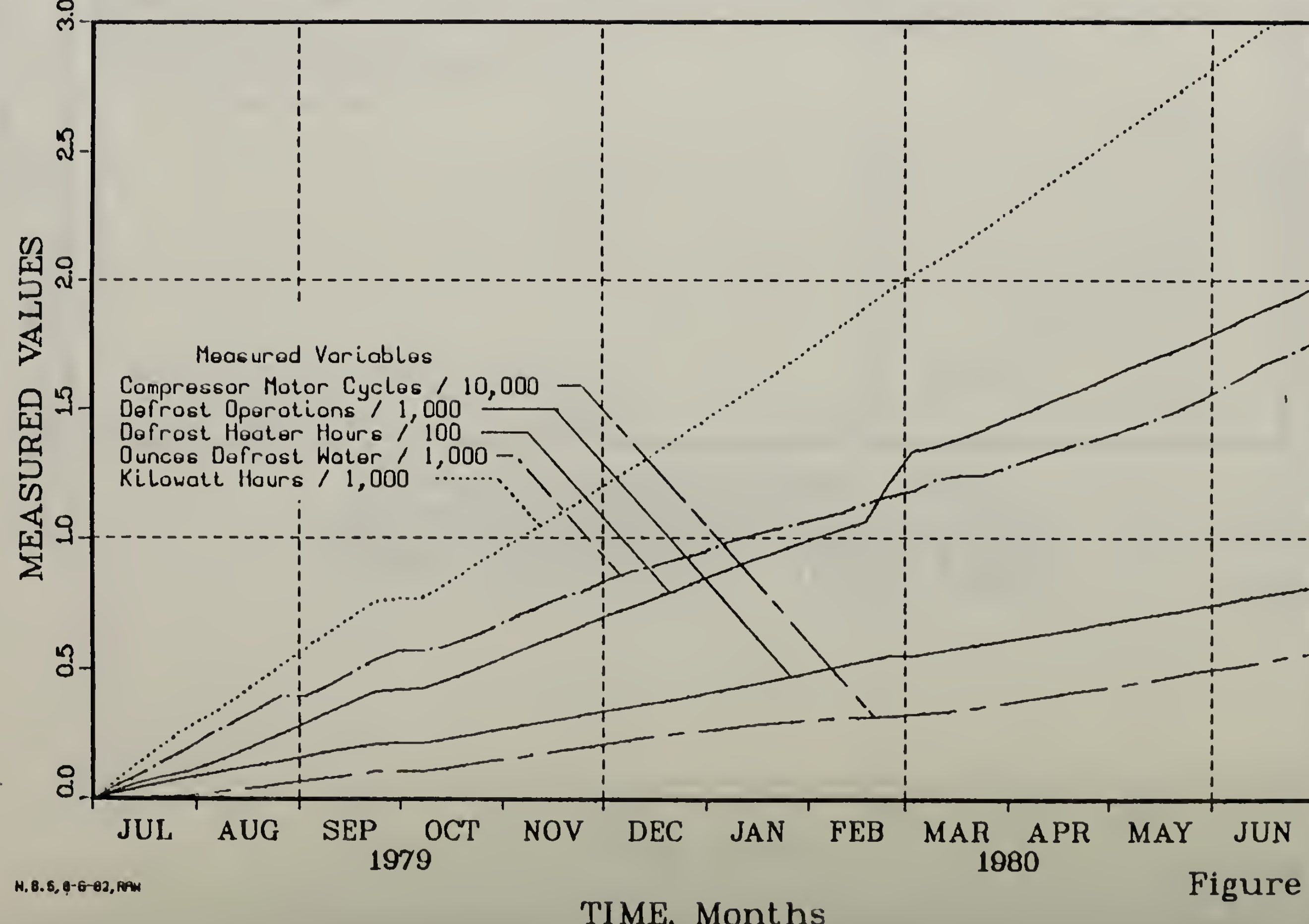


Figure 2B

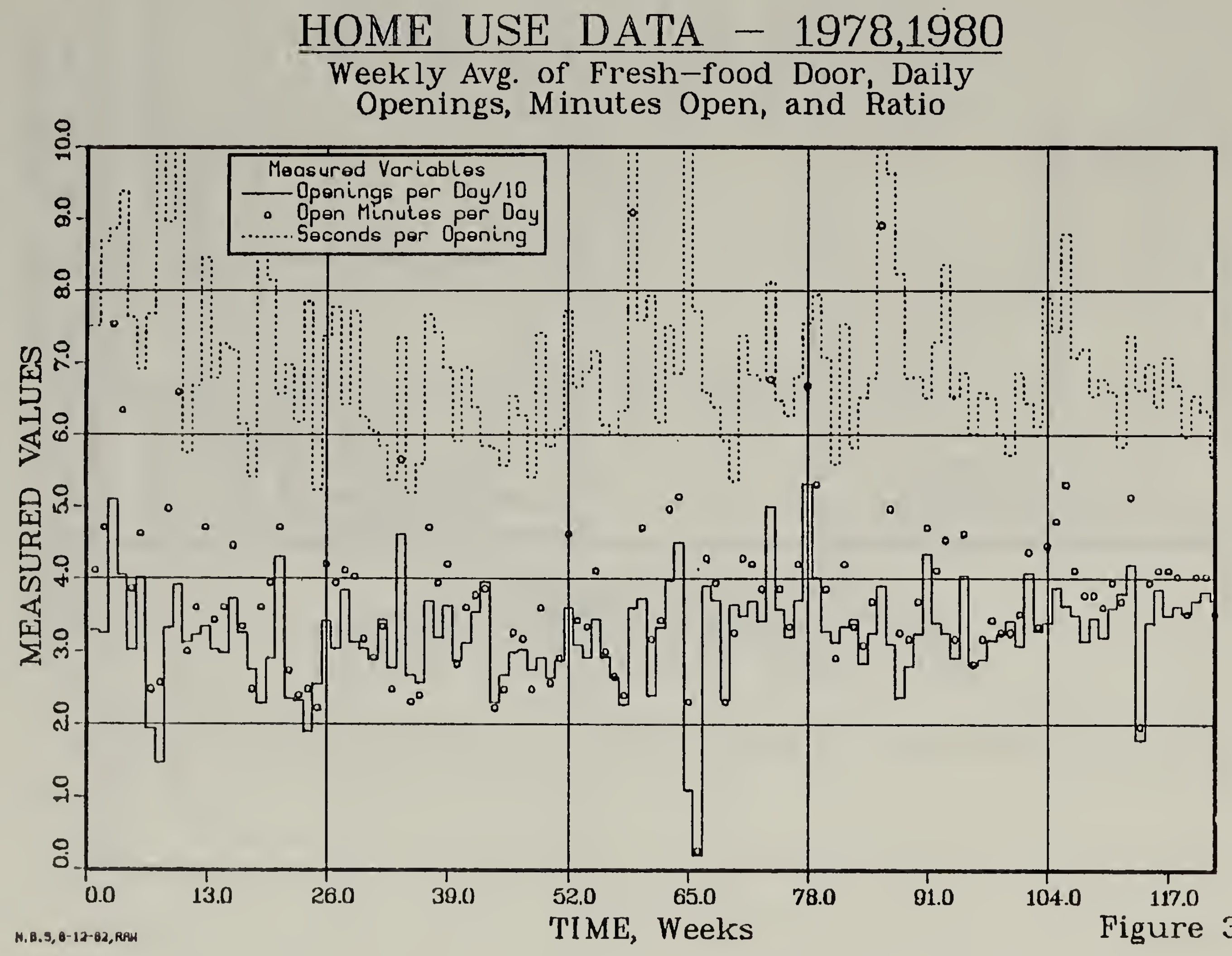

HOME USE DATA – 1978,1980
Weekly Avg. of Fresh–food Door, Daily
Openings, Minutes Open, and Ratio
Measured Variables
Openings per Day/10
Open Minutes per Day
Seconds per Opening
MEASURED VALUES
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
0.0
13.0
26.0
39.0
52.0
65.0
78.0
91.0
104.0
117.0
TIME, Weeks
N.B.S, 8-12-82, RAW

Figure 3

HOME USE DATA, 1978–1980

Weekly Averages of Defrost Water,
Defrost Hours, and Ratio

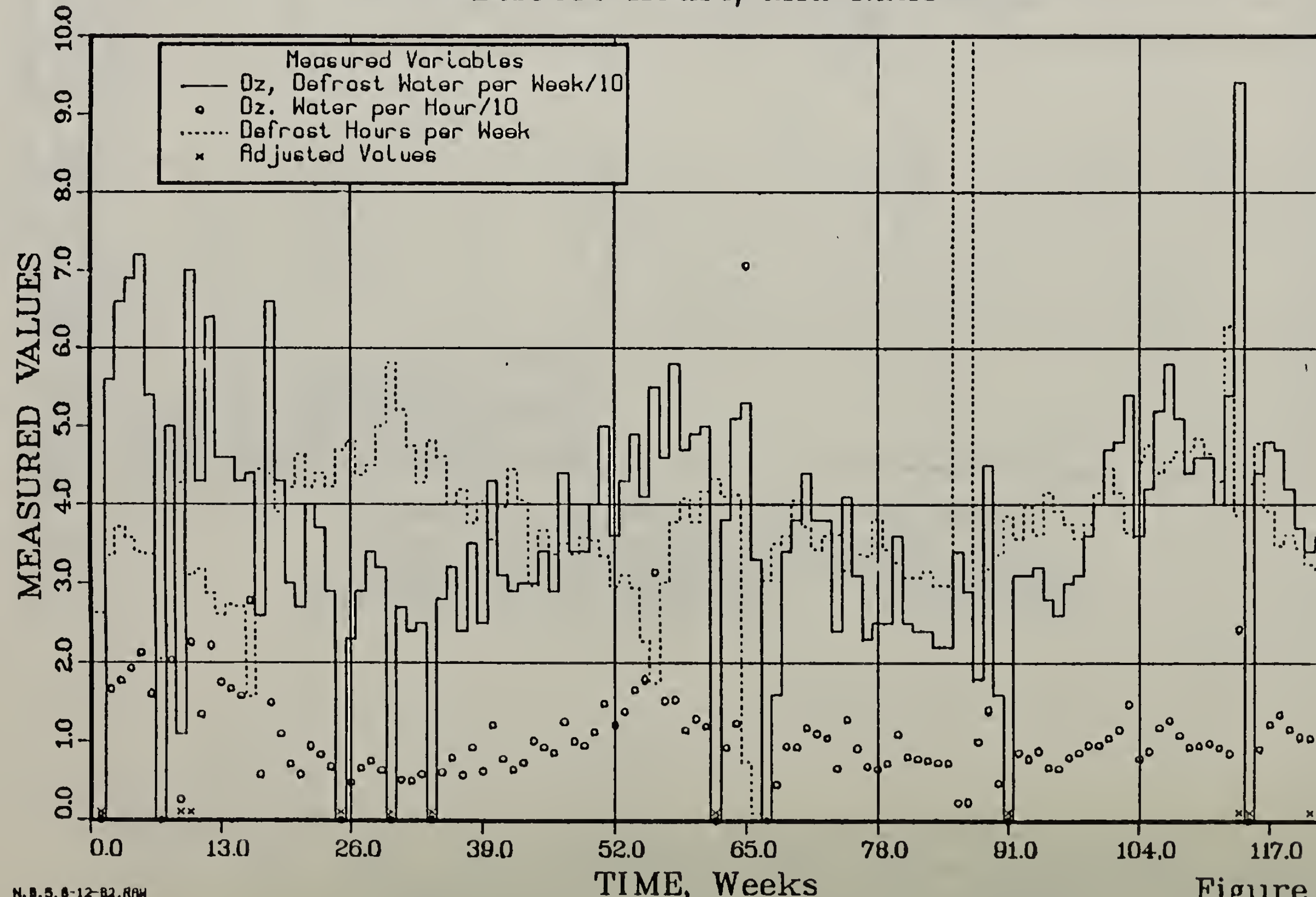


Figure 4

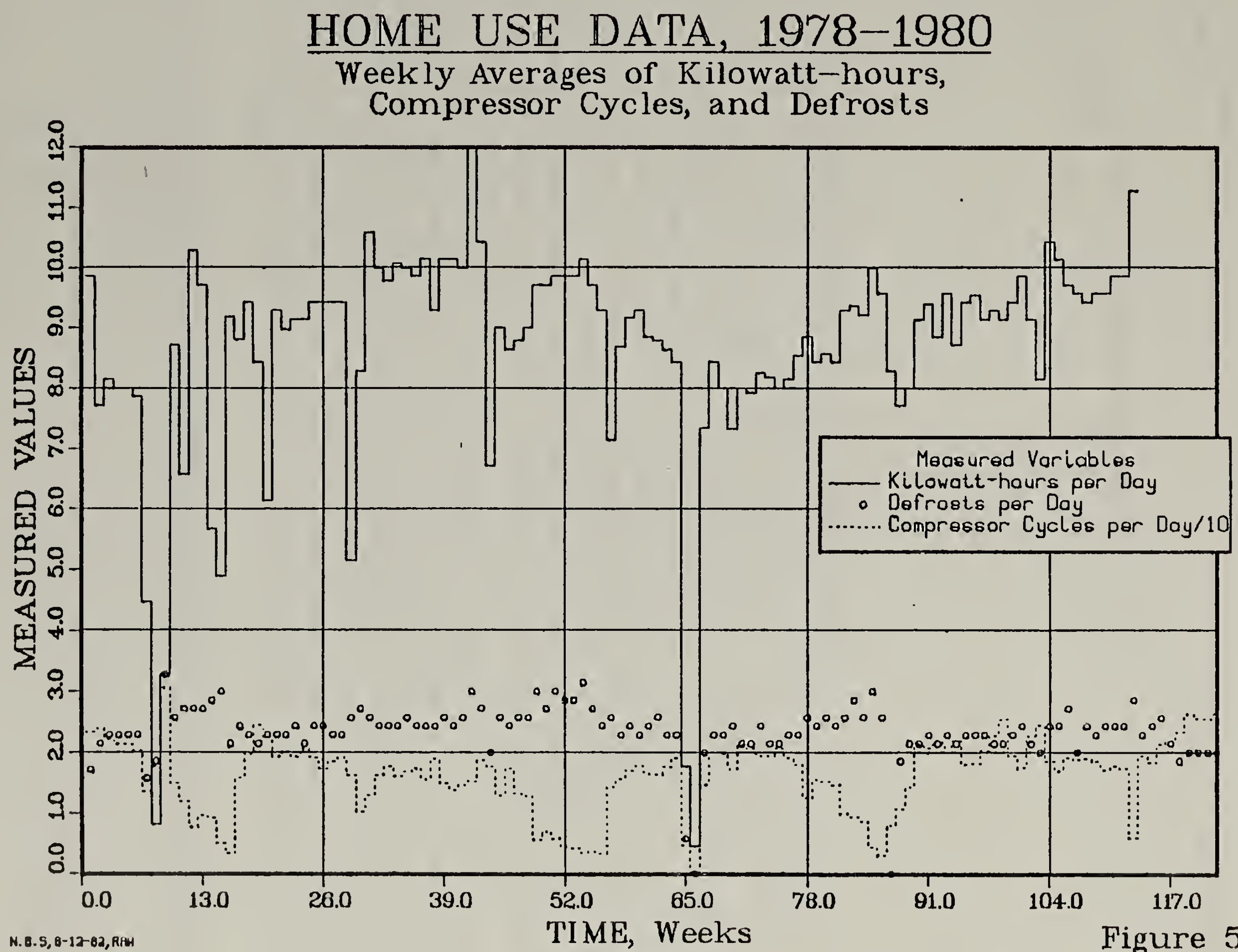

HOME USE DATA, 1978–1980
Weekly Averages of Kilowatt–hours,
Compressor Cycles, and Defrosts
MEASURED VALUES
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
Measured Variables
Kilowatt-hours per Day
Defrosts per Day
Compressor Cycles per Day/10
0.0
13.0
26.0
39.0
52.0
65.0
78.0
91.0
104.0
117.0
TIME, Weeks
N.B.S, 8-12-82, RHW

Figure 5

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NATIONAL BUREAU OF STANDARDS
DEPARTMENT OF COMMERCE
WASHINGTON, D.C. 20234

7. Contract/Grant No.

8. Type of Report & Period Covered

9. SPONSORING ORGANIZATION NAME AND COMPLETE ADDRESS (Street, City, State, ZIP)
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585

10. SUPPLEMENTARY NOTES

☐ Document describes a computer program; SF-185, FIPS Software Summary, is attached.

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

The operation of a side-by-side 623 L (22 cubic foot) refrigerator-freezer in use in a single family residence was continuously monitored for over two years. During this time, the daily cumulative number of freezer and fresh-food door openings, ice-maker operations, defrost cycles, and compressor cycles were recorded. In addition, the lengths of time the doors were open, the length of defrost heater "on" time, and the watt-hours energy use were recorded. On a weekly basis the amount of accumulated defrost water was measured. All information was entered into a computer file and analyzed to determine the magnitudes, variations, and trends of the data. The effects of such variables as the season of the year, number of people using the test unit, and a slow refrigerant leak were evaluated.

Graphic representations of many of the variables vs. time and vs. each other are included in the report. The small effect that ambient or variable use conditions had on long term cumulative energy use and the great variation found in the use conditions on both a daily and weekly basis are typical observations. Averaged over the entire data collection period, the fresh food compartment door was opened 32.5 times per day for a total of 3.8 minutes per day. The freezer compartment door was opened seven times per day for a total of 1 minute per day, and the ice-maker operated 2.4 times per day producing 14 ice cubes.

12. KEY WORDS (Six to twelve entries; alphabetical order; capitalize only proper names; and separate key words by semicolons)
consumer; defrost; door-openings; energy use; field test; home; ice cubes; ice-maker; refrigerator; refrigerator-freezer

13. AVAILABILITY

[XX] Unlimited
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