NATIONAL BUREAU OF STANDARDS REPORT

10 390

PERFORMANCE EVALUATION OF A PROPANE-FIRED HOUSEHOLD-TYPE ABSORPTION REFRIGERATOR

Manufactured by

Excel Refrigeration Corporation
Fort Lauderdale, Florida

Report to

U. S. Army Natick, Massachusetts
Natick, Massachusetts

U.S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards [1] was established by an act of Congress March 3, 1901. Today, in addition to serving as the Nation's central measurement laboratory, the Bureau is a principal focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. To this end the Bureau conducts research and provides central national services in four broad program areas. These are: (1) basic measurements and standards, (2) materials measurements and standards, (3) technological measurements and standards, and (4) transfer of technology.

The Bureau comprises the Institute for Basic Standards, the Institute for Materials Research, the Institute for Applied Technology, the Center for Radiation Research, the Center for Computer Sciences and Technology, and the Office for Information Programs.

THE INSTITUTE FOR BASIC STANDARDS provides the central basis within the United States of a complete and consistent system of physical measurement; coordinates that system with measurement systems of other nations; and furnishes essential services leading to accurate and uniform physical measurements throughout the Nation's scientific community, industry, and commerce. The Institute consists of an Office of Measurement Services and the following technical divisions:

Applied Mathematics—Electricity—Metrology—Mechanics—Heat—Atomic and Molecular Physics—Radio Physics [2]—Radio Engineering [2]—Time and Frequency [2]—Astrophysics [2]—Cryogenics.[2]

THE INSTITUTE FOR MATERIALS RESEARCH conducts materials research leading to improved methods of measurement standards, and data on the properties of well-characterized materials needed by industry, commerce, educational institutions, and Government; develops, produces, and distributes standard reference materials; relates the physical and chemical properties of materials to their behavior and their interaction with their environments; and provides advisory and research services to other Government agencies. The Institute consists of an Office of Standard Reference Materials and the following divisions:

Analytical Chemistry—Polymers—Metallurgy—Inorganic Materials—Physical Chemistry.

THE INSTITUTE FOR APPLIED TECHNOLOGY provides technical services to promote the use of available technology and to facilitate technological innovation in industry and Government; cooperates with public and private organizations in the development of technological standards, and test methodologies; and provides advisory and research services for Federal, state, and local government agencies. The Institute consists of the following technical divisions and offices:

Engineering Standards—Weights and Measures — Invention and Innovation — Vehicle Systems Research—Product Evaluation—Building Research—Instrument Shops—Measurement Engineering—Electronic Technology—Technical Analysis.

THE CENTER FOR RADIATION RESEARCH engages in research, measurement, and application of radiation to the solution of Bureau mission problems and the problems of other agencies and institutions. The Center consists of the following divisions:

Reactor Radiation—Linac Radiation—Nuclear Radiation—Applied Radiation.

THE CENTER FOR COMPUTER SCIENCES AND TECHNOLOGY conducts research and provides technical services designed to aid Government agencies in the selection, acquisition, and effective use of automatic data processing equipment; and serves as the principal focus for the development of Federal standards for automatic data processing equipment, techniques, and computer languages. The Center consists of the following offices and divisions:

Information Processing Standards—Computer Information — Computer Services — Systems Development—Information Processing Technology.

THE OFFICE FOR INFORMATION PROGRAMS promotes optimum dissemination and accessibility of scientific information generated within NBS and other agencies of the Federal government; promotes the development of the National Standard Reference Data System and a system of information analysis centers dealing with the broader aspects of the National Measurement System, and provides appropriate services to ensure that the NBS staff has optimum accessibility to the scientific information of the world. The Office consists of the following organizational units:

Office of Standard Reference Data—Clearinghouse for Federal Scientific and Technical Information [3]—Office of Technical Information and Publications—Library—Office of Public Information—Office of International Relations.

---

[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234.
[2] Located at Boulder, Colorado 80302.
[3] Located at 5285 Port Royal Road, Springfield, Virginia 22151.

NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT		NBS REPORT
4212435	November 24, 1970	10 390

PERFORMANCE EVALUATION OF A PROPANE-FIRED HOUSEHOLD-TYPE ABSORPTION REFRIGERATOR

Manufactured by
Excel Refrigeration Corporation
Fort Lauderdale, Florida

by
Patrick J. Reynolds
Clinton W. Phillips
Environmental Engineering Section
Building Research Division
Institute for Applied Technology
National Bureau of Standards
Washington, D. C. 20234

Report to
U. S. Army Natick Laboratories
Natick, Massachusetts

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

Table of Contents

Table of Contents - Continued

1.0 Introduction

The Excel refrigerator was received at the National Bureau of Standards Laboratories on July 5, 1968 and tests were subsequently conducted at the request of the U. S. Army Natick Laboratories. The initial request was to determine the maximum ambient temperature at which the refrigerator could function effectively. This and other information was developed in the course of this investigation.

This report presents the results of a laboratory investigation of a propane-fired absorption refrigerator manufactured by the Excel Refrigeration Corporation, Fort Lauderdale, Florida.

The purpose of this investigation was to determine quantitatively several performance characteristics of this refrigerator. The major characteristics were (in the order that they were studied):

a. The fuel line pressure that allowed the refrigerator to operate at its maximum cooling capacity in an ambient temperature of 90 °F at 50% relative humidity.
b. Determination of maximum ambient temperatures in which this refrigerator would operate effectively.
c. Maximum ambient temperature at which this refrigerator established a primary failure mode.
d. Minimum thermostat setting that allowed the refrigerator to operate effectively in an ambient temperature that approached the primary failure mode temperature.

e. Determination of whether this refrigerator could satisfy the temperature criteria established in the American Standard Test Procedures for Household Electric Refrigerators (Mechanically Operated) (B38.2-1961), i.e.,

Ambient Temperature (°F)	Avg. General Food Compart. Temp. (°F)
70	36
90	38
110	41

f. Maximum tilt angle at which the refrigerator would operate satisfactorily.

In addition to the above purpose a second objective was to provide results for use in establishing an American Standard Test Procedures for Household Absorption Refrigerators.

The refrigerator was not dismantled and parts were not disassembled during the course of this investigation. The unit was in operating condition at the conclusion of the study. The refrigerator specification name plate allowed energy sources of both propane and butane. Only propane was used in this study.

Conclusions concerning quantitative performance characteristics were arrived at by computations and analysis of experimental data as presented in detailed graphic and tabular form given in the appendices.

The data listings and plots were completed using the Environmental Engineering Section's Data Acquisition System and the National Bureau of Standards' Univac 1108 computer.

2.0 Description of Test Specimen

The Excel refrigerator was manufactured by the Excel Refrigeration Corporation, 5320 Worthwest 10th Terrace, Fort Lauderdale, Florida 33309.

The Excel refrigerator specification plate read:

Model No. X-L-600

Serial No. 6-337

Producer rated energy input, 1600 Btu/hr

Energy source, i) propane, ii) butane

Ammonia weight, less than two (2) pounds

Test pressure, less than 1500 psig

The outside physical dimensions were 26 1/2" wide, 23 1/2" deep and 43 1/2" high.

This refrigerator contained the following equipment inside: (See Figure 1):

Three (3) food shelves

One crisper with cover

One freezer compartment with three (3) ice trays

One defrost tray

Two (2) door shelves (formed from the interior door liner)

The door seal was a gasket-magnet combination.

Figures 1, 2 and 3 show the front, back and freezer compartment of the Excel refrigerator, respectively. Figure 4 is a side view of Excel burner assembly.

3.0 Test Apparatus and Procedure

The test procedure necessary to accomplish each objective as indicated in the introduction required occasional modification of the testing apparatus. Consequently, discussion of each of the following test procedures includes a description of the addition or alteration of the testing equipment relative to that particular test.

All testing was conducted in one of the National Bureau of Standards environmental testing laboratories having a controllable ambient temperature range of 40 °F to 150 °F with simultaneous control of relative humidity.

Prior to actual testing, the refrigerator was placed in the laboratory test room. The back of the refrigerator was placed parallel to one of the laboratory walls, approximately six (6) inches from the wall. The refrigerator was then leveled in the manner prescribed in the manufacturers instruction manual that accompanied the refrigerator.

3.1 Fuel Line Pressure Test

The first test was conducted to determine the fuel line pressure that would allow the refrigerator to operate at its optimum cooling capacity in an ambient temperature of 90 °F and 50% R.H. The laboratory test room conditions were maintained at 90 °F and 50% R.H. Four fuel line pressures were investigated, a) eight (8) inches W.G., b) eleven (11) inches W.G., c) thirteen (13) inches W.G. and d) fifteen (15) inches W.G.

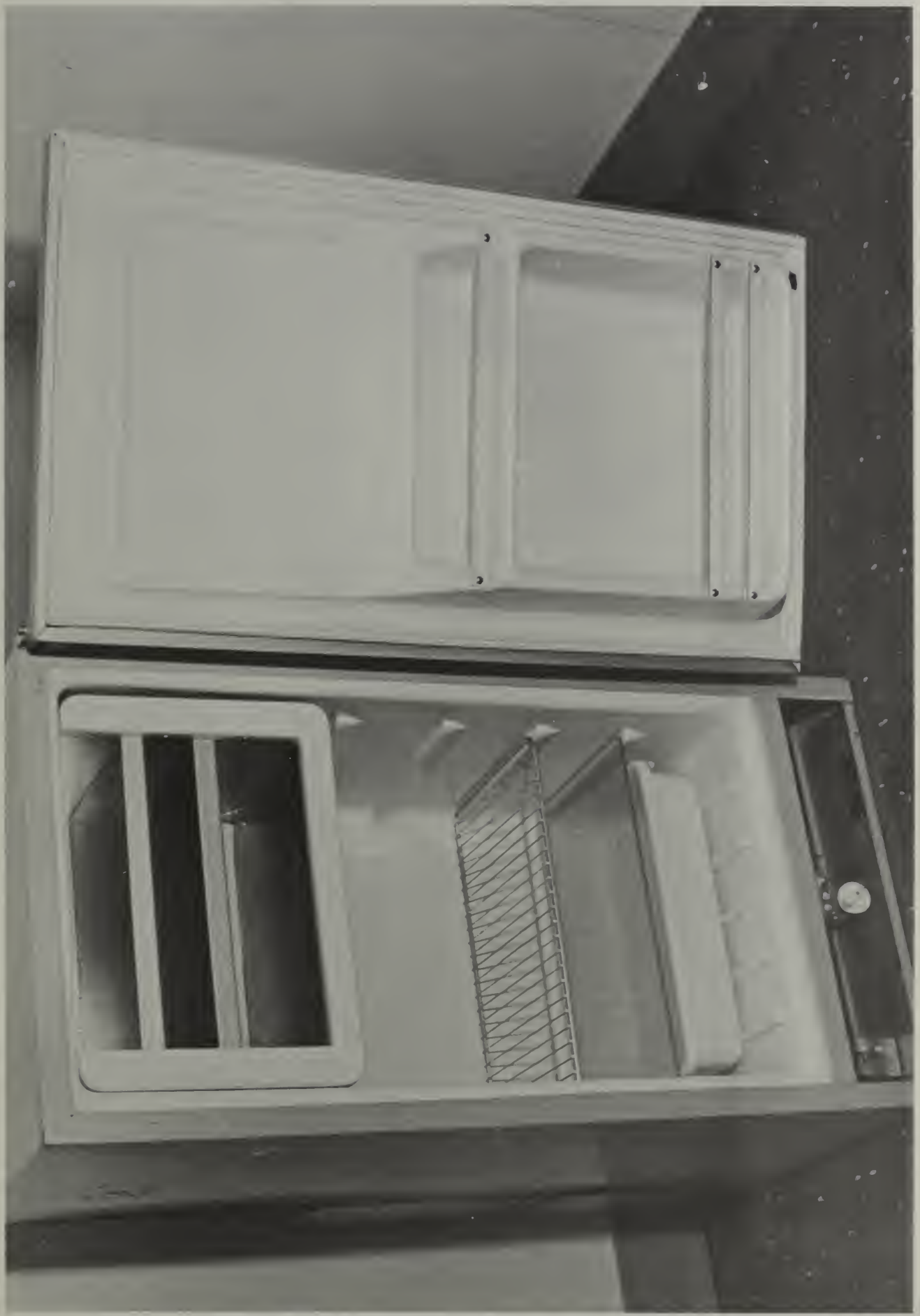


Fig 1. Interior - Excel refrigerator

Fig 2. Absorber, condenser, heater box, and associated apparatus of Excel absorption cooling system

Fig 3. Freezer compartment - Excel refrigerator

Fig 4. Burner assembly - Excel refrigerator

A water manometer was used to measure the fuel line pressure. A propane pressure regulator was used to control the fuel line pressures. A portable propane tank was used to supply fuel to operate the refrigerator. The fuel consumption rate was determined by daily weighings of the gas tank. The difference between the weight of the tank one day and the preceding day, divided by the number of hours elapsed between readings, yielded the average fuel consumption rate in pounds per hour.

Thermocouples were placed in the following locations: a) one in the air of the freezer compartment, b) a two-in-one averaging thermocouple in the air of the general food compartment, c) a two-in-one averaging thermocouple outside of the refrigerator to measure the average ambient air temperature, and d) one in an ice bath for reference. Midway through this test a thermocouple was installed at the outlet of the general food compartment evaporator coil and a thermocouple was placed in the middle of an ice cube in an ice tray in the freezer compartment. Thermocouples were read using a self-balancing electronic potentiometer that displayed the temperatures on chart paper in degrees Fahrenheit. The thermostat sensor normally attached to the general food compartment evaporator coil was removed from its receptor and exposed to the laboratory ambient air. This was done to assure that the thermostat would call for maximum cooling of the refrigerator throughout the test. Figure 5 shows the general food compartment evaporator coil and the thermostat sensor in its receptor.

Fig 5. General food compartment evaporator coil and thermostat sensor in receptor - Excel refrigerator

3.2 Elevated Ambient Temperature Test

The maximum ambient temperature in which this refrigerator could operate effectively was determined in the following manner. The ambient temperature was initially maintained at 90 °F. The fuel line pressure was kept at the optimum level determined in the previous test (this pressure was not altered for the remainder of the testing). If the refrigerator could operate effectively in a 90 °F ambient, the ambient was increased 10 °F. If the refrigerator could operate at this temperature the ambient would again be increased 10 °F. This procedure was repeated until the refrigerator ceased to function effectively. The refrigerator was allowed to operate at each ambient temperature for a minimum of one week. This minimum time period was sufficient to permit the refrigerator to achieve a thermal steady state. The results of this test thus allowed a closer look at the operating characteristics of the refrigerator resulting from near-failure-point ambient temperature operation. The transition temperature between effective and ineffective operation was determined by slowly increasing the ambient temperature from 100 °F until a portion of the refrigerator cooling system showed ineffective operation. This type of ineffective operation was defined as primary failure mode operation. Two additional thermocouples were installed for this test. The new thermocouple locations were at the inlet point and at the midpoint of the general food compartment evaporator coil.

3.3 Thermostat Tests

3.3.1

The thermostat test was conducted in two parts. The first test was to determine which setting allowed the refrigerator to operate effectively in an ambient temperature that approached the primary failure mode temperature. Prior to this test the thermostat sensor was reinstalled in its receptor. Also, the thermostat control knob range was calibrated such that there was five equal increments between the minimum (defrost) and maximum cooling positions. The ambient temperature was then adjusted to about 105 °F (this was near the primary failure mode temperature). The thermostat was then set at each of the six settings, and the resulting behavior characteristics were observed.

3.3.2

The second part of the thermostat test was to determine whether the refrigerator could satisfy the temperature criteria suggested in the American Standard Test Procedures for Household Electric Refrigerators (Mechanically Operated) (B38.2-1961). For this test the ambient temperature was maintained, successively, at 70 °F, 90 °F, and 110 °F. At each of these ambient temperatures, the thermostat was adjusted to its warmest position (not defrosting), position #1, the coldest position (#5), and two intermediate positions (#2 and #3.5).

3.4 Tilt Test

The last test was to investigate the ability of the refrigerator to operate while inclined in a pitch or a yaw position. The refrigerator was tilted in one degree increments with each position held for 24 hours or until positive failure due to tilt occurred. Preliminary tests showed that failure would be apparent within about five hours from the time of each tilting. All refrigerator temperatures rapidly approached ambient temperature when failure was produced by tilting.

To determine the tilt angle two large protractors, accurate to $\pm$ .5°, were drawn on construction paper. These protractors were trued vertically with a plumb bob and secured to the front and side of the refrigerator. The refrigerator was tilted by lifting one of its base edges at a time with a hydraulic jack. The angle the refrigerator had been tilted was measured using the protractor and a plumb bob.

4.0 Results and Discussion of Results

4.1 Fuel Line Pressure Test

The optimum fuel line pressure tests results are summarized in Table 1. The results of this test were used to determine the fuel line pressure that was used in all the subsequent tests.

Three main factors were used to select an optimum fuel line pressure. Considered were the general food compartment temperature, the frozen food compartment temperature, and the corresponding fuel consumption rate. The fuel line pressure that delivered continuously stable optimum refrigerator operation with the lowest fuel consumption rate was considered to be the optimum.

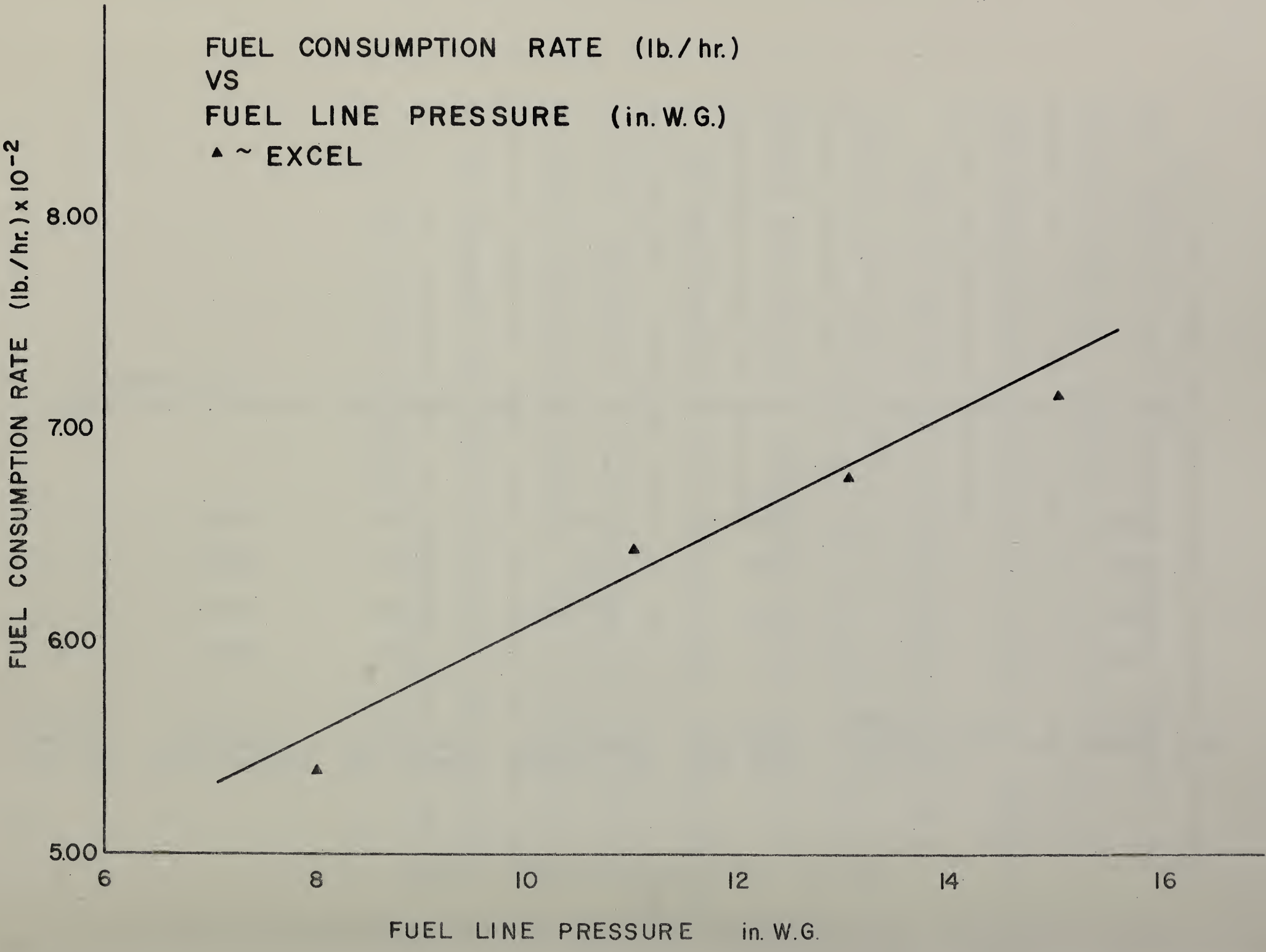
During the eight (8) inch W.G. fuel line pressure test, the refrigerator showed signs of unstable operation. The temperature in the freezer compartment and the general food compartment rose almost continuously during this test. Consequently, the eight inch W.G. fuel line pressure possibility was rejected.

The three remaining fuel line pressures, eleven, thirteen, and fifteen inches W.G., fulfilled the continuous stable refrigerator operation criterion. Consequently, the lowest fuel consumption rate determined the choice of these fuel line pressures. This fuel line pressure was eleven (11) inches W.G. Graph 1 shows the linear relationship between the fuel consumption rate and fuel line pressure. Detailed data and plots of fuel consumption rates and temperatures versus test time in calendar days are given in Appendix.

Table 1 Fuel Line Pressure Tests Results

Fuel Line Pressure In. W.G.	Avg. Gen. Food Comp. Temp. (°F)	Avg. Freezer Comp. Temp. (°F)	Avg. Ice Tray Comp. Temp. (°F)	Avg. Evap. Coil Temp. (°F)	Avg. Fuel Consump. Rate (lb/hr) x 10^{-2}	Avg. Ambient Temp. (°F)
8	45.87	25.5	*	*	5.1	91.1
11	33.56	24.42	12.77	3.22	6.4	91.1
13	31.45	21.54	9.41	0.92	6.7	89.8
15	29.65	22.35	11.09	2.62	7.2	90.7

* Thermocouples to monitor these temperatures had not been installed at the time of the 8 in. W.G. fuel line pressure test.


FUEL CONSUMPTION RATE (lb./hr.)
VS
FUEL LINE PRESSURE (in. W.G.)
▲ ~ EXCEL
FUEL CONSUMPTION RATE (lb./hr.) x 10⁻²
8.00
7.00
6.00
5.00
6
8
10
12
14
16
FUEL LINE PRESSURE in. W.G.

Graph 1

4.2 Elevated Ambient Temperature Tests

The primary purpose of the maximum ambient temperature test was to determine the lowest elevated temperature increment in which the refrigerator would fail to operate effectively.

The ambient temperature was increased from 90 °F to an average of 102.6 °F, and then to an average of 109.7 °F. It was held in excess of a week at each of these average ambient temperatures. It was then adjusted to an average of 118.2 °F for three days. It was apparent during this short test period that the refrigerator could not operate effectively at this elevated ambient temperature. The ambient temperature was then reduced to 112 °F where it was held for ten days. The ambient temperature was then reduced to an average of 88.2 °F. The results of these tests are given in Table 2.

While at 102.6 °F ambient temperature, the refrigerator operated satisfactorily. Once the refrigerator established steady state conditions, which took approximately 24 hours, there was very little fluctuation of its temperatures for the duration of the test.

The refrigerator behaved somewhat differently, however, in an average ambient temperature of 109.7 °F. All the internal temperatures except the evaporator coil temperature rose continually during this test. In a later test, it was discovered that this upward trend of refrigerator temperatures would occur when the ambient temperature went above the primary failure mode temperature. However, this behaviour did not become evident until the average ambient temperature was increased to 118.2 °F.

Table 2 Elevated Ambient Temperature Tests Results

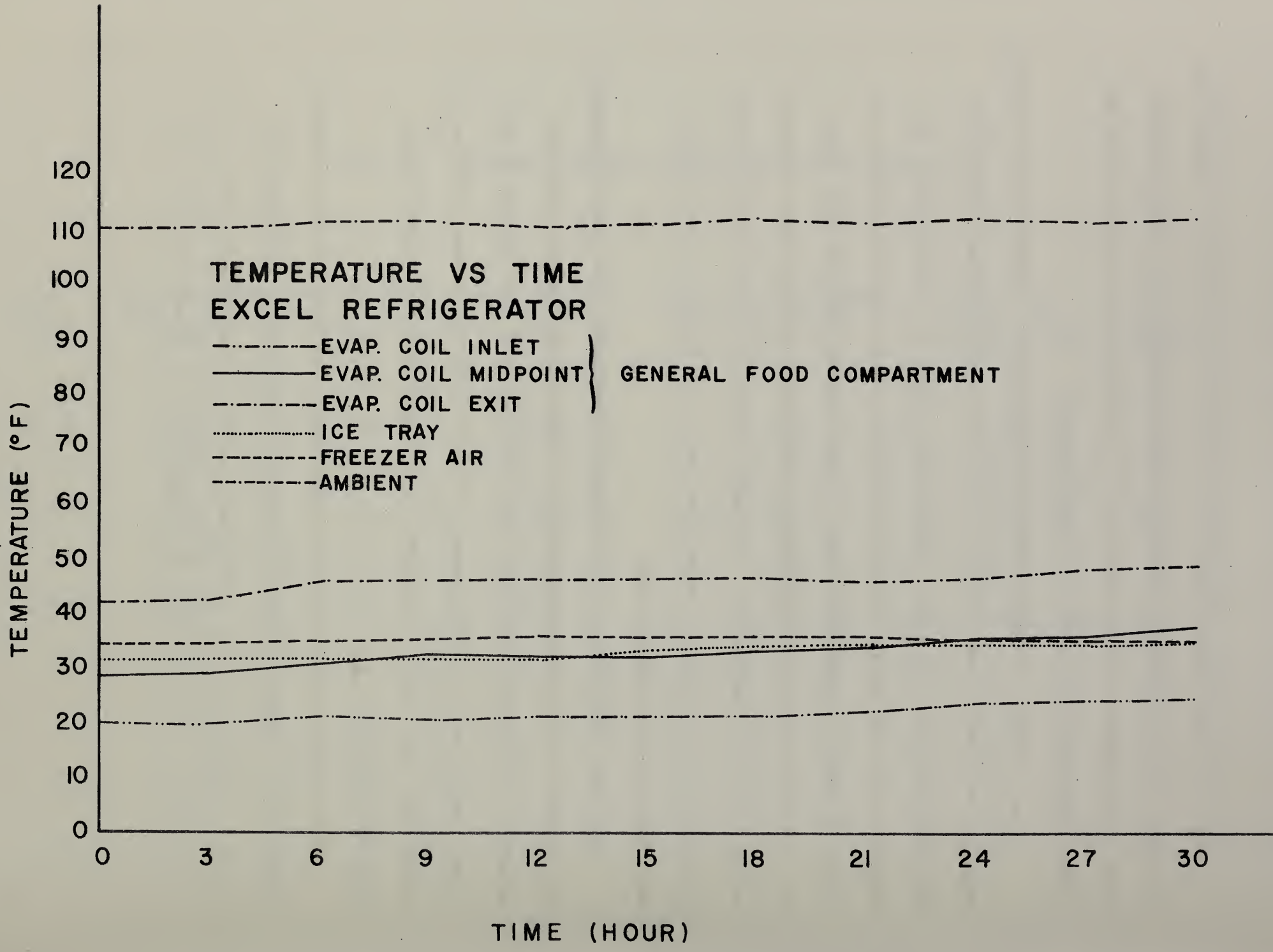
Avg. Ambient (°F)	Avg. Gen Food Comp. Temp. (°F)	Avg. Freezer Comp. Temp. (°F)	Avg. Ice Tray Temp. (°F)	Avg. Gen. Food Comp. Evap. Inlet Temp. (°F)	Avg. Fuel Consump. Rate (lb/hr) x 10^{-2}	Test Number
102.6	41.3	29.8	26.9	16.2	6.61	I
109.7	52.3	29.1	42.6	43.4	6.38	II
118.2	58.7	37.0	49.0	51.7	6.32	III
112.6	58.3	41.7	49.6	51.6	6.95	IV
88.2	28.8	24.4	12.2	7.4	6.62	V

In only three days of operation at this average ambient temperature of 118.2 °F, the freezer, ice tray, and evaporator coil temperature of both refrigerators climbed above 32 °F. Refrigeration at this high ambient temperature was totally unsatisfactory.

In an attempt to regain effective refrigerator operation, the average ambient temperature was lowered to 112.6 °F. This ambient temperature was maintained for ten days. During this time, the refrigerator temperatures did not drop, but rose even higher than they were during the 118.2 °F ambient temperature test. This behavior implied that there was a definite ambient temperature, above which, refrigerator operation would always be ineffective. To regain effective operation and thermal equilibrium, the ambient temperature had to be dropped below the primary failure mode temperature.

The last objective of the elevated temperature test was to determine the primary failure mode temperature. Sub-primary failure mode temperature refrigerator operation was established by maintaining an ambient temperature of approximately 90 °F for fourteen days. The ambient temperature was slowly increased until evidence of a primary failure mode was observed.

The results of this test are most easily interpreted when presented graphically. Graph 2 clearly illustrates the ambient temperature at which a component of the refrigerator began to function ineffectively. In the Excel, the evaporator coil exhibited the primary failure mode.


TEMPERATURE VS TIME
EXCEL REFRIGERATOR
EVAP. COIL INLET
EVAP. COIL MIDPOINT
EVAP. COIL EXIT
GENERAL FOOD COMPARTMENT
ICE TRAY
FREEZER AIR
AMBIENT
TEMPERATURE (°F)
120
110
100
90
80
70
60
50
40
30
20
10
0
0
3
6
9
12
15
18
21
24
27
30
TIME (HOUR)

Graph 2

At rising ambient temperatures below 110 °F, the Excel internal temperatures stayed relatively constant with respect to each other. Between 110 °F and 111 °F, the midpoint temperature of the evaporator coil began to rise at a faster rate than any of the other temperatures. This temperature was 1 °F and 4 °F lower than the ice tray and freezer air temperatures, respectively, at 110 °F ambient temperature. At 111 °F ambient temperature, the midpoint of the evaporator coil was 3 °F higher than both the ice tray and freezer air temperatures. In this ambient temperature interval of 110 °F to 111 °F, the ice tray temperature rose from below freezing to 35 °F. Therefore, between 110 °F and 111 °F, the Excel refrigerator established a failure mode.

4.3 Thermostat Tests

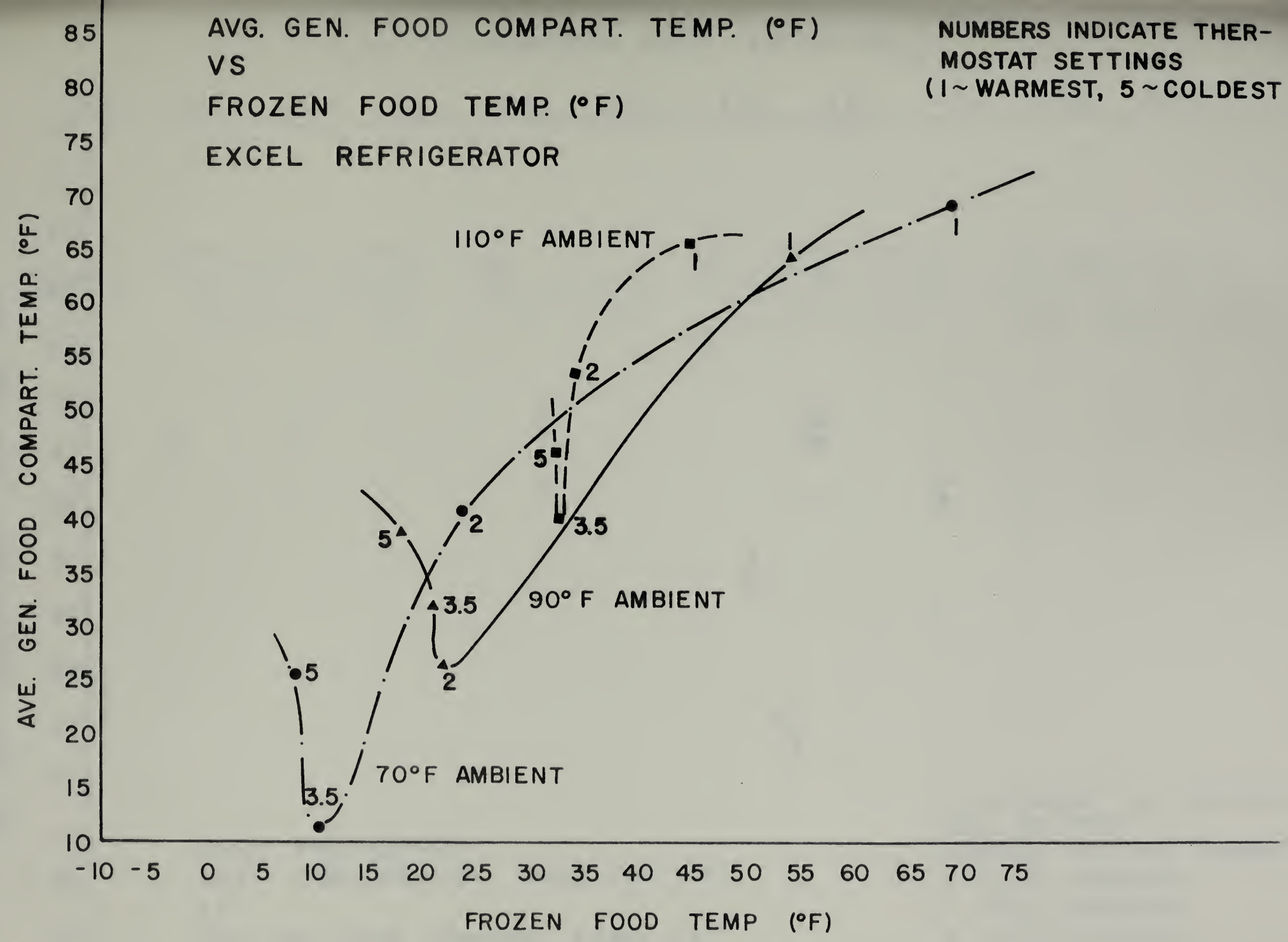
4.3.1

The purpose of the first thermostat test was to determine the minimum thermostat setting that would allow the Excel refrigerator to operate effectively in an ambient temperature that approached the primary failure mode temperature. For this test, the ambient temperature was kept at about 105 °F.

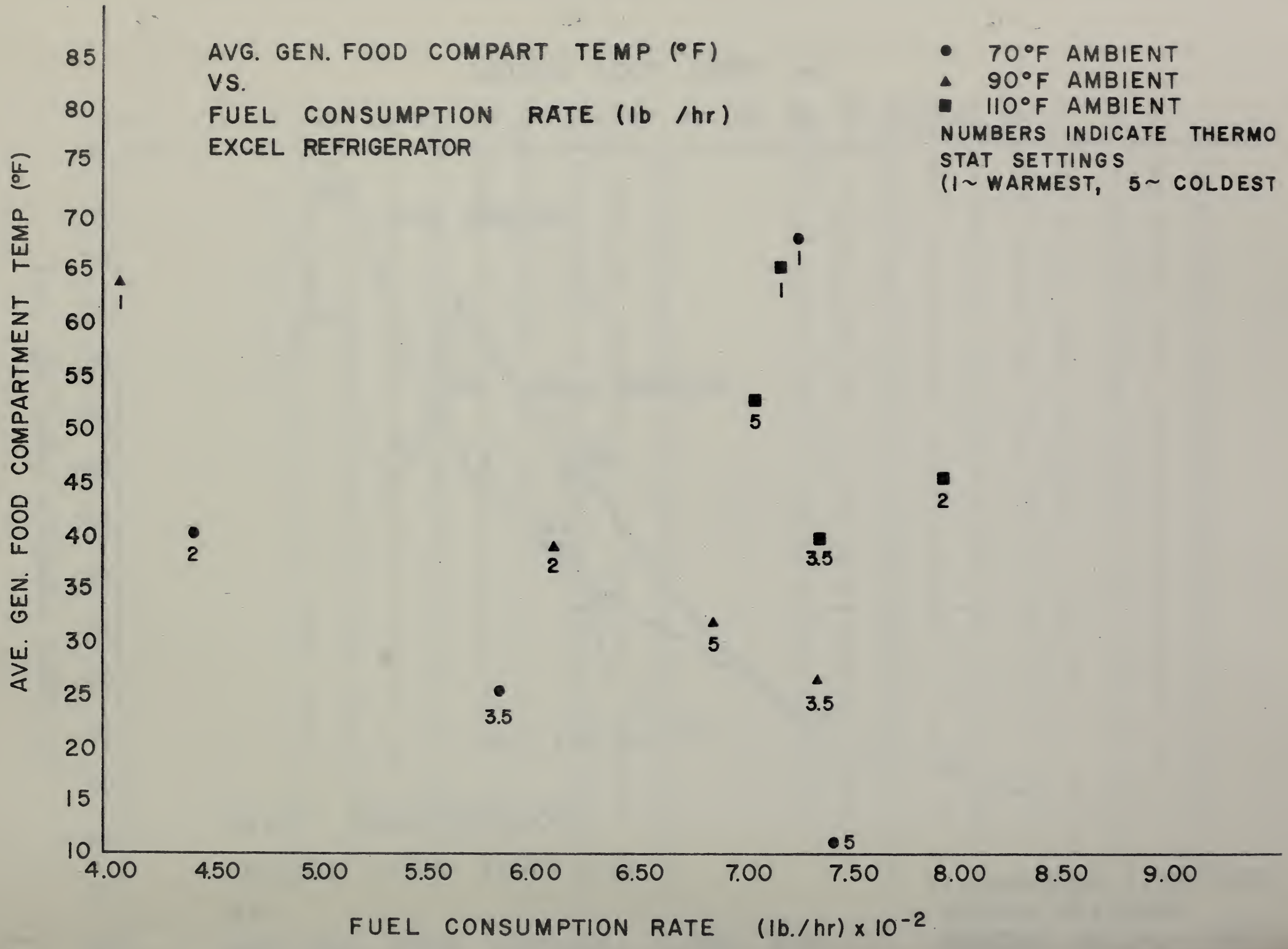
The refrigerator performed satisfactorily with its thermostat in positions five and four. The ice tray temperature rose from 31 °F to 42.5 °F with its thermostat in position three. The other Excel temperatures did not change substantially. In position two, the Excel maintained the same temperatures that were observed at the end of position three test. Operating in position one, the Excel temperatures rose until they were in the temperature interval 35 °F to 57 °F. In the zero or defrost position, all the Excel temperatures rose to about 97 °F. Therefore, position 4 was the optimum operating thermostat setting with regard to effective operation and fuel consumption.

4.3.2

The second thermostat test determined how closely the refrigerator could satisfy the temperature criterion suggested in the American Standard Test Procedures for Household Electric Refrigerators (Mechanically Operated) (B38.2-1961). These temperatures and the results of this test are summarized in Table 3. To assist in interpretation of the data, Graph 3 shows the frozen food temperature (i.e., ice tray temperature) versus the average general food compartment temperature and Graph 4 shows the fuel consumption rate versus the average general food compartment temperature for each of the three ambient temperatures (i.e., 70 °F, 90 °F, and 110 °F).


AVG. GEN. FOOD COMPART. TEMP. (°F)
VS
FROZEN FOOD TEMP. (°F)
EXCEL REFRIGERATOR
NUMBERS INDICATE THERMOSTAT SETTINGS
(1 ~ WARMEST, 5 ~ COLDEST
110°F AMBIENT
90° F AMBIENT
70°F AMBIENT
AVE. GEN. FOOD COMPART. TEMP. (°F)
FROZEN FOOD TEMP (°F)
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
-10 -5 0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75

Graph 3


AVG. GEN. FOOD COMPART TEMP (°F)
VS.
FUEL CONSUMPTION RATE (lb /hr)
EXCEL REFRIGERATOR
● 70°F AMBIENT
▲ 90°F AMBIENT
■ 110°F AMBIENT
NUMBERS INDICATE THERMO STAT SETTINGS
(1~ WARMEST, 5~ COLDEST
AVE. GEN. FOOD COMPARTMENT TEMP (°F)
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
4.00
4.50
5.00
5.50
6.00
6.50
7.00
7.50
8.00
8.50
9.00
FUEL CONSUMPTION RATE (lb./hr) x 10⁻²

Graph 4

Table 3 Results of B38.2 Thermostat Test

Ambient Temperature (°F)	General Food Compartment Temp. Deemed Acceptable by B.38.2 at Ambient Temperature (°F)	Lowest General Food Compartment Temp. (°F)	Frozen Food Temperature Corresponding to Lowest Gen. Food Compartment Temperature (°F)	Fuel Consumption Rate Corresponding to Lowest General Food Compartment Temp. (lb/hr) x 10^{-2}
70	36	11.5	10.5	7.45
90	38	26.5	22.0	5.87
110	41	40.0	32.5	7.37

A typical cooling curve for the Excel refrigerator revealed the following. As the cooling load increased because of increasing ambient temperature, the general food compartment temperature initially fell and simultaneously the frozen food temperature rose. A minimum general food compartment temperature was ultimately reached, after which, this temperature began to climb. The frozen food temperature climbed continually as the cooling load increased. It is apparent from the plot of general food compartment temperatures versus the frozen food temperature that the Excel refrigerant circuits give preference, first, to the general food compartment, and second, to the freezer compartment.

The refrigerator had more than enough cooling capacity to satisfy the general food compartment temperatures suggested in B38.2 ASA Standard at each of the three ambient temperatures referenced in that standard (but not at one thermostat setting).

4.4 Tilt Test Results

The refrigerator was tilted in one degree increments, forward, backward, right, and left. The conditions of this test are shown in Table 4. The angle shown beside each direction of tilt in Table 4 is the maximum inclination prior to inducing failure.

Table 4

Direction of Tilt	Angle (degrees)
Backward	1
Forward	2
Right	0
Left	2

5. Conclusions

The Excel refrigerator investigated in this study was found to operate most effectively and economically at a fuel line pressure of eleven inches of water. This result is in agreement with the recommendations of the refrigerator manufacturer.

The maximum ambient temperature in which this refrigerator functioned effectively was 110 °F. Above this ambient temperature, the refrigerator would display primary failure mode behavior.

The thermostat tests showed that a) the Excel refrigerator had more than enough cooling capacity to satisfy the general food compartment temperatures suggested in B38.2 ASA Standard 1961 at each of the three ambient temperatures referenced in that standard (but not at one thermostat setting), and b) in an ambient temperature of about 105 °F, (approaching the primary failure mode temperature) the Excel thermostat had to be kept in position four, or colder to produce effective operation.

The tilt test revealed that the operating ability of the refrigerator was extremely sensitive to the degree that it was inclined from the vertical. Depending on the direction of tilt, the Excel refrigerator could only tolerate tilts from 0 to 2°.

6. Acknowledgment

The authors appreciate the technical assistance of Mr. John Grimes. He helped assemble the testing apparatus and was responsible for the environmental control of the testing laboratory.

Appendix A Temperature Data Listings

	Frame Numbers
Fuel Line Pressure Test	1, 2, 3
Elevated Ambient Temperature Tests	4, 5, 6, 7
Thermostat Test I	8
Thermostat Test II	9

FRAME NUMBER 1 EXCEL REFRIGERATOR

DAY	GEN FOOD COMPART TEMP	FREEZER COIL IN TEMP	AMBIENT TEMP	GEN EVAP COIL IN TEMP	GEN EVAP COIL MID TEMP	GEN EVAP COIL OUT TEMP	ICE TRAY TEMP
1	********	********	********	********	********	********	********
2	********	********	********	********	********	********	********
3	37.00	25.00	93.00	********	********	********	********
4	********	********	********	********	********	********	********
5	34.50	22.00	90.20	********	********	********	********
6	********	********	********	********	********	********	********
7	********	********	********	********	********	********	********
8	********	********	********	********	********	********	********
9	********	********	********	********	********	********	********
10	39.00	24.00	90.00	********	********	********	********
11	39.50	22.00	91.00	********	********	********	********
12	39.00	22.00	90.00	********	********	********	********
13	41.00	23.00	92.00	********	********	********	********
14	********	********	********	********	********	********	********
15	********	********	********	********	********	********	********
16	39.00	12.50	90.00	********	********	********	********
17	39.00	12.50	90.00	********	********	********	********
18	38.00	20.50	91.00	********	********	********	********
19	38.50	20.00	90.00	********	********	********	********
20	38.00	19.00	90.00	********	********	********	********
21	********	********	********	********	********	********	********
22	********	********	********	********	********	********	********
23	********	********	********	********	********	********	********
24	39.00	20.00	91.00	********	********	********	********
25	38.50	19.50	90.50	********	********	********	********
26	38.50	19.50	90.50	********	********	********	********
27	40.00	18.50	89.00	********	********	********	********
28	********	********	********	********	********	********	********
29	********	********	********	********	********	********	********
30	43.00	19.00	91.00	********	********	********	********
31	26.50	23.20	91.20	********	********	********	********
32	26.00	22.50	90.00	********	********	********	********
33	26.00	22.00	90.00	********	********	********	********
34	25.50	22.00	90.50	********	********	********	********
35	********	********	********	********	********	********	********
36	********	********	********	********	********	********	********

NOTE--ASTERISK DENOTES NO DATA

FRAME NUMBER 2 EXCEL REFRIGERATOR

DAY	GEN FOOD COMPART TEMP	FREEZER COIL IN TEMP	AMBIENT TEMP	GEN EVAP COIL IN TEMP	GEN EVAP COIL MID TEMP	GEN EVAP COIL OUT TEMP	ICE TRAY TEMP
36	********	********	********	********	********	********	********
37	26.50	22.00	92.00	********	********	********	********
38	42.00	20.00	90.50	********	********	********	********
39	45.00	26.00	90.00	********	********	********	********
40	48.00	29.50	91.50	********	********	********	********
41	48.50	30.00	91.50	********	********	********	********
42	********	********	********	********	********	********	********
43	********	********	********	********	********	********	********
44	46.50	25.50	91.80	********	********	********	********
45	31.80	24.50	92.50	********	********	********	********
46	32.00	25.50	90.00	********	********	********	********
47	31.00	29.00	91.00	********	********	********	********
48	31.00	28.50	91.00	********	********	********	********
49	********	********	********	********	********	********	********
50	********	********	********	********	********	********	********
51	********	********	********	********	********	********	********
52	27.50	18.50	89.50	9.50	********	********	********
53	27.00	28.50	90.50	2.50	********	********	********
54	26.50	22.50	90.00	2.50	********	********	10.50
55	26.50	22.50	90.00	1.50	********	********	10.00
56	********	********	********	********	********	********	********
57	********	********	********	********	********	********	********
58	27.50	23.00	91.50	2.50	********	********	10.50
59	26.50	23.00	90.00	2.00	********	********	10.00
60	27.50	23.00	91.50	2.50	********	********	11.00
61	27.50	23.50	91.50	2.50	********	********	10.50
62	27.50	23.50	92.00	2.00	********	********	10.50
63	********	********	********	********	********	********	********
64	********	********	********	********	********	********	********
65	********	********	********	********	********	********	********
66	28.50	25.00	91.00	5.00	********	********	12.00
67	27.00	24.00	93.00	3.00	********	********	11.00
68	27.00	24.00	91.50	3.00	********	********	11.00
69	26.50	23.00	90.50	2.50	********	********	10.50
70	********	********	********	********	********	********	********
71	********	********	********	********	********	********	********

NOTE--ASTERISK DENOTES NO DATA

FRAME NUMBER 3 EXCEL REFRIGERATOR

DAY	GEN FOOD COMPART TEMP	FREEZER COIL IN TEMP	AMBIENT TEMP	GEN EVAP COIL IN TEMP	GEN EVAP COIL MID TEMP	GEN EVAP COIL OUT TEMP	ICE TRAY TEMP
71	********	********	********	********	********	********	********
72	24.50	21.00	88.00	.50	********	********	8.00
73	24.00	21.00	88.00	.00	********	********	8.50
74	24.00	21.00	88.00	.00	********	********	8.00
75	25.50	22.00	89.00	.50	********	********	9.00
76	27.50	24.00	92.00	2.00	********	********	12.00
77	********	********	********	********	********	********	********
78	********	********	********	********	********	********	********
79	36.00	32.00	112.00	10.00	********	********	19.00
80	28.00	24.00	92.00	2.50	********	********	11.00
81	********	********	********	********	********	********	********
82	********	********	********	********	********	********	********
83	********	********	********	********	********	********	********
84	********	********	********	********	********	********	********
85	********	********	********	********	********	********	********
86	********	********	********	********	********	********	********
87	********	********	********	********	********	********	********
88	********	********	********	********	********	********	********
89	********	********	********	********	********	********	********
90	********	********	********	********	********	********	********
91	********	********	********	********	********	********	********
92	********	********	********	********	********	********	********
93	********	********	********	********	********	********	********
94	********	********	********	********	********	********	********
95	********	********	********	********	********	********	********
96	********	********	********	********	********	********	********
97	********	********	********	********	********	********	********
98	********	********	********	********	********	********	********
99	********	********	********	********	********	********	********
100	********	********	********	********	********	********	********
101	********	********	********	********	********	********	********
102	********	********	********	********	********	********	********
103	********	********	********	********	********	********	********
104	********	********	********	********	********	********	********
105	********	********	********	********	********	********	********
106	********	********	********	********	********	********	********

NOTE--ASTERISK DENOTES NO DATA

FRAME NUMBER 4 EXCEL REFRIGERATOR

DAY	GEN FOOD COMPART TEMP	FREEZER COIL IN TEMP	AMBIENT TEMP	GEN EVAP COIL IN TEMP	GEN EVAP COIL MID TEMP	GEN EVAP COIL OUT TEMP	ICE TRAY TEMP
1	********	********	********	********	********	********	********
2	********	********	********	********	********	********	********
3	********	********	********	********	********	********	********
4	27.50	23.50	91.50	2.50	********	********	10.50
5	29.50	24.00	91.50	3.50	********	********	13.00
6	29.00	24.50	92.00	2.50	********	********	11.50
7	********	********	********	********	********	********	********
8	********	********	********	********	********	********	********
9	31.50	24.00	92.00	3.50	********	********	14.50
10	30.50	24.50	90.50	2.50	********	********	9.00
11	30.00	24.50	92.00	3.50	********	********	14.00
12	30.00	24.50	91.50	3.00	********	********	14.00
13	29.00	24.50	91.50	2.50	********	********	12.00
14	********	********	********	********	********	********	********
15	********	********	********	********	********	********	********
16	********	********	********	********	********	********	********
17	32.00	23.50	91.50	5.50	********	********	16.50
18	40.00	30.00	103.00	14.00	********	********	25.50
19	41.00	30.50	102.50	15.50	********	********	26.00
20	41.50	30.50	102.00	16.50	********	********	27.00
21	********	********	********	********	********	********	********
22	********	********	********	********	********	********	********
23	41.00	30.00	100.50	15.50	********	********	26.00
24	40.50	29.50	102.00	16.00	********	********	27.00
25	41.50	30.00	103.00	16.00	********	********	27.00
26	42.00	30.00	103.50	17.00	********	********	27.50
27	42.00	30.00	105.00	17.50	********	********	28.00
28	********	********	********	********	********	********	********
29	********	********	********	********	********	********	********
30	44.50	30.50	108.50	22.00	********	********	31.00
31	41.00	29.00	102.50	16.00	********	********	26.50
32	40.50	28.50	102.50	14.50	********	********	25.50
33	********	********	********	********	********	********	********
34	40.00	29.00	102.00	14.50	********	********	25.50
35	********	********	********	********	********	********	********
36	********	********	********	********	********	********	********

NOTE--ASTERISK DENOTES NO DATA

FRAME NUMBER 5 EXCEL REFRIGERATOR

DAY	GEN FOOD COMPART TEMP	FREEZER COIL IN TEMP	AMBIENT TEMP	GEN EVAP COIL IN TEMP	GEN EVAP COIL MID TEMP	GEN EVAP COIL OUT TEMP	ICE TRAY TEMP
36	********	********	********	********	********	********	********
37	50.50	32.00	110.50	41.00	********	********	41.50
38	51.00	31.00	110.00	41.50	********	********	41.50
39	52.00	30.50	110.00	42.00	********	********	42.00
40	52.00	30.00	110.00	42.50	********	********	42.00
41	52.00	29.50	110.00	43.50	********	********	42.50
42	********	********	********	********	********	********	********
43	********	********	********	********	********	********	********
44	51.50	28.00	105.00	42.50	********	********	42.00
45	52.00	29.50	110.50	43.00	********	********	42.50
46	53.00	27.50	110.50	45.00	********	********	43.50
47	54.50	27.00	110.50	46.00	********	********	44.00
48	54.50	26.00	111.00	46.50	********	********	44.50
49	********	********	********	********	********	********	********
50	********	********	********	********	********	********	********
51	55.50	27.50	119.50	47.50	********	********	44.50
52	59.50	40.50	117.50	52.00	********	********	49.50
53	61.00	43.00	117.50	55.50	********	********	53.00
54	59.00	40.00	113.50	53.00	********	********	50.50
55	58.50	40.50	113.50	53.00	********	********	50.00
56	********	********	********	********	********	********	********
57	********	********	********	********	********	********	********
58	56.50	39.00	114.00	50.00	********	********	47.50
59	54.00	32.00	112.00	46.00	********	********	44.00
60	********	********	********	********	********	********	********
61	53.00	37.00	110.50	45.50	********	********	44.50
62	57.50	41.00	113.50	51.00	********	********	49.00
63	********	********	********	********	********	********	********
64	********	********	********	********	********	********	********
65	55.00	36.50	111.50	47.50	********	********	46.00
66	73.00	66.00	78.50	66.50	********	********	65.00
67	********	********	********	********	********	********	********
68	39.50	30.00	88.50	28.00	********	********	29.00
69	39.50	30.00	89.50	28.00	********	********	29.00
70	********	********	********	********	********	********	********
71	********	********	********	********	********	********	********

NOTE--ASTERISK DENOTES NO DATA

FRAME NUMBER 6 EXCEL REFRIGERATOR

DAY	GEN FOOD COMPART TEMP	FREEZER COIL IN TEMP	AMBIENT TEMP	GEN EVAP COIL IN TEMP	GEN EVAP COIL MID TEMP	GEN EVAP COIL OUT TEMP	ICE TRAY TEMP
71	********	********	********	********	********	********	********
72	39.50	30.00	91.50	28.00	********	********	28.50
73	38.50	28.50	87.00	28.00	********	********	28.00
74	37.50	27.00	86.50	25.00	********	********	26.00
75	38.00	28.50	88.50	27.50	********	********	27.50
76	38.00	28.00	********	26.00	********	********	26.00
77	********	********	********	********	********	********	********
78	********	********	********	********	********	********	********
79	22.00	21.50	85.50	-1.00	********	********	4.00
80	23.00	21.50	86.00	-.50	********	********	4.00
81	23.50	22.50	87.00	.00	********	********	4.50
82	24.00	22.50	87.50	.00	********	********	5.00
83	25.50	23.50	89.00	1.00	********	********	5.50
84	********	********	********	********	********	********	********
85	********	********	********	********	********	********	********
86	********	********	********	********	********	********	********
87	25.50	23.50	89.00	.50	********	********	6.00
88	26.00	24.00	89.50	1.00	********	********	6.00
89	27.00	24.50	90.50	1.50	********	********	7.00
90	28.50	25.00	91.50	3.00	********	********	9.00
91	********	********	********	********	********	********	********
92	********	********	********	********	********	********	********
93	23.50	22.50	86.50	-1.00	********	********	4.00
94	24.50	23.00	87.50	-1.00	********	********	5.00
95	********	********	********	********	********	********	********
96	30.00	25.00	94.50	8.00	9.00	22.50	27.00
97	63.50	42.50	115.50	49.00	67.00	61.00	44.00
98	********	********	********	********	********	********	********
99	********	********	********	********	********	********	********
100	50.50	35.00	110.00	27.00	49.00	48.00	34.50
101	49.00	35.00	109.50	23.50	36.50	47.50	34.00
102	49.00	35.00	110.00	24.50	37.00	47.00	33.50
103	42.00	31.50	102.50	16.50	26.00	39.50	39.50
104	39.10	30.50	93.00	13.20	22.50	37.00	29.50
105	********	********	********	********	********	********	********
106	********	********	********	********	********	********	********

NOTE--ASTERISK DENOTES NO DATA

FRAME NUMBER 7 EXCEL REFRIGERATOR

DAY	GEN FOOD COMPART TEMP	FREEZER COIL IN TEMP	AMBIENT TEMP	GEN EVAP COIL IN TEMP	GEN EVAP COIL MID TEMP	GEN EVAP COIL OUT TEMP	ICE TRAY TEMP
106	********	********	********	********	********	********	********
107	44.00	32.00	101.50	18.00	29.50	49.00	31.00
108	44.50	33.00	104.00	18.00	30.00	43.00	31.50
109	46.00	33.50	104.50	19.50	32.50	43.50	32.00
110	50.00	36.00	110.00	25.00	38.00	49.00	35.00
111	43.50	32.00	105.00	17.50	27.00	42.50	31.00
112	********	********	********	********	********	********	********
113	********	********	********	********	********	********	********
114	37.00	29.00	102.00	12.50	17.00	33.50	28.00
115	38.00	28.50	103.50	12.50	18.00	35.00	28.00
116	36.50	28.00	103.00	11.00	16.00	33.00	27.00
117	39.00	29.00	104.50	12.50	19.50	36.00	28.50
118	********	********	********	********	********	********	********
119	********	********	********	********	********	********	********
120	********	********	********	********	********	********	********
121	41.50	30.50	109.00	13.50	21.00	37.00	31.00
122	43.00	26.50	105.00	21.00	37.50	43.50	26.00
123	43.50	29.00	101.50	17.50	33.50	42.50	28.50
124	38.50	30.50	103.00	13.00	16.50	34.00	19.00
125	40.00	31.50	104.00	14.00	20.00	37.50	31.00
126	********	********	********	********	********	********	********
127	********	********	********	********	********	********	********
128	35.00	35.00	110.00	22.50	37.50	49.00	35.50
129	50.50	35.00	110.50	23.00	38.00	49.00	35.00
130	********	********	********	********	********	********	********
131	52.00	34.50	109.00	26.00	41.00	50.00	35.00
132	********	********	********	********	********	********	********
133	********	********	********	********	********	********	********
134	********	********	********	********	********	********	********
135	71.00	51.50	76.50	65.00	64.00	61.50	28.50
136	********	********	********	********	********	********	********
137	********	********	********	********	********	********	********
138	********	********	********	********	********	********	********
139	********	********	********	********	********	********	********
140	********	********	********	********	********	********	********
141	********	********	********	********	********	********	********

NOTE--ASTERISK DENOTES NO DATA

FRAME NUMBER 8 EXCEL REFRIGERATOR

DAY	GEN FOOD COMPART TEMP	FREEZER COIL IN TEMP	AMBIENT TEMP	GEN EVAP COIL IN TEMP	GEN EVAP COIL MID TEMP	GEN EVAP COIL OUT TEMP	ICE TRAY TEMP
1	********	********	********	********	********	********	********
2	********	********	********	********	********	********	********
3	********	********	********	********	********	********	********
4	33.50	28.00	100.00	11.00	9.00	16.00	29.50
5	46.00	34.00	106.50	20.00	32.50	46.00	35.00
6	********	********	********	********	********	********	********
7	********	********	********	********	********	********	********
8	********	********	********	********	********	********	********
9	37.00	31.50	103.00	13.00	12.50	23.00	33.50
10	37.00	31.50	104.00	13.00	13.00	24.00	34.00
11	37.00	31.50	104.50	13.00	12.50	23.50	********
12	38.00	32.50	106.00	13.50	14.00	24.00	35.00
13	38.00	32.50	105.50	14.50	14.00	24.00	35.50
14	********	********	********	********	********	********	********
15	********	********	********	********	********	********	********
16	36.50	31.50	104.50	13.00	11.50	21.50	35.00
17	38.50	32.50	105.00	13.50	13.50	26.50	31.00
18	37.00	31.50	105.00	13.00	11.50	23.50	35.50
19	36.50	31.00	103.50	12.00	12.00	26.00	37.50
20	38.50	33.50	105.00	14.50	13.50	26.00	41.50
21	********	********	********	********	********	********	********
22	********	********	********	********	********	********	********
23	********	********	********	********	********	********	********
24	39.00	34.00	105.50	14.00	13.50	29.50	42.50
25	40.00	33.00	104.00	13.00	18.50	40.50	41.00
26	39.00	32.50	105.00	12.50	16.50	38.50	41.00
27	39.50	33.00	104.50	12.50	18.00	39.50	41.00
28	********	********	********	********	********	********	********
29	********	********	********	********	********	********	********
30	40.00	31.50	103.00	14.00	20.50	40.50	40.00
31	61.50	48.00	103.00	56.50	48.00	54.50	56.00
32	57.50	41.00	103.00	48.00	49.50	50.50	36.00
33	57.00	40.50	103.00	48.00	49.50	50.00	35.50
34	57.50	41.00	102.50	48.00	********	50.50	35.50
35	********	********	********	********	********	********	********
36	********	********	********	********	********	********	********

NOTE--ASTERISK DENOTES NO DATA

FRAME NUMBER 9 EXCEL REFRIGERATOR

DAY	GEN FOOD COMPART TEMP	FREEZER COIL IN TEMP	AMBIENT TEMP	GEN EVAP COIL IN TEMP	GEN EVAP COIL MID TEMP	GEN EVAP COIL OUT TEMP	ICE TRAY TEMP
1	********	********	********	********	********	********	********
2	********	********	********	********	********	********	********
3	36.50	30.00	103.50	13.00	16.50	32.00	30.00
4	29.50	20.50	92.50	5.00	16.00	30.50	20.00
5	27.00	19.00	91.00	2.00	14.00	28.00	18.50
6	32.00	16.00	86.00	7.00	29.00	30.00	27.50
7	********	********	********	********	********	********	********
8	********	********	********	********	********	********	********
9	33.50	24.00	94.50	8.50	19.50	34.50	24.00
10	35.50	29.50	68.50	31.00	32.00	34.00	30.00
11	11.50	9.50	69.00	-7.00	-10.00	-5.00	10.50
12	40.50	9.50	69.00	********	37.50	38.50	23.50
13	********	********	********	********	********	********	********
14	********	********	********	********	********	********	********
15	25.50	8.00	69.50	19.00	20.00	22.00	6.50
16	32.00	21.00	89.00	10.50	24.00	32.50	21.00
17	64.00	56.50	90.00	60.50	61.50	62.50	54.00
18	26.50	21.50	89.00	4.50	10.00	24.00	22.00
19	38.50	21.00	90.00	32.50	34.00	36.00	18.00
20	********	********	********	********	********	********	********
21	********	********	********	********	********	********	********
22	53.00	32.50	109.50	38.00	47.00	51.50	34.00
23	65.00	52.50	109.50	61.50	62.00	63.00	44.50
24	38.50	32.00	106.50	15.00	24.00	39.50	32.00
25	40.00	32.50	110.00	16.00	23.00	40.00	32.50
26	46.00	31.50	110.50	22.50	38.00	46.50	32.50
27	********	********	********	********	********	********	********
28	********	********	********	********	********	********	********
29	********	********	********	********	********	********	********
30	********	********	********	********	********	********	********
31	********	********	********	********	********	********	********
32	********	********	********	********	********	********	********
33	********	********	********	********	********	********	********
34	********	********	********	********	********	********	********
35	********	********	********	********	********	********	********
36	********	********	********	********	********	********	********

NOTE--ASTERISK DENOTES NO DATA

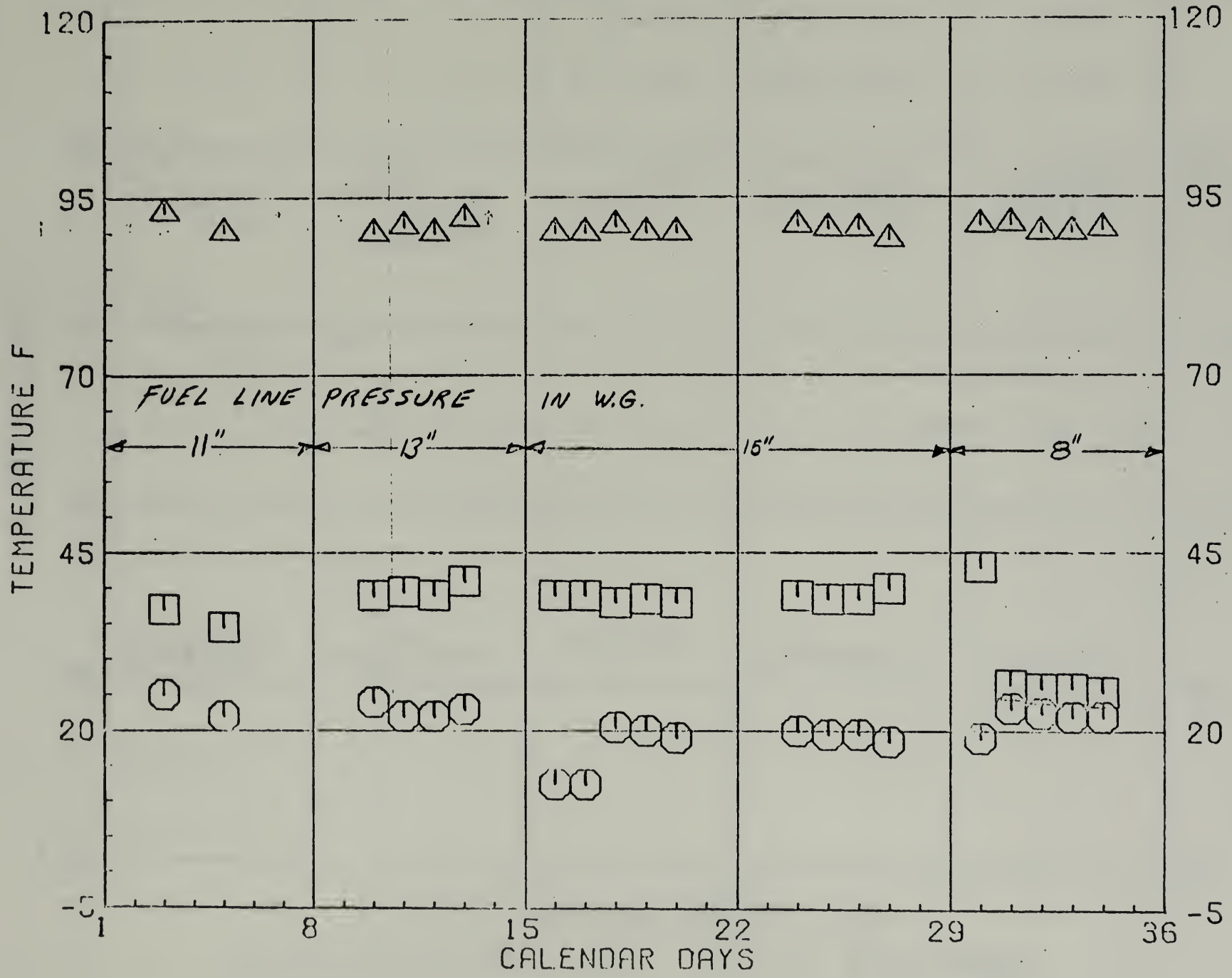
Appendix B Temperature Plots

	Frame Numbers
Fuel Line Pressure Test	1, 2, 3
Elevated Temperature Test	4, 5, 6, 7
Thermostat Test I	8
Thermostat Test II	9

SYMBOL LEGEND

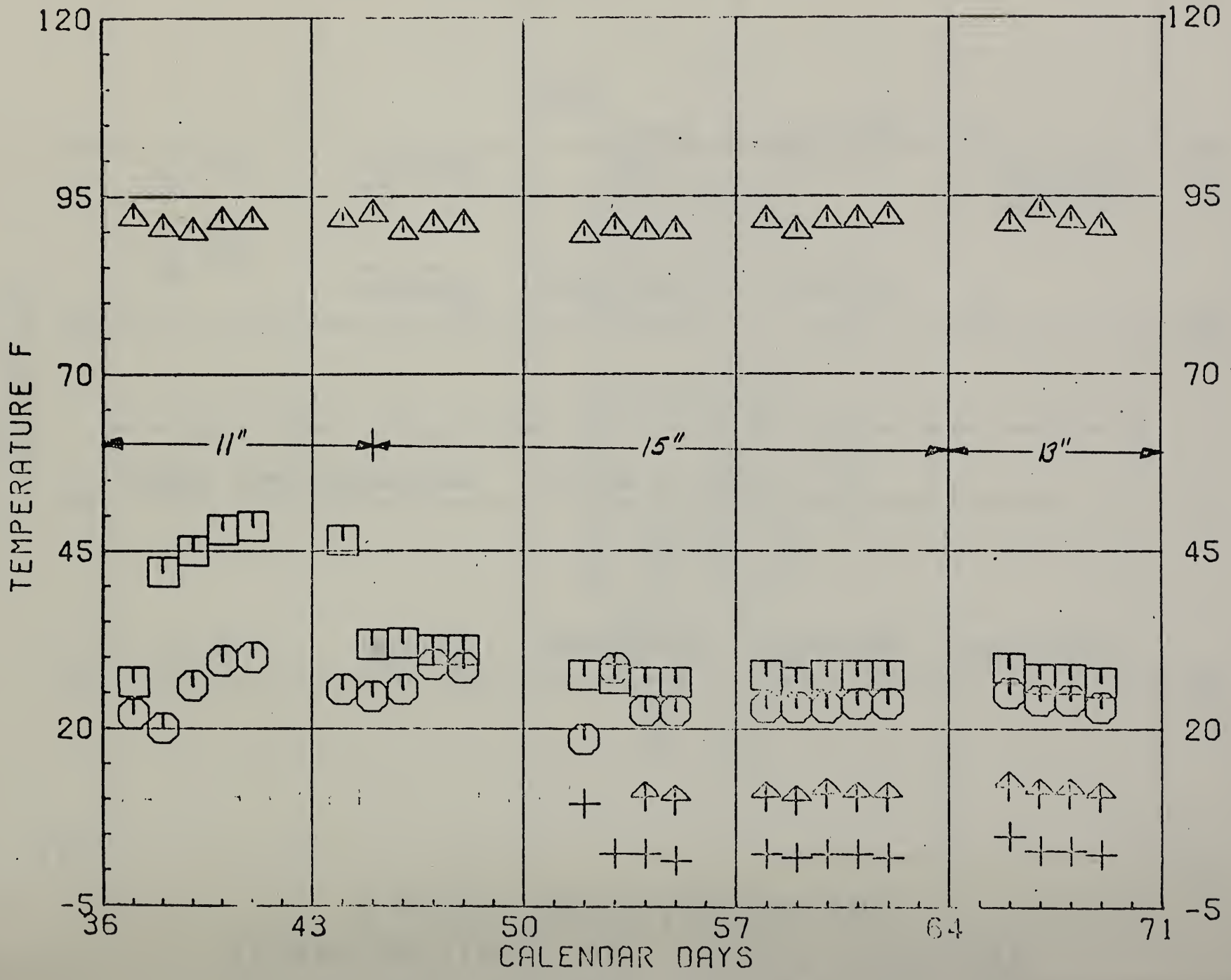
□ GENERAL FOOD COMPART TEMP
○ FREEZER EVAP COIL INLET TEMP
△ AMBIENT TEMPERATURE
+ GEN EVAP COIL INLET TEMP
× GEN EVAP COIL MIDPOINT TEMP
◇ GEN EVAP COIL EXIT TEMP
⏃ ICE TRAY TEMPERATURE

TEMPERATURE VS. TEST PERIOD
EXCEL REFRIGERATOR

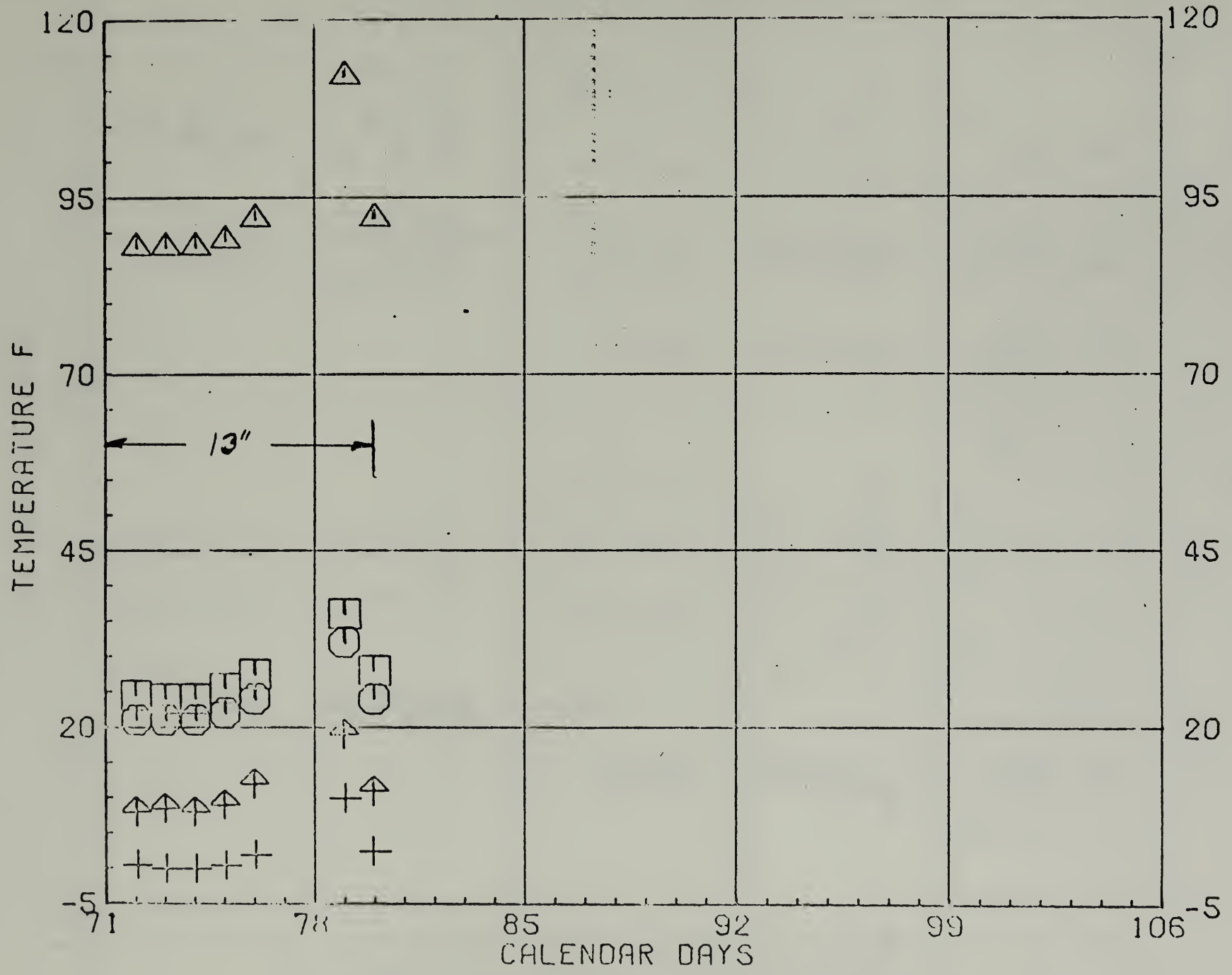


FRAME NUMBER 1

TEMPERATURE VS. TEST PERIOD
EXCEL REFRIGERATOR

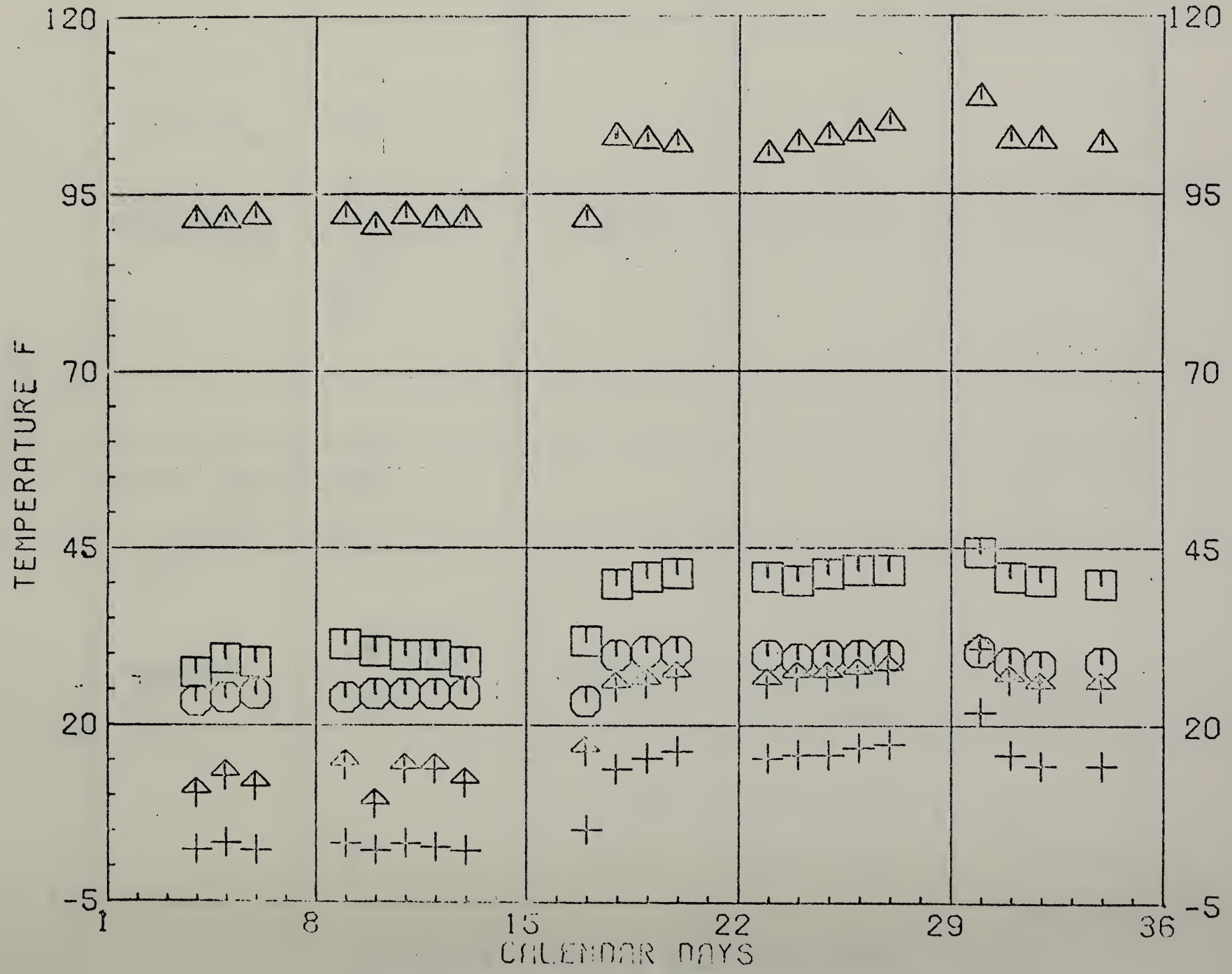


TEMPERATURE VS. TEST PERIOD
EXCEL REFRIGERATOR



FRAME NUMBER 3

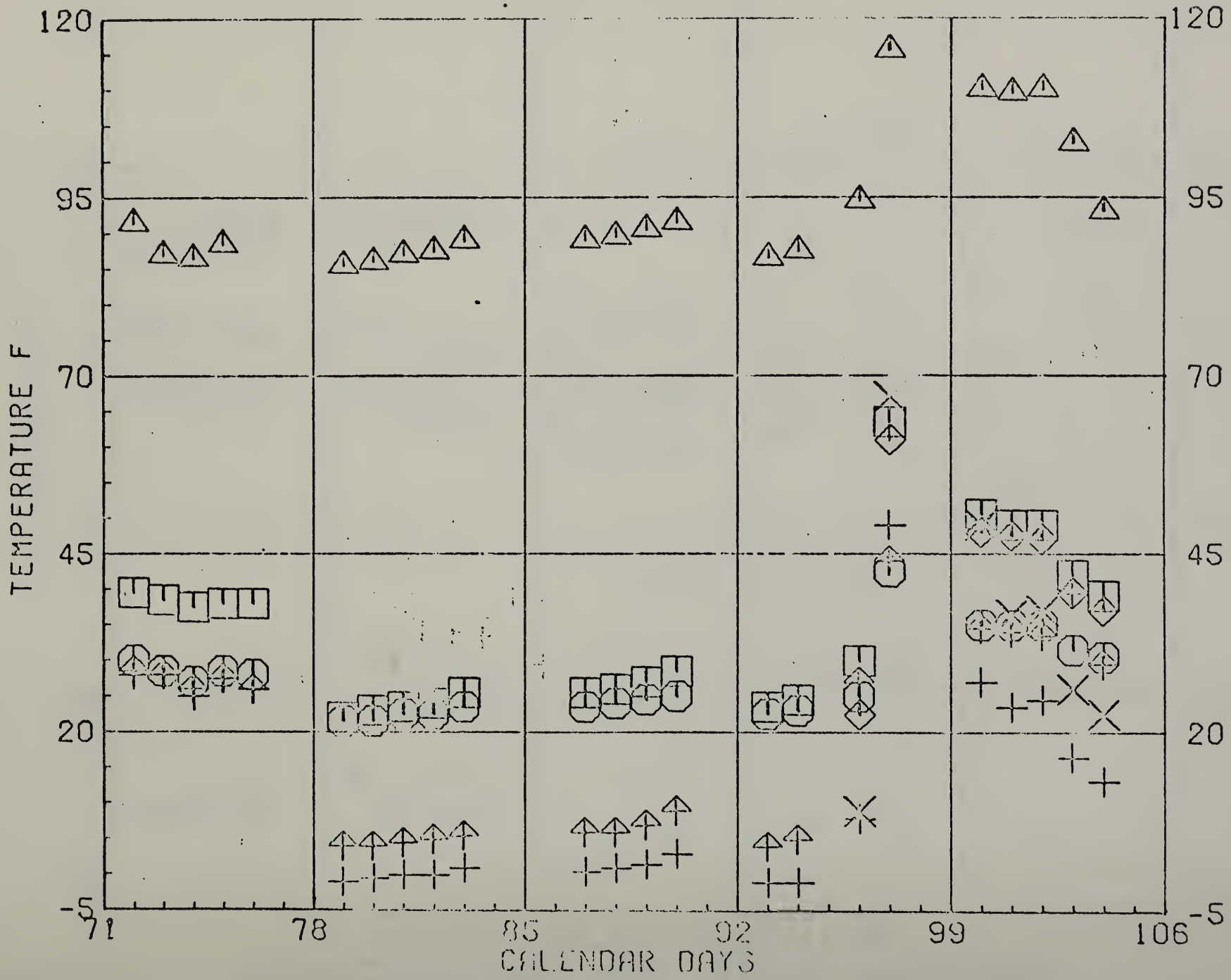
TEMPERATURE VS. TEST PERIOD
EXCEL REFRIGERATOR



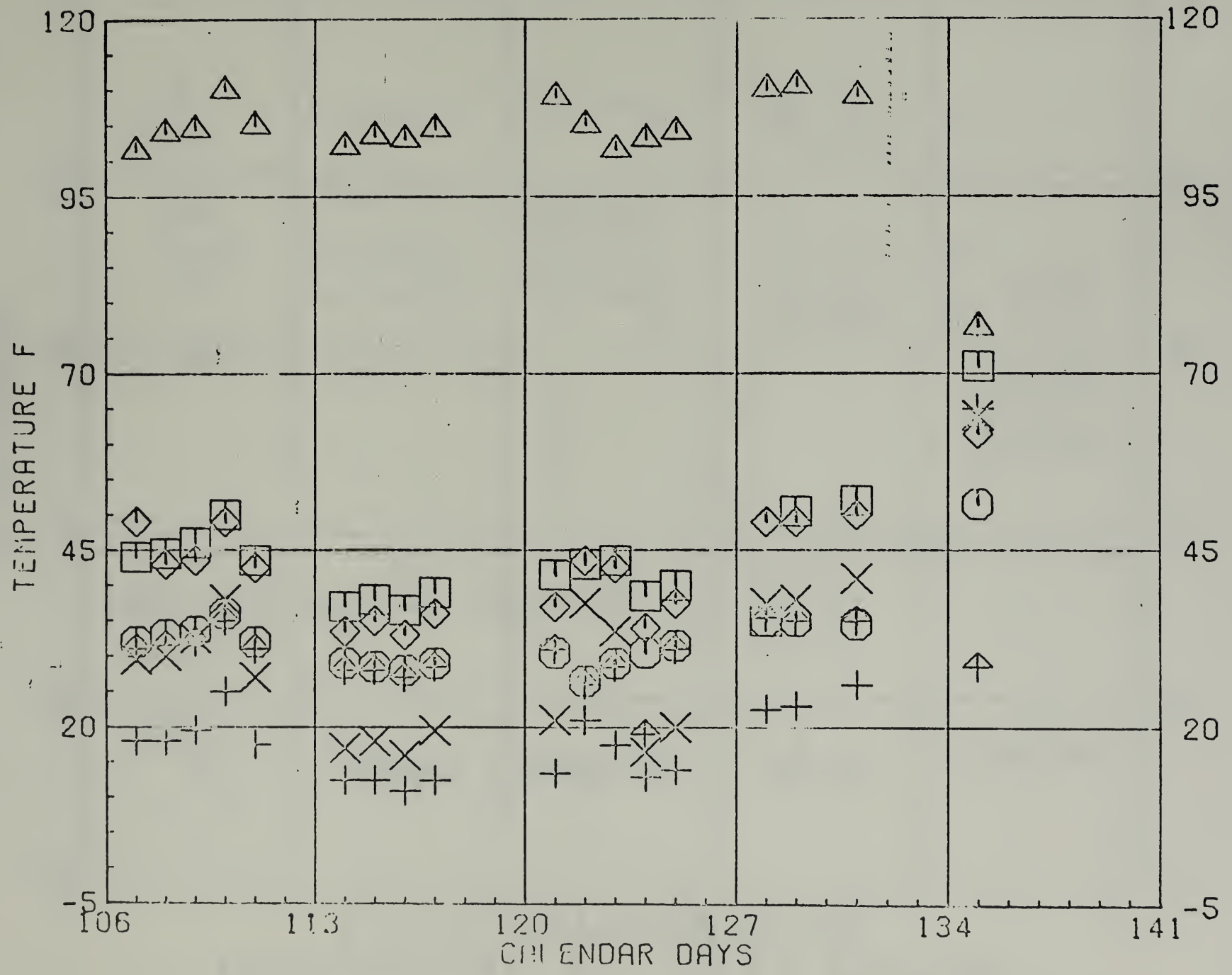
TEMPERATURE VS. TEST PERIOD
EXCEL REFRIGERATOR

FRAME NUMBER 5

TEMPERATURE VS. TEST PERIOD
EXCEL REFRIGERATOR

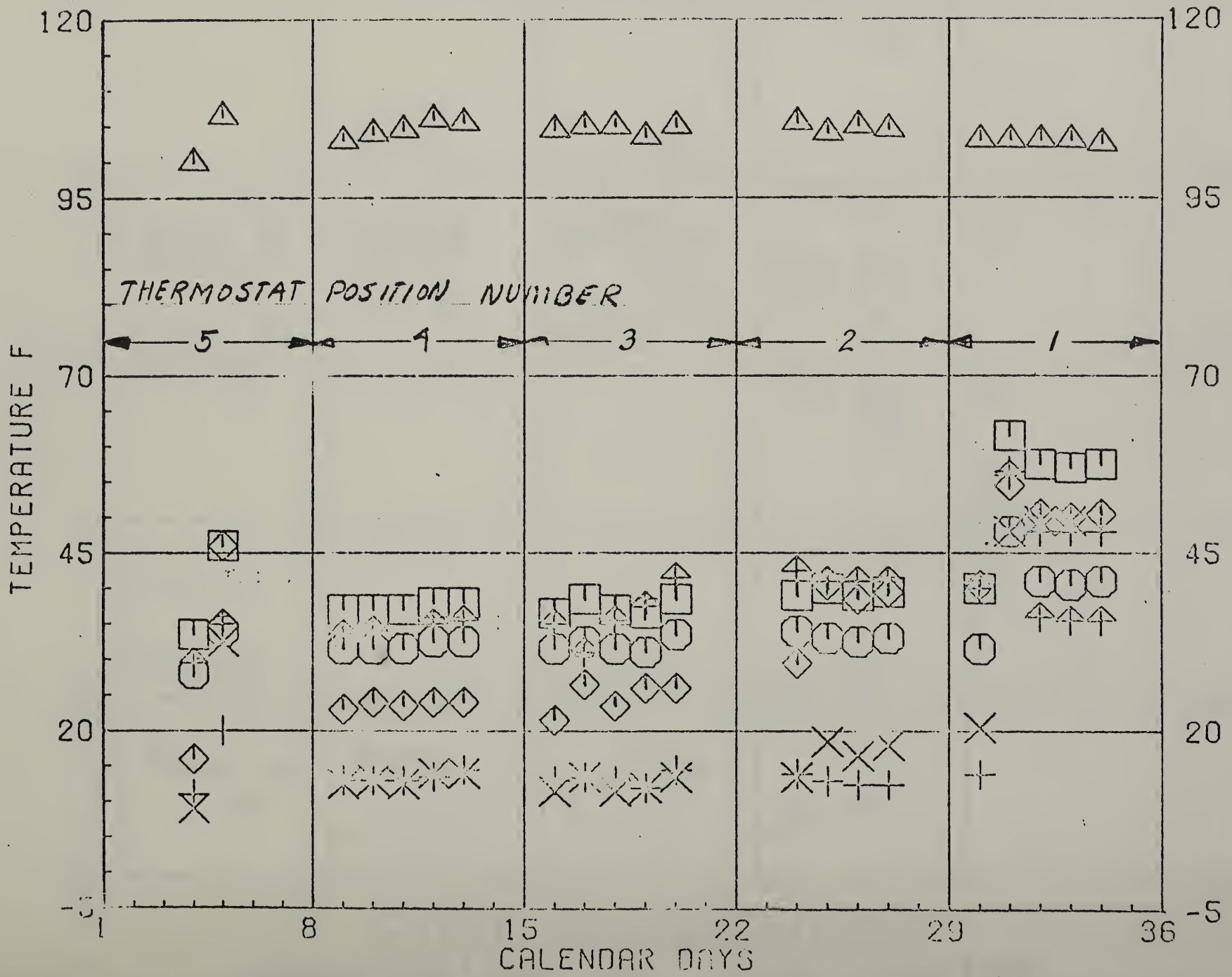


TEMPERATURE VS. TEST PERIOD
EXCEL REFRIGERATOR



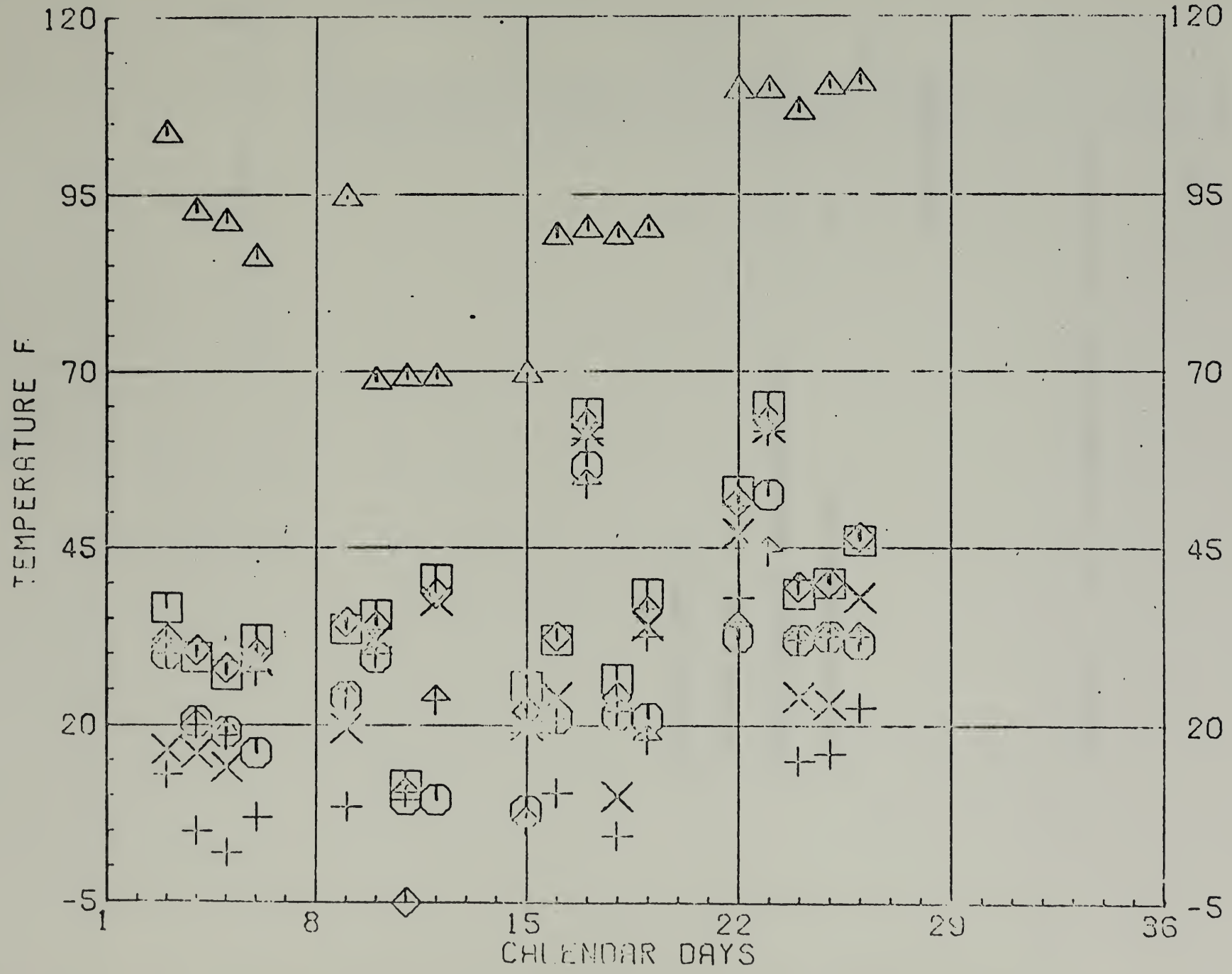
FRAME NUMBER 7

TEMPERATURE VS. TEST PERIOD
EXCEL REFRIGERATOR



FRAME NUMBER 8

TEMPERATURE VS. TEST PERIOD
EXCEL REFRIGERATOR



FRAME NUMBER 9

Appendix C Fuel Consumption Rate Data Listing

	Frame Number
Fuel Line Pressure Test	10, 11, 12
Elevated Ambient Temperature Test	13, 14, 15, 16
Thermostat Test I	17
Thermostat Test II	18

FRAME NUMBER 10 EXCEL FUEL

DAY	CONSUMPTION (LBM/HR)
1	********
2	********
3	********
4	********
5	********
6	********
7	********
8	********
9	.0625
10	.0667
11	.0667
12	.0667
13	.0695
14	********
15	********
16	.0687
17	.0709
18	.0705
19	.0729
20	.0641
21	********
22	********
23	********
24	.0763
25	.0717
26	.0750
27	.0739
28	********
29	********
30	.0716
31	.0761
32	.0750
33	.0730
34	.0750
35	********
36	********

NOTE--ASTERISK DENOTES NO DATA

FRAME NUMBER	EXCEL FUEL
DAY	CONSUMPTION (LBM/HR)
36	********
37	.0562
38	.0525
39	.0538
40	.0521
41	.0549
42	********
43	********
44	.0659
45	.0633
46	.0667
47	.0654
48	.0600
49	********
50	********
51	.0706
52	.0688
53	.0709
54	.0688
55	.0688
56	********
57	********
58	.0696
59	.0717
60	.0696
61	.0709
62	.0709
63	********
64	********
65	.0697
66	.0708
67	.0700
68	.0692
69	.0707
70	********
71	********

NOTE--ASTERISK DENOTES NO DATA

FRAME NUMBER 14 EXCEL FUEL

DAY	CONSUMPTION (LBM/HR)
36	********
37	.0658
38	.0604
39	.0642
40	.0616
41	.0632
42	********
43	********
44	.0672
45	.0591
46	.0634
47	.0679
48	.0679
49	********
50	********
51	.0679
52	.0671
53	********
54	.0625
55	.0630
56	********
57	********
58	.0671
59	.0625
60	********
61	.0649
62	.0652
63	********
64	********
65	.0634
66	.0642
67	.0638
68	.0634
69	.0667
70	********
71	********

NOTE--ASTERISK DENOTES NO DATA

FRAME NUMBER 15 EXCEL FUEL

DAY	CONSUMPTION (LBM/HR)
71	********
72	.0679
73	.0642
74	.0688
75	.0663
76	.0659
77	********
78	********
79	********
80	.0670
81	.0663
82	.0659
83	.0657
84	********
85	********
86	.0667
87	.0644
88	.0700
89	.0679
90	.0652
91	********
92	********
93	.0661
94	.0651
95	.0663
96	.0663
97	.0664
98	********
99	********
100	.0656
101	.0674
102	.0688
103	.0658
104	.0666
105	********
106	********

NOTE--ASTERISK DENOTES NO DATA

FRAME NUMBER 14 EXCEL FUEL

DAY	CONSUMPTION (LBM/HR)
36	********
37	.0658
38	.0604
39	.0642
40	.0616
41	.0632
42	********
43	********
44	.0672
45	.0591
46	.0634
47	.0679
48	.0679
49	********
50	********
51	.0679
52	.0671
53	********
54	.0625
55	.0630
56	********
57	********
58	.0671
59	.0625
60	********
61	.0649
62	.0652
63	********
64	********
65	.0634
66	.0642
67	.0638
68	.0634
69	.0667
70	********
71	********

NOTE--ASTERISK DENOTES NO DATA

FRAME NUMBER 15 EXCEL FUEL

DAY	CONSUMPTION (LBM/HR)
71	********
72	.0679
73	.0642
74	.0688
75	.0663
76	.0659
77	********
78	********
79	********
80	.0670
81	.0663
82	.0659
83	.0657
84	********
85	********
86	.0667
87	.0644
88	.0700
89	.0679
90	.0652
91	********
92	********
93	.0661
94	.0651
95	.0663
96	.0663
97	.0664
98	********
99	********
100	.0656
101	.0674
102	.0688
103	.0658
104	.0666
105	********
106	********

NOTE--ASTERISK DENOTES NO DATA

FRAME NUMBER 16 EXCEL FUEL

DAY	CONSUMPTION (LBM/HR)
106	********
107	.0666
108	.0666
109	.0675
110	.0694
111	********
112	********
113	********
114	.0617
115	.0629
116	.0676
117	.0686
118	.0686
119	********
120	********
121	.0644
122	.0668
123	********
124	.0656
125	.0628
126	********
127	********
128	.0000
129	.0874
130	.0884
131	********
132	.0791
133	********
134	********
135	.0800
136	.0767
137	.0846
138	.0792
139	.0812
140	********
141	********

NOTE--ASTERISK DENOTES NO DATA

FRAME NUMBER 17 EXCEL FUEL

DAY	CONSUMPTION (LBM/HR)
1	********
2	.0738
3	.0744
4	.0732
5	.0770
6	.0770
7	********
8	********
9	********
10	.0696
11	.0726
12	.0675
13	.0711
14	********
15	********
16	.0497
17	.0554
18	.0604
19	.0590
20	.0249
21	********
22	********
23	.0742
24	.0704
25	.0659
26	.0571
27.	.0608
28	********
29	********
30	.0608
31	.0729
32	.0742
33	.0442
34	.0581
35	********
36	********

NOTE--ASTERISK DENOTES NO DATA

FRAME NUMBER 18 EXCEL FUEL

DAY	CONSUMPTION (LBM/HR)
1	********
2	.0683
3	.0408
4	.0739
5	.0612
6	.0706
7	********
8	********
9	.0716
10	.0625
11	.0738
12	.0796
13	********
14	********
15	********
16	********
17	********
18	********
19	********
20	********
21	********
22	********
23	********
24	********
25	********
26	********
27	********
28	********
29	********
30	********
31	********
32	********
33	********
34	********
35	********
36	********

NOTE--ASTERISK DENOTES NO DATA

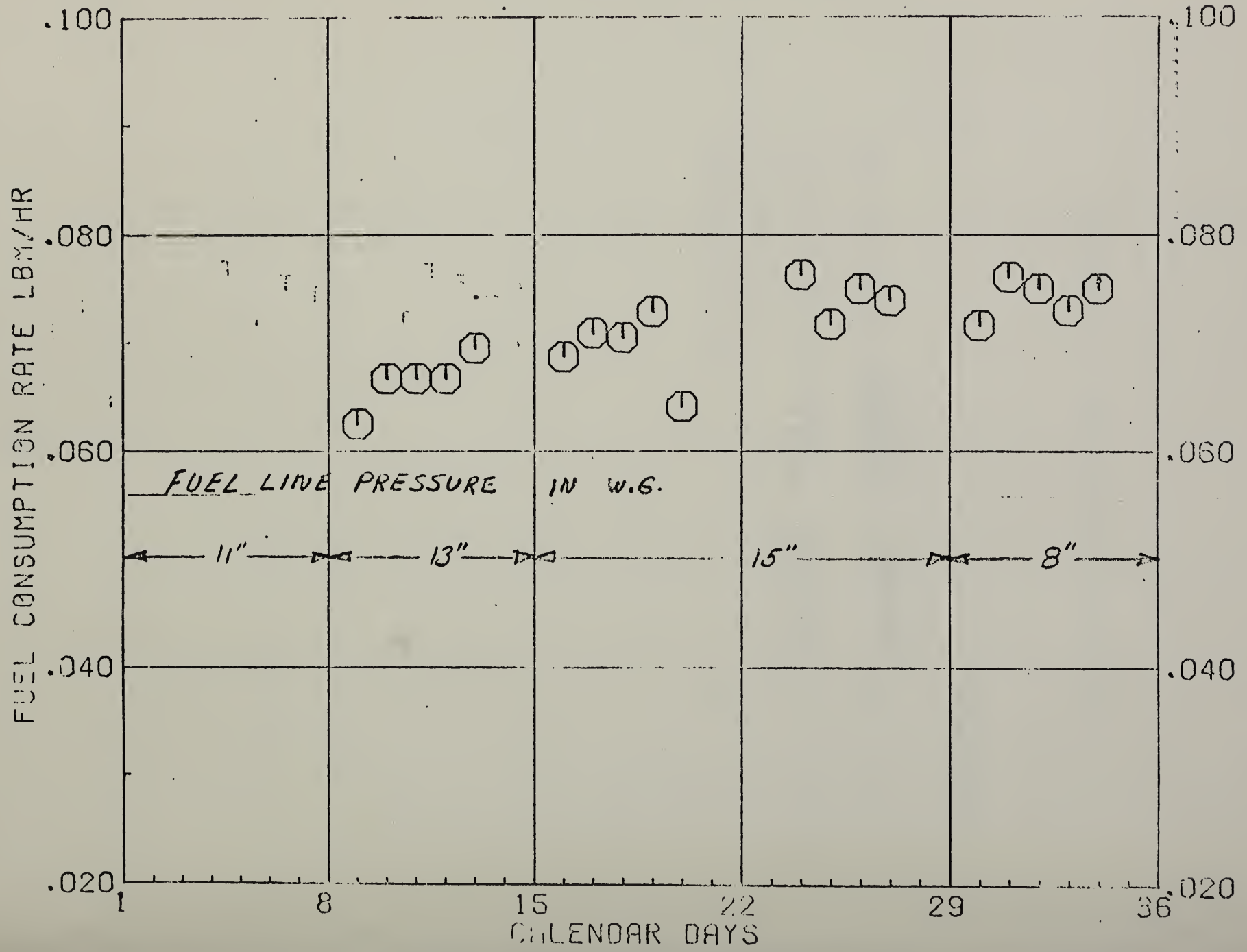
Appendix D Fuel Consumption Rate Plots

	Frame Number
Fuel Line Pressure Test	10, 11, 12
Elevated Temperature Test	13, 14, 15, 16
Thermostat Test I	17
Thermostat Test II	18

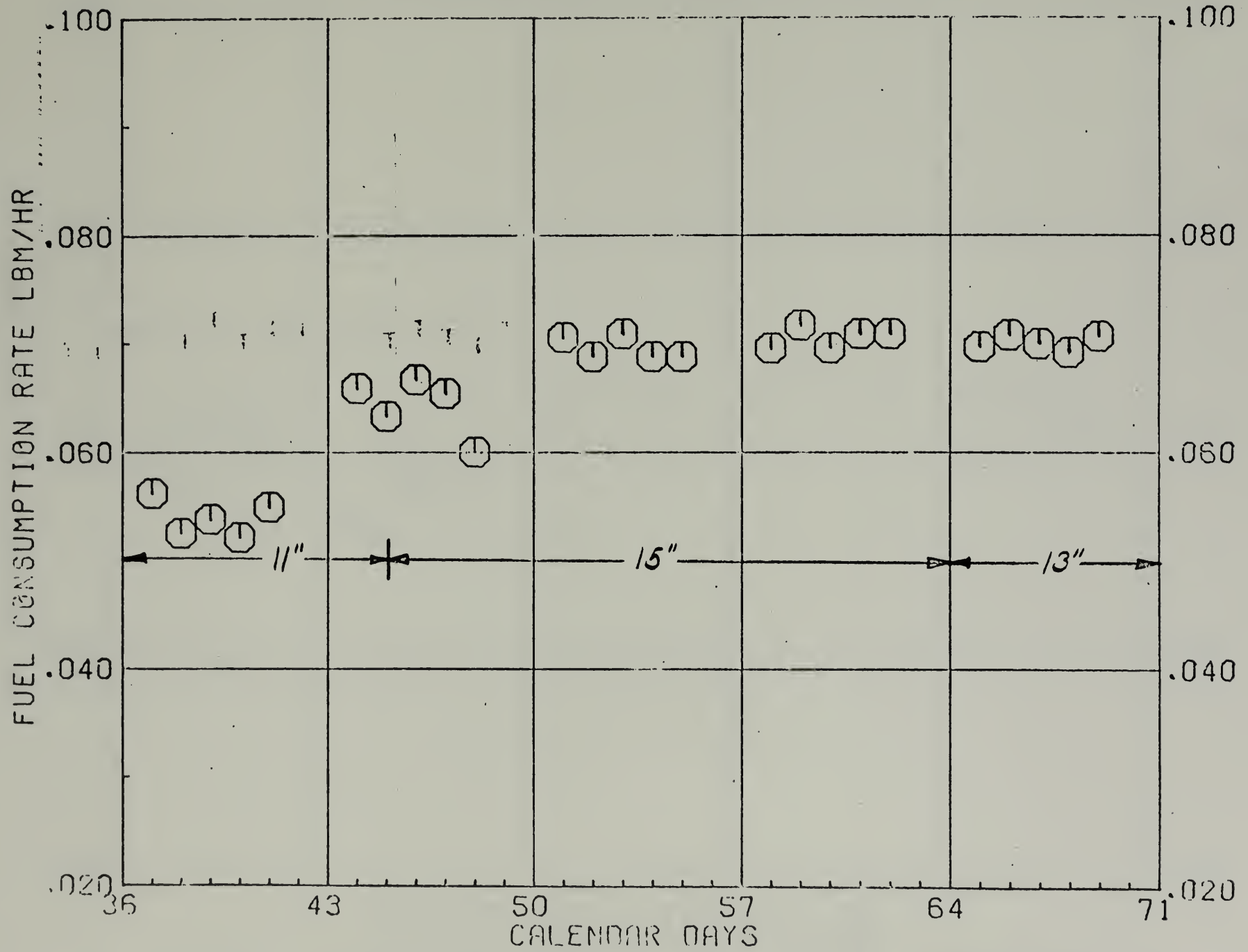
SYMBOL LEGEND

Ⓔ EXCEL UNIT

FUEL CONSUMP RATE VS TEST PERIOD
EXCEL REFRIGERATOR

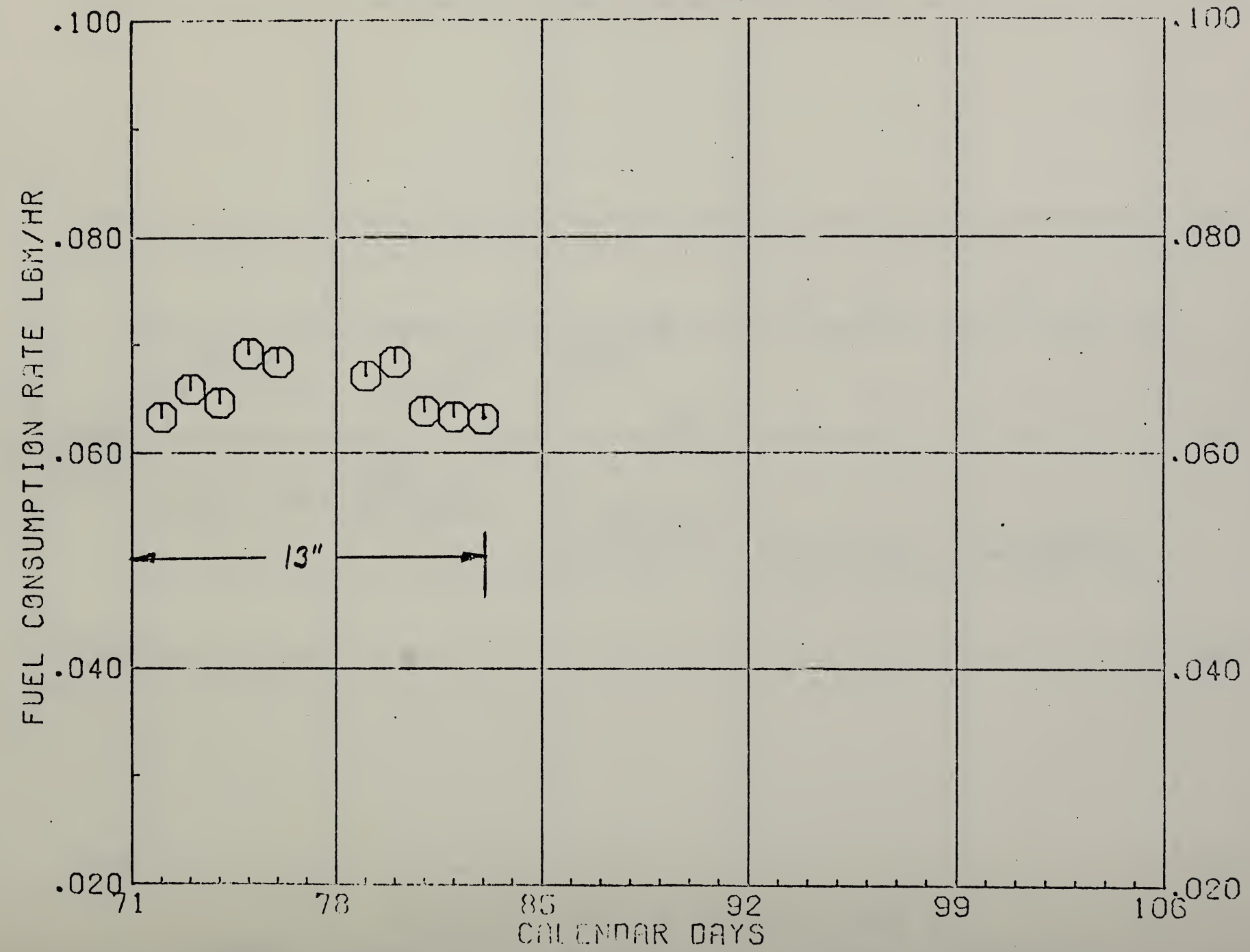


FUEL CONSUMP RATE VS TEST PERIOD
EXCEL REFRIGERATOR



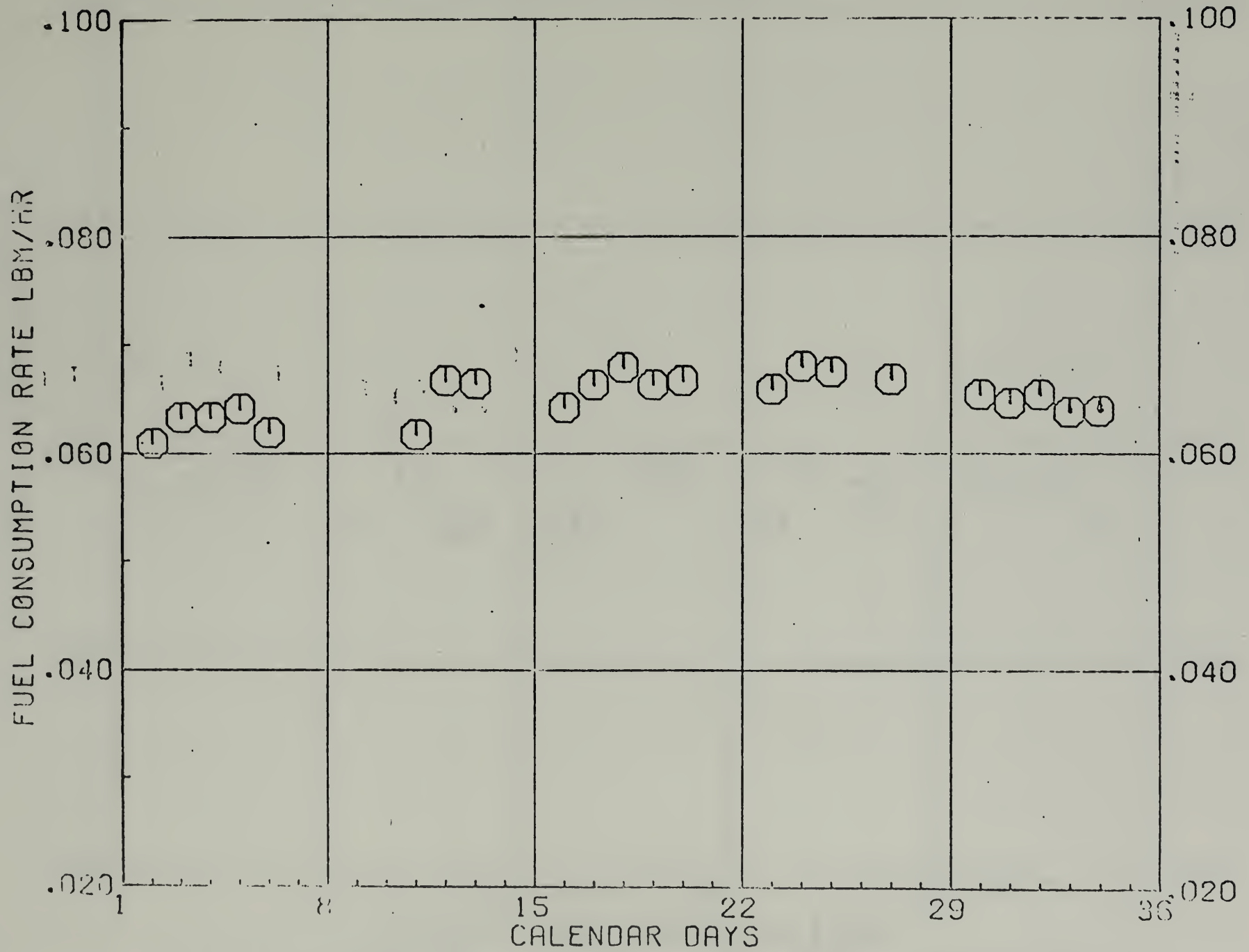
FRAME NUMBER 11

FUEL CONSUMP RATE VS TEST PERIOD
EXCEL REFRIGERATOR



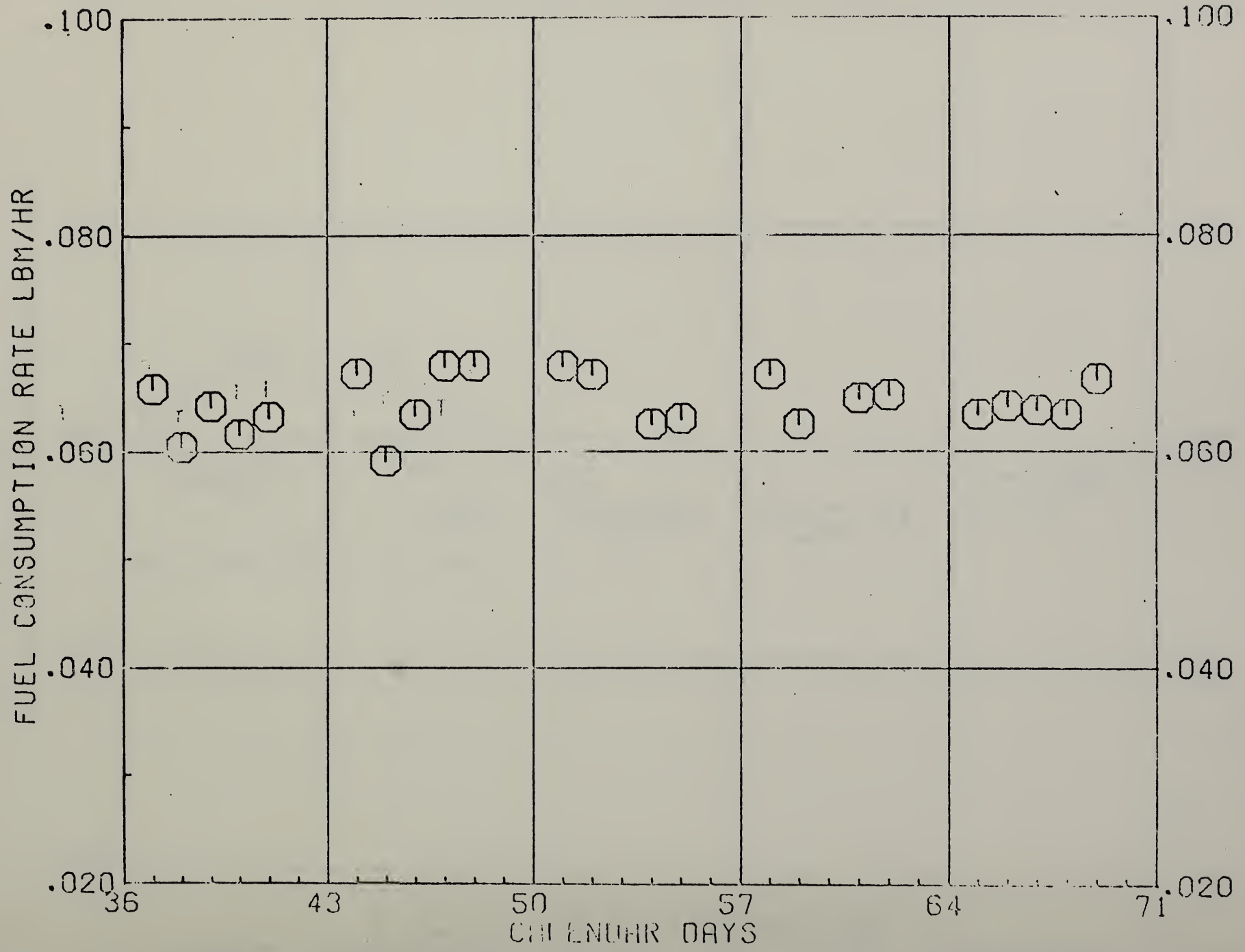
64

FUEL CONSUMP RATE VS TEST PERIOD
EXCEL REFRIGERATOR



FRAME NUMBER 13

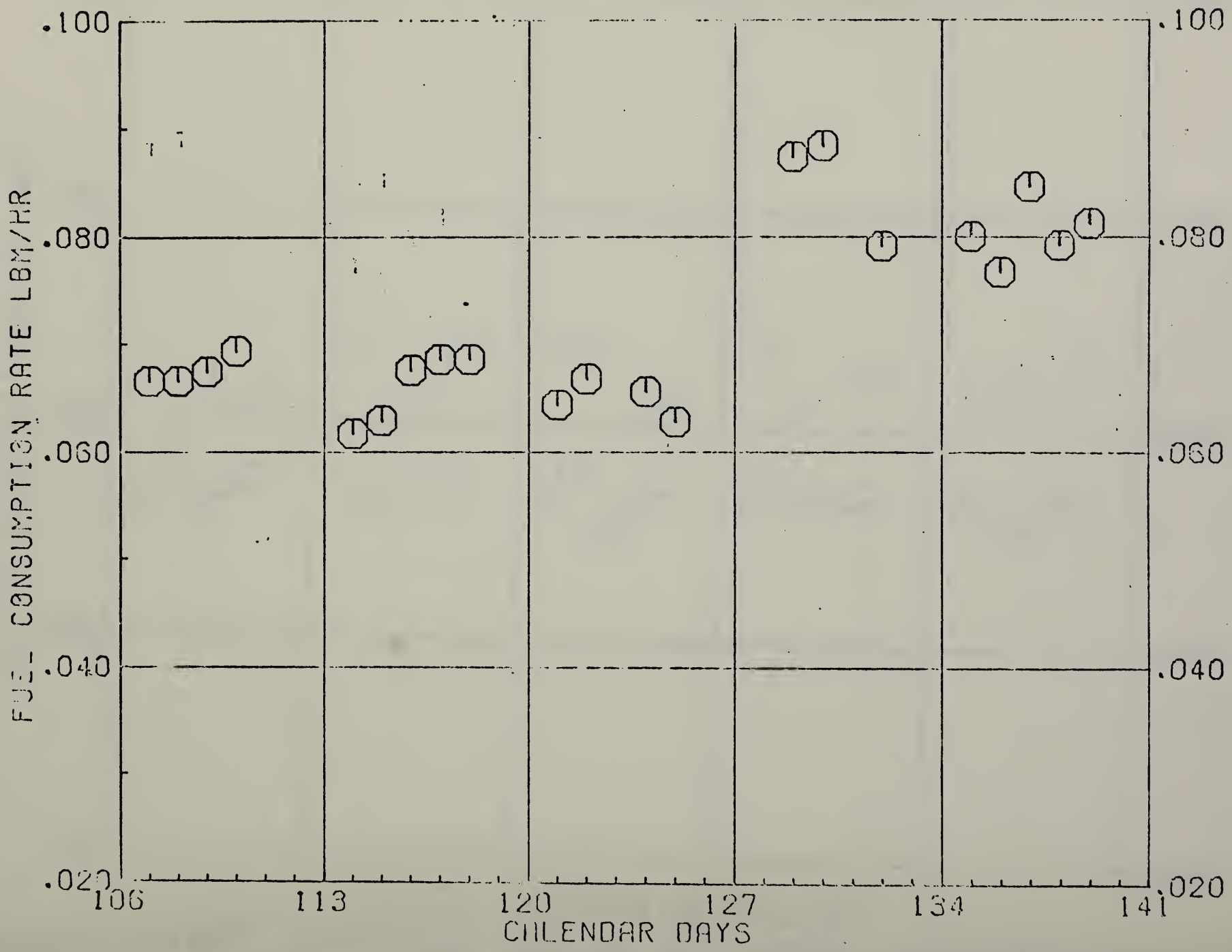
FUEL CONSUMP RATE VS TEST PERIOD
EXCEL REFRIGERATOR



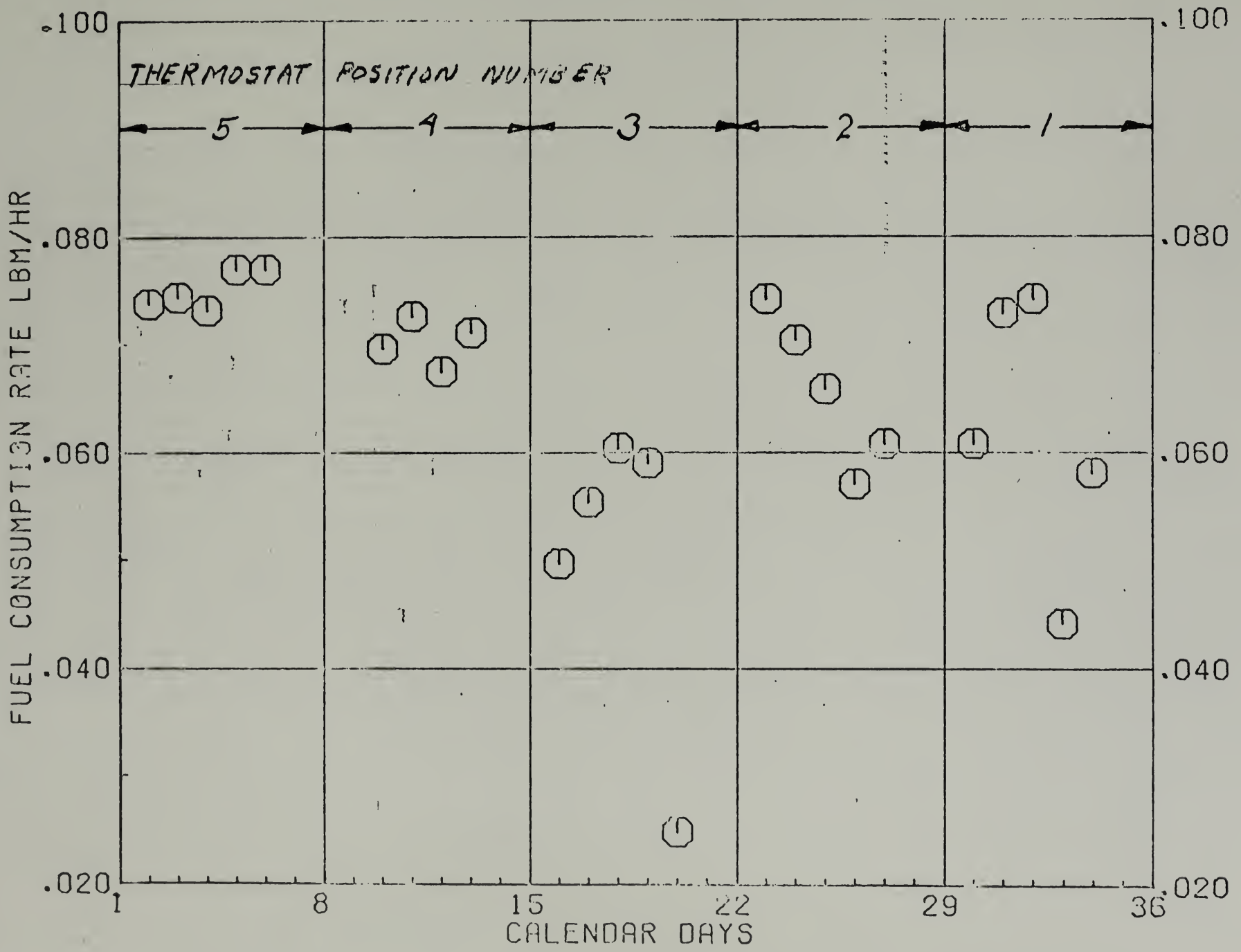
FRAME NUMBER 14

FUEL CONSUMP RATE VS TEST PERIOD
EXCEL REFRIGERATOR

FUEL CONSUMP RATE VS TEST PERIOD
EXCEL REFRIGERATOR

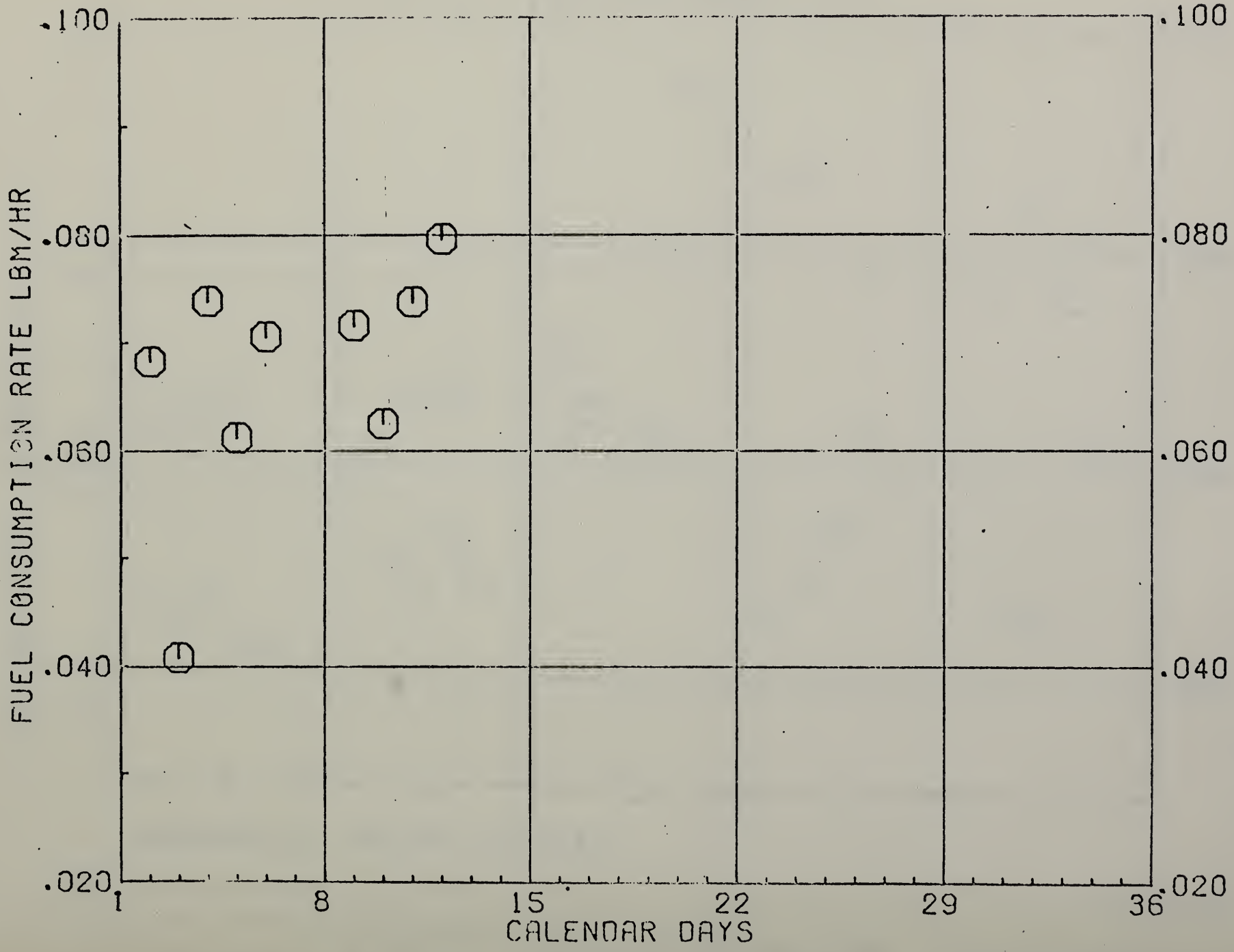


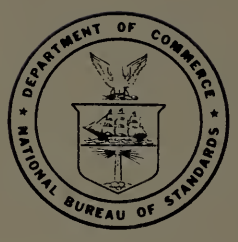
FUEL CONSUMP RATE VS TEST PERIOD
EXCEL REFRIGERATOR



FRAME NUMBER 17

FUEL CONSUMP RATE VS TEST PERIOD
EXCEL REFRIGERATOR




DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS