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MARS 1414 Recorder Environmental Tests

David Langjahr

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David Langjahr
Goddard Space Flight Center
Greenbelt, Maryland

National Aeronautics
and Space Administration

**Scientific and Technical
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1980

ABSTRACT

This technical paper describes environmental testing and presents the data of the Modular Airborne Recording System (MARS) 1414. This paper is intended to be used as a tool for analysis of this recorder. The preliminary data marks a starting point for more complete thermal testing in the future. The unit was operated at the limits specified by the manufacturer (Bell and Howell), that is +/-55°C at one atmosphere, -10°C at 75,000 feet (28mmHg) at the other. Temperatures at 13 locations on the unit were monitored and plotted against elapsed time. From the test results, some estimation can be made of ambient temperatures in which the heaters will operate and shut off. This data is sufficient to complete a preliminary analysis of the MARS 1414 Recorder, and to design further tests in which to obtain greater results and more thorough analysis.

CONTENTS

MARS 1414 RECORDER ENVIRONMENTAL TESTS

David Langjahr

INTRODUCTION

A MARS 1414 tape recorder (Part #535990 Rev Xl, serial 1001, Goddard #262636) was tested to the maker's specifications: Nonoperating: -55°C and +71°C and sea level to 75,000 feet; Operating: -55°C to +55°C and sea level to 75,000 feet per MIL-E-5400J, class 1, (Figure 4, Curve A) extrapolated. This curve is reproduced in Figure 1. Straight line extrapolation to 75,000 feet indicates a temperature of approximately -10°C.

TEST PROCEDURE

The unit was outfitted with 13 thermocouples (T/C's) at various locations inside and outside (see Figure 2). It was then placed in the chamber and run in the forward record mode at 1-7/8 ips for approximately four hours, with the chamber at 22°C nominal and standard pressure. A sine wave of 2 volts P-P amplitude was recorded on channels 7 and 9, while the reference oscillator signal supplied by the tape recorder was inputted to channel 8, leaving 11 channels unused.

The chamber environment was then changed to:

-55°C, 760 mmHg (8 April 1980) for nominal 5 hours
+55°C, 760 mmHg (9 April 1980) for nominal 5 hours
-10°C, 28 mmHg (6 May 1980) for nominal 6 hours

A summary of the data is given in Figure 2.

Infomag, who supplies tape headstacks, says the stack can "withstand" 71°C, which is apparently how the non-operating upper temperature limit was determined. During testing, this temperature was monitored to ensure that it did not exceed this limit.

During the testing, the power consumed by the recorder was nominally 56 watts at 28 volts. An internal thermostat designed to go on at 0°C and off at +4°C controls the heaters: when they are on, power consumption was an additional 280 watts, (totalling 336 watts). The heaters did not cycle at the -55°C ambient or at any time during the tests.

At the end of test, the tape was played back through the tape control unit supplied with the recorder, to check for proper operation.

COMMENTS

The tests run at one atmosphere were conducted in facility 230 (see Figure 3) in which the air is changed twice/minute. This corresponds to an airflow over the recorder of about 24 feet/minute, introducing a "chill factor" which reduces the thermal resistance (recorder case-to-ambient) an estimated 6%.

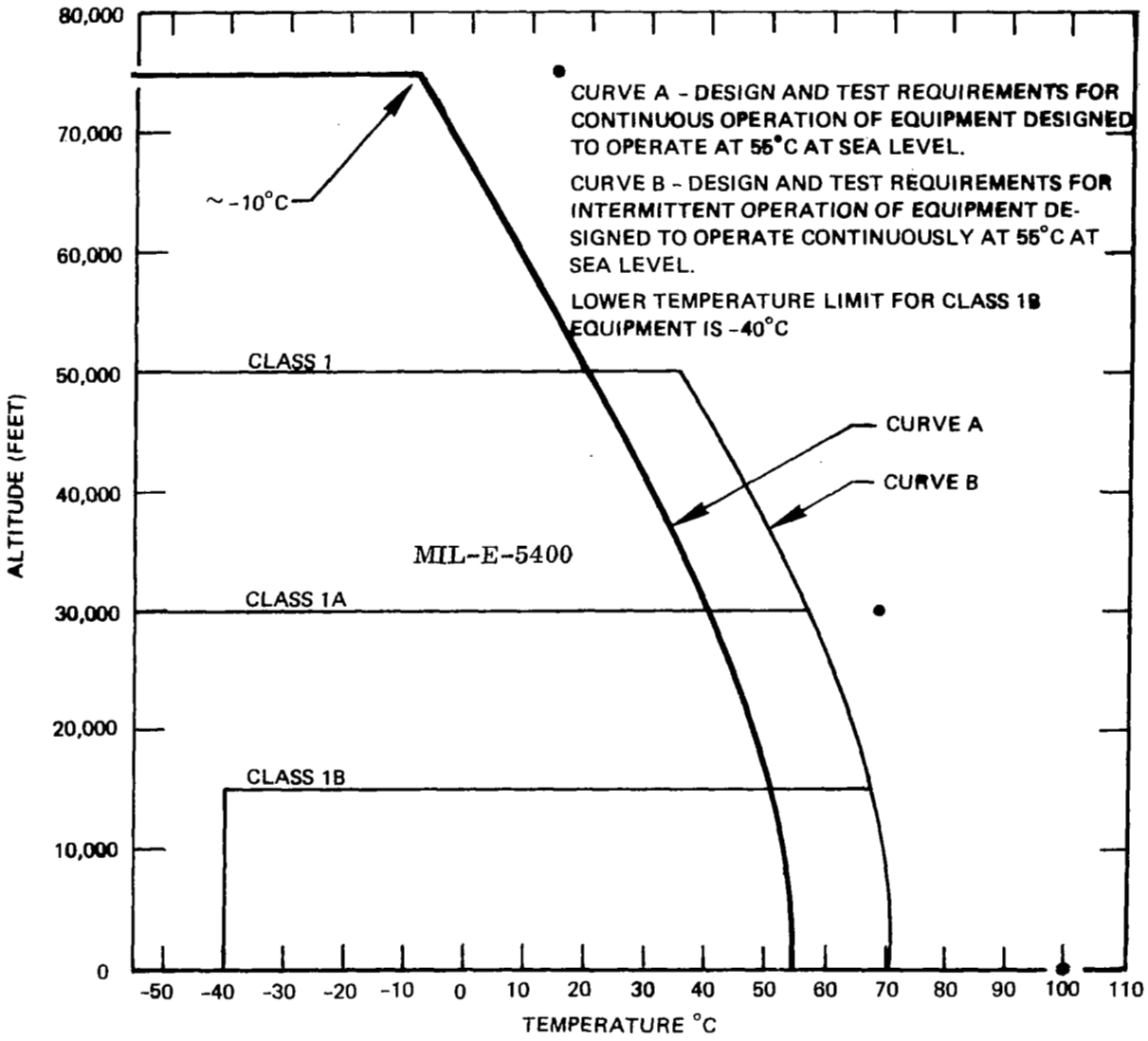


Figure 1. Operational Requirements for Class 1 Airborne Electronic Equipment (Temperature vs. Altitude)

DATA SUMMARY

T/C Title	T/C	Final temperature rise above ambient			
		Ambient = -55°C	-10°C	+22°C	+55°C
thermostat	A	45	27	12	9.1
L reel mot.	B	50	37	19	15
R reel mot.	C	49	35	18	14
internal air	D	39	*	11	7.4
headstack	E	44	32	17	12
top panel	F	17	18	7.2	4.1
bottom panel	G	24	4.0	7.6	4.5
bottom	H	33	6.0	8.4	5.4
top	I	31	18	7.1	4.1
right side	J	41	20	8.5	5.2
left side	K	31	18	7.1	4.1
front	L	36	25	13	9.2
back	M	7.0	15	4.2	0.6
chamber air	#14	See graphs			

Notes:

*defective thermocouple
The first five thermocouples are internal
T/C's H, I, J, K, L are on panels that are heated. These heaters were on during the -55°C test.

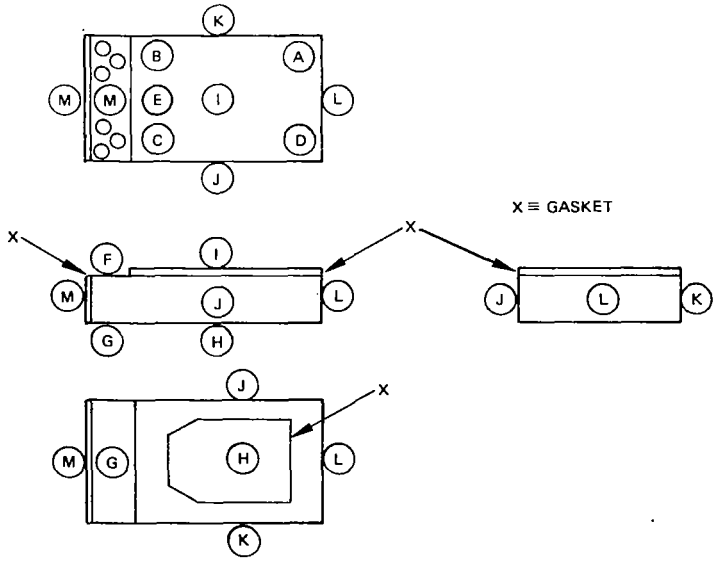


Figure 2. Data Summary and Recorder Configuration

FACILITY NO. 230

MFG: Guardite Company, Division of American-Marietta

CHAMBER SIZE

Nominal Working Dimensions:	3′ X 3′ X 6′ High (91 cm X 91 cm X 183 cm hi
Nominal Volume:	54 Cubic Feet (1.5 cu.m.)
	Stainless Steel Walls
	Air Flow ~120 CFM

THERMAL SYSTEM

Heat Transfer Fluid:	Forced Air
Temperature Range:	-65°C to +100°C
Thermal Control Medium:	Cooling - Cascade Freon Refrigeration F22/F13
	Heating - Electric Heater (6.6 KW)
Relative Humidity:	10% to 95%, Controllable; Dehumidification by F12 Refrigeration System
Heat Load Capacity:	2 KW

INSTRUMENTATION

Data Central:	12 T/C Channels; R.T.O.S. every 100 seconds
Telemetry Data:	Available through R. F. Loop to Operations Ctr
Viewing Port:	Door Window (24" X 24")
Instrumentation Ports:	Number - 2
	Dimension - 7" X 5"

AUXILIARY EQUIPMENT

Temperature Conditioner	GN_2 Dehumidification

PAYLOAD MOUNTING

Rack - Front Loading

COMMUNICATIONS

P. A. MITOC System

REFERENCE

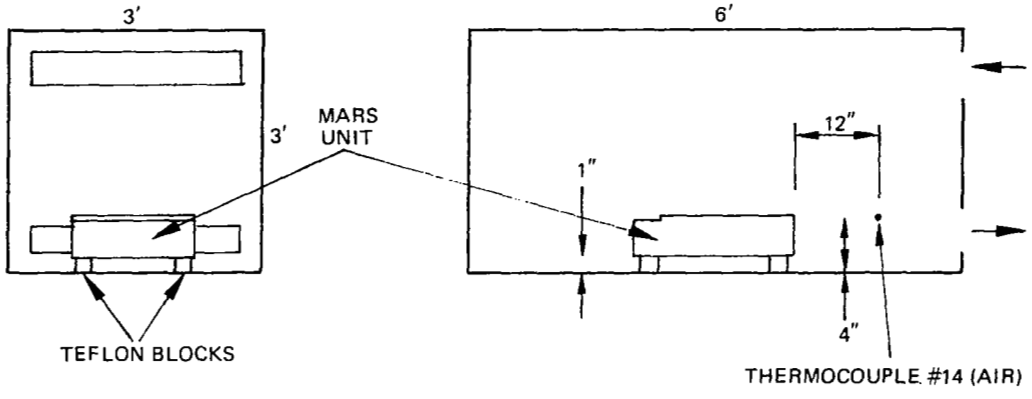
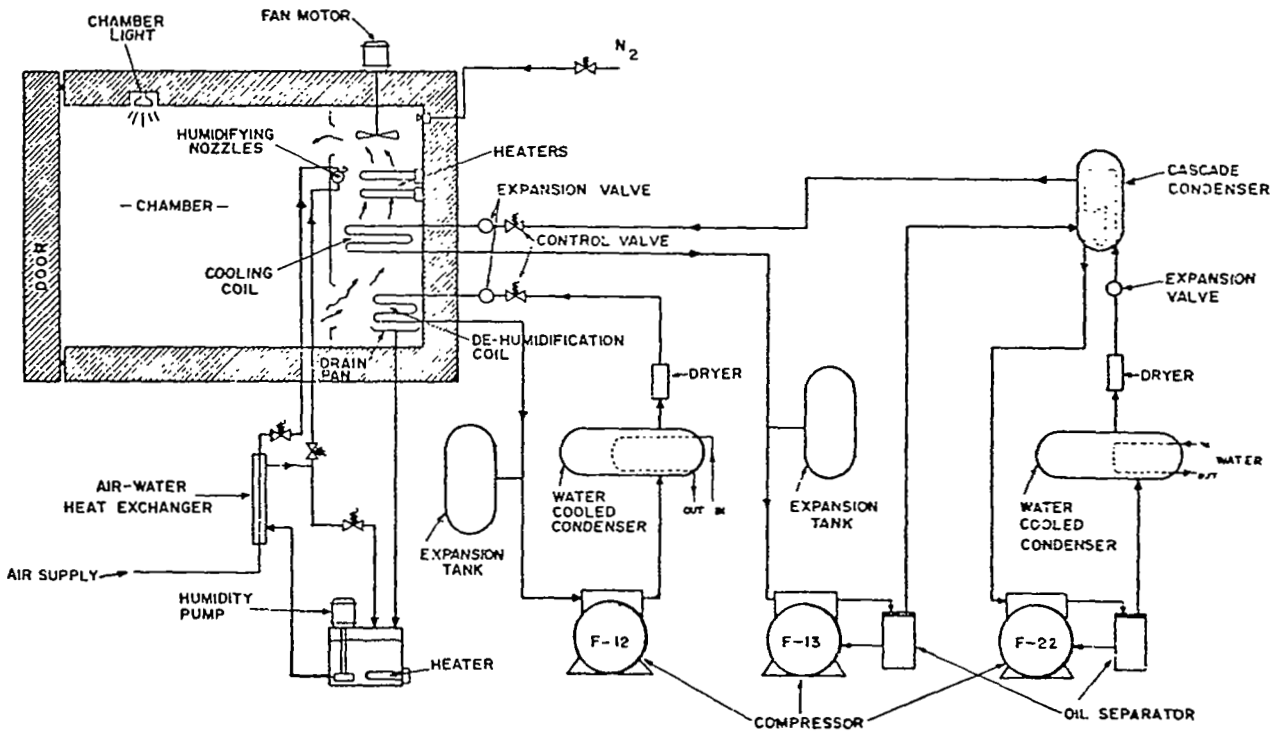


Figure 3. Facility 230 Specifications & Configuration



REFRIGERATION SYSTEM
FACILITY 230

Figure 3 (Continued). Facility 230 Specifications & Configuration

The data from facility 237 (see Figure 4) shows temperature rises above ambient generally higher than the results from the standard atmosphere data. Apparently this is due to reduced conduction and convection. The chamber walls were maintained at -10°C with no airflow.

Examining the data for one atmosphere, it can be seen that the thermostat temperature was 12 and 45 degrees above ambients of +22 and -55 degrees, respectively. Since the thermostat on/off temperatures are 0 and +4 degrees respectively, some estimation can be made of the ambient temperatures during which the heaters will operate. If the recorder is allowed to run until stabilized at 22°C, the ambient temperature could be lowered to approximately 0-12 = -12°C, before the heaters would begin cycling, with a very low duty cycle. If the ambient temperature was now lowered to +4 - 45 = -41°C, the heaters would be at the point of being on all the time (high duty cycle). Note that if the recorder was cold soaked (no heater or recorder power connected) between 0°C and -12°C, the application of all power should result in the heater coming on long enough to warm the thermostat and then shutting off, with no cycling.

In the graphs following time increases from left to right; estimated accuracy of temperatures is +/- one degree C.

ACKNOWLEDGMENTS

Thanks to C. Klotz, S. Costa and R. Haney for their technical direction during these tests.

FACILITY NO. 237

MFG: Stokes, Division of Pennsalt Chemicals Corporation

CHAMBER SIZE

Nominal Working Dimensions	7' Dia. X 8' Long (213 cm Dia X 244 cm Long)
Nominal Volume:	305 Cubic Feet (8.5 cu.m.)

VACUUM SYSTEM

1 - 32" Dia. Diffusion Pump:	40,000 lit/sec
1 - Mechanical Pump:	300 std cfm (142 lit/sec)

THERMAL SYSTEM

Heat Transfer Fluid:	GN_2 - LN_2
Temperature Range:	GN_2 Mode - -140°C to +100°C LN_2 Mode - -190°C
Thermal Control Medium:	Cooling - LN_2 Heating - Electric Heaters
Shrouds:	Material - Aluminum (Traced Tube on Sheet) Finish - Cat-A-Lac Flat Black
Heat Load Capacity:	15 KW

PAYLOAD MOUNTING

Two rails running length of chamber
86" Long X 45" between rails
Upper support rail on vertical centerline for supporting payload.

INSTRUMENTATION

Data Central:	136 T/C and 44 T/M Channels; R.T.O.S. printouts every 100 seconds
Telemetry Data:	Available through R.F. Loop to Operations Ctr.
Vacuum Measurement:	Alphatron 760 to 10^{-3} Torr Ion Gauge 10^{-4} to 10^{-9} Torr
Contamination Measurement:	LN_2 Coldfinger available to collect condensable materials
Viewing Port:	12" Diameter located on door at vertical and horizontal centerline of chamber. Also used for solar capability
Instrumentation Ports:	Number - 6 Dimensions - 11" Diameter

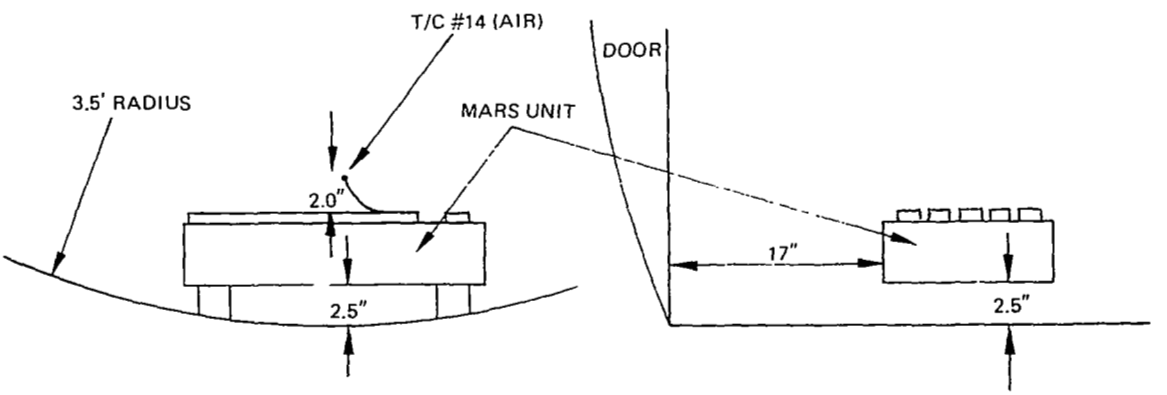
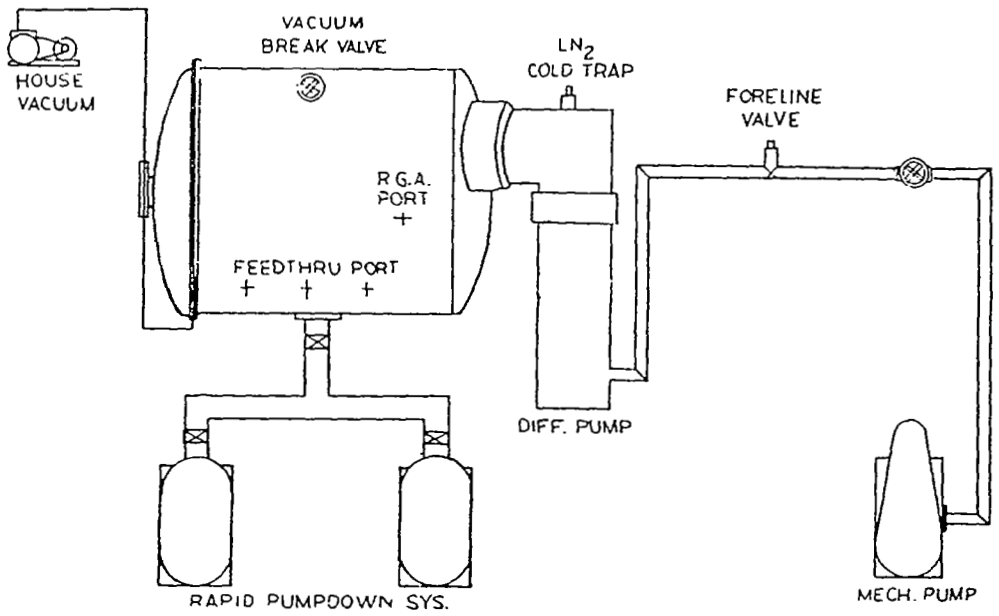
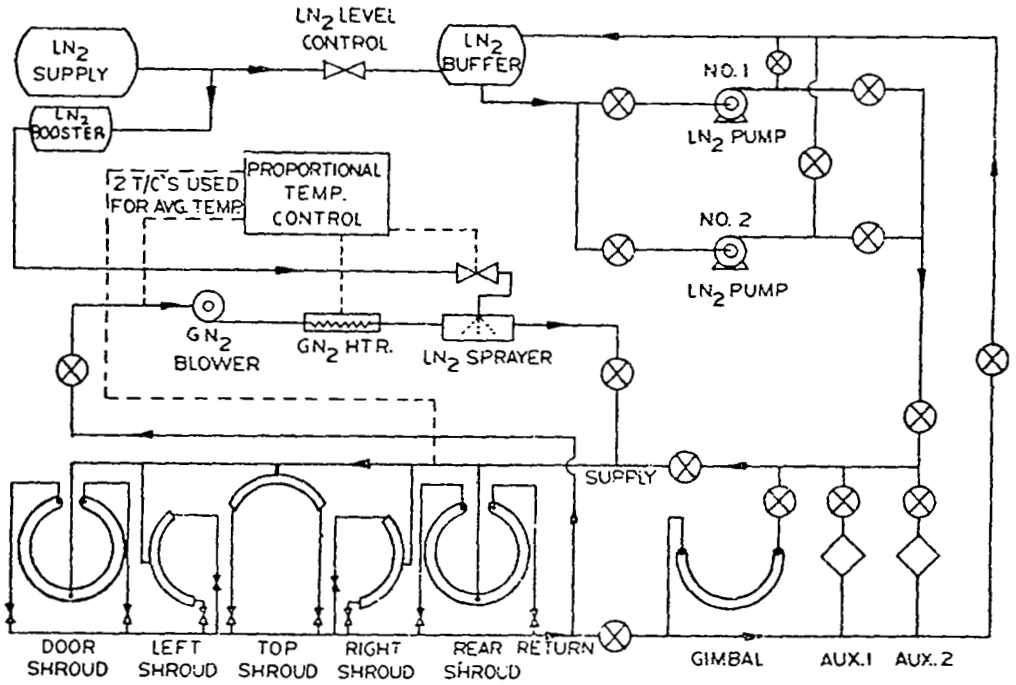


Figure 4. Facility 237 Specifications & Configuration



VACUUM SYSTEM
FACILITY 237

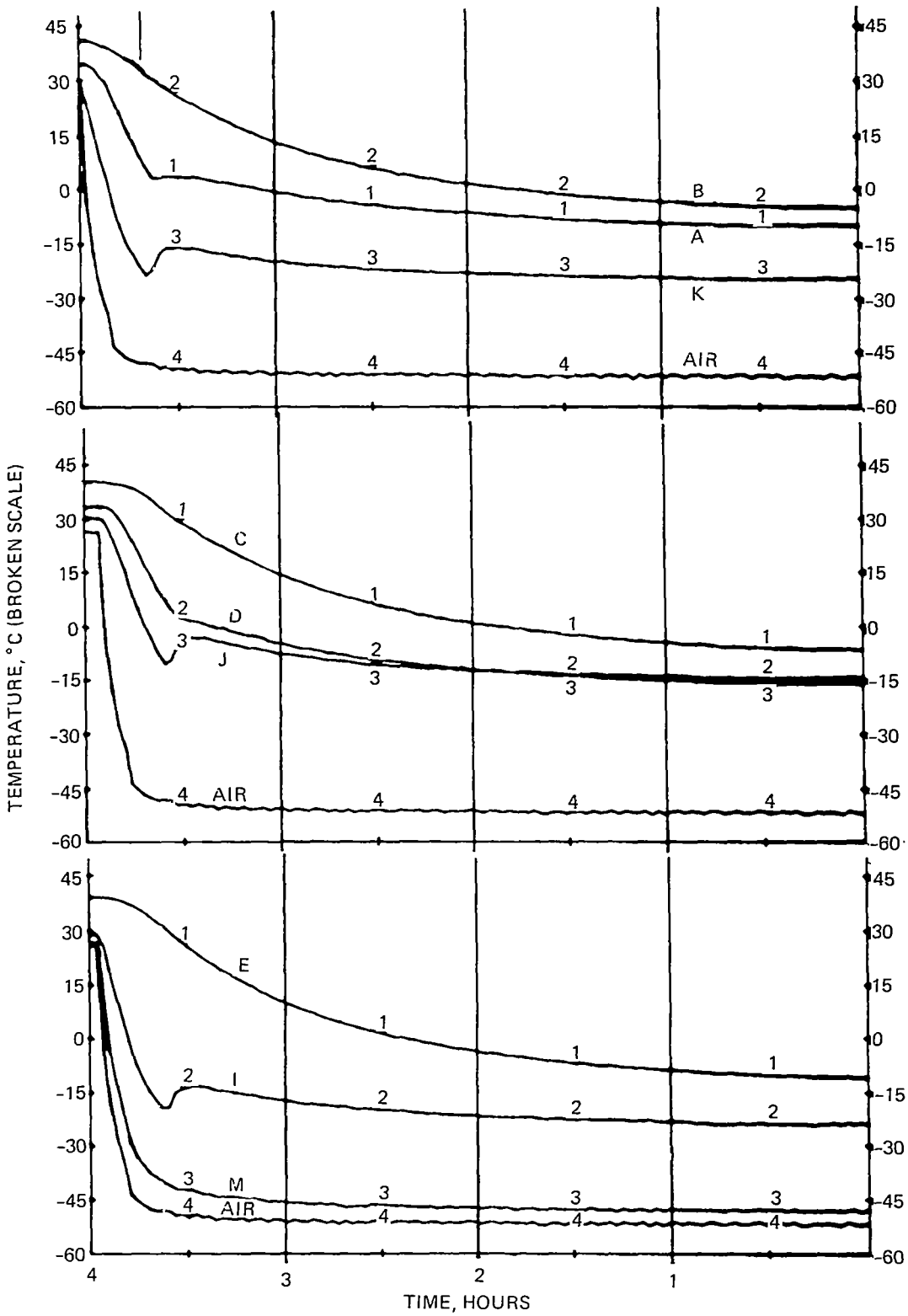


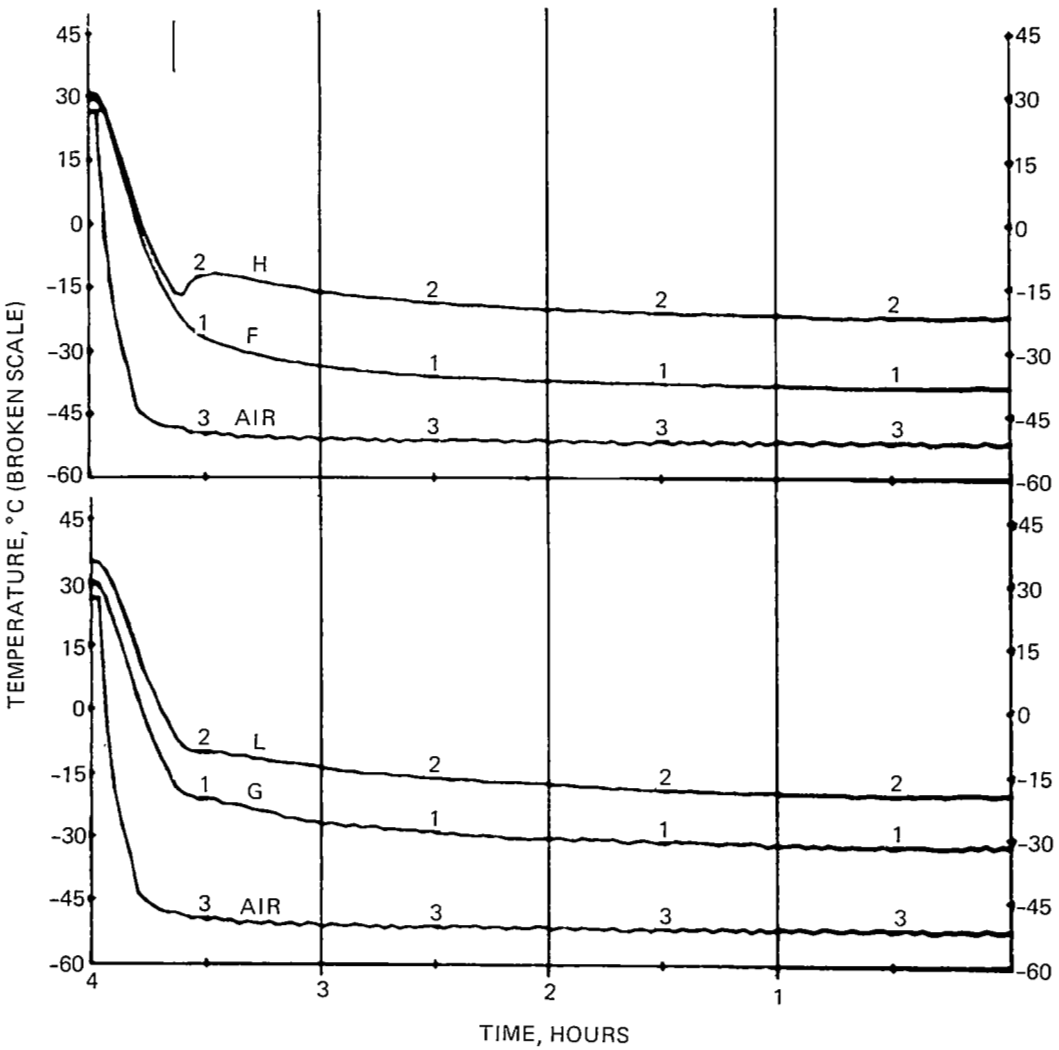
THERMAL SYSTEM
FACILITY 237

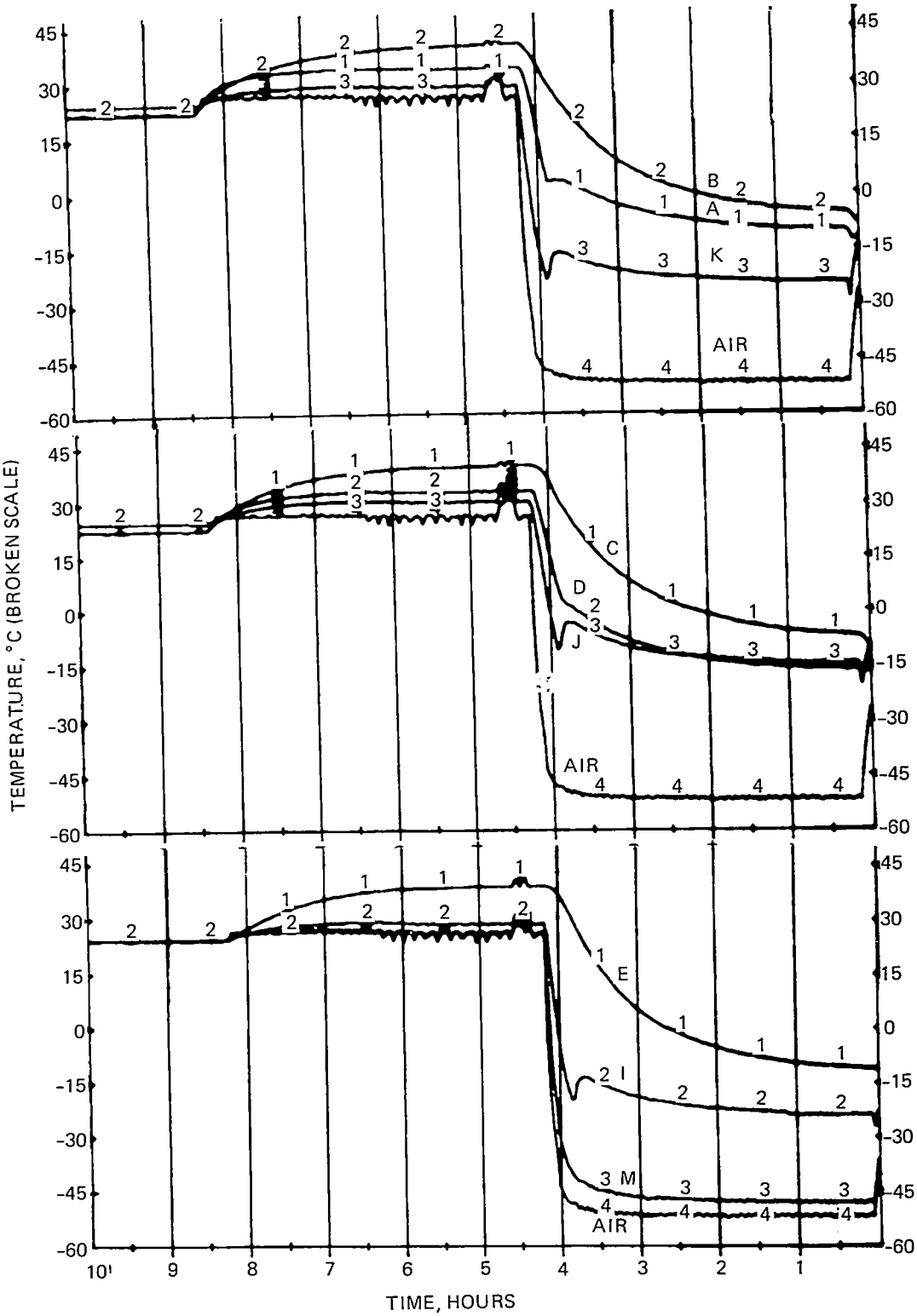
Figure 4 (Continued). Facility 237 Specifications & Configuration

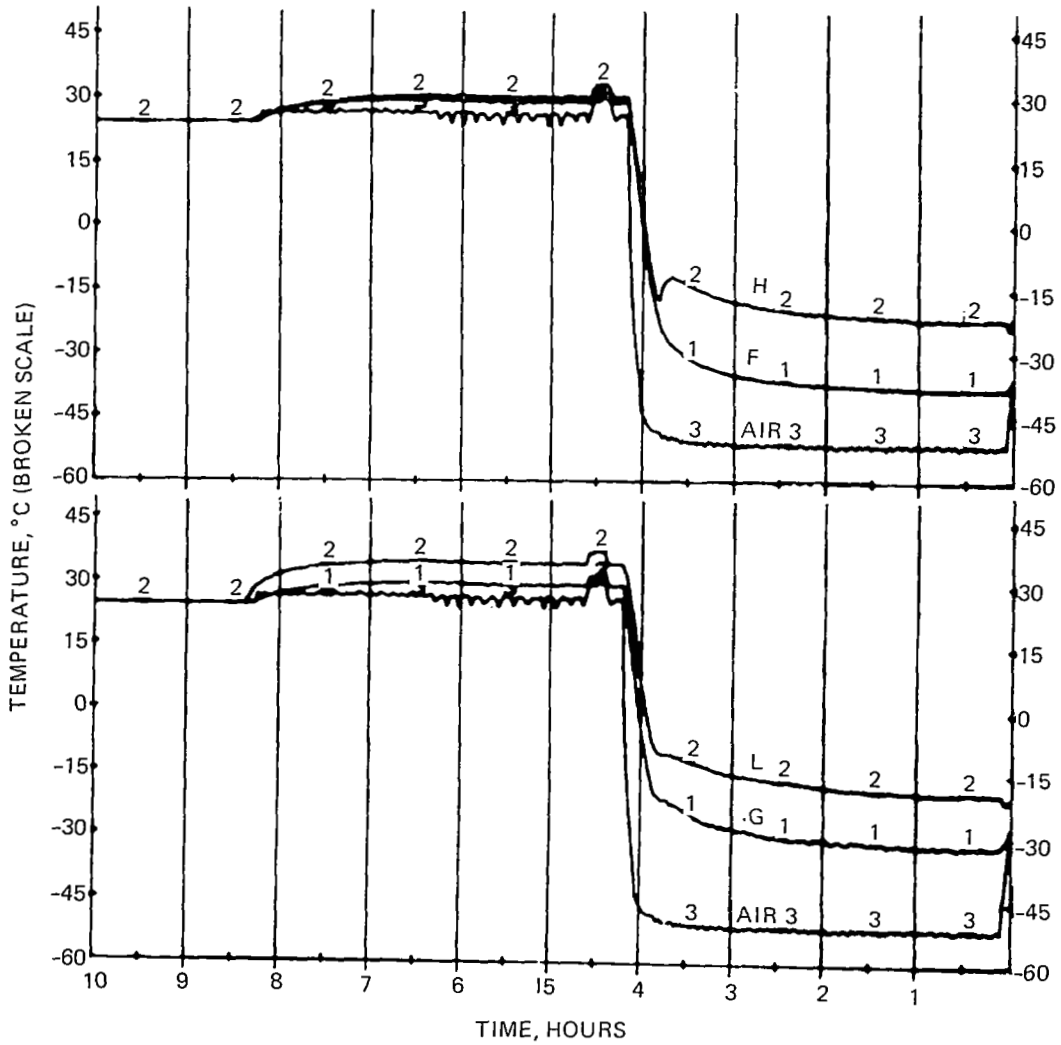
Temperature Vs. Time

-55°C, 1 ATM Ambient


TEMPERATURE, °C (BROKEN SCALE)
45
30
15
0
-15
-30
-45
-60
A
B
C
D
E
I
J
K
M
AIR
4
3
2
1
TIME, HOURS


TEMPERATURE, °C (BROKEN SCALE)
45
30
15
0
-15
-30
-45
-60
2 H
1 F
3 AIR
2 L
1 G
3 AIR
4
3
2
1
TIME, HOURS


TEMPERATURE, °C (BROKEN SCALE)
TIME, HOURS
AIR
AIR
AIR
A
B
C
D
E
I
J
K
M

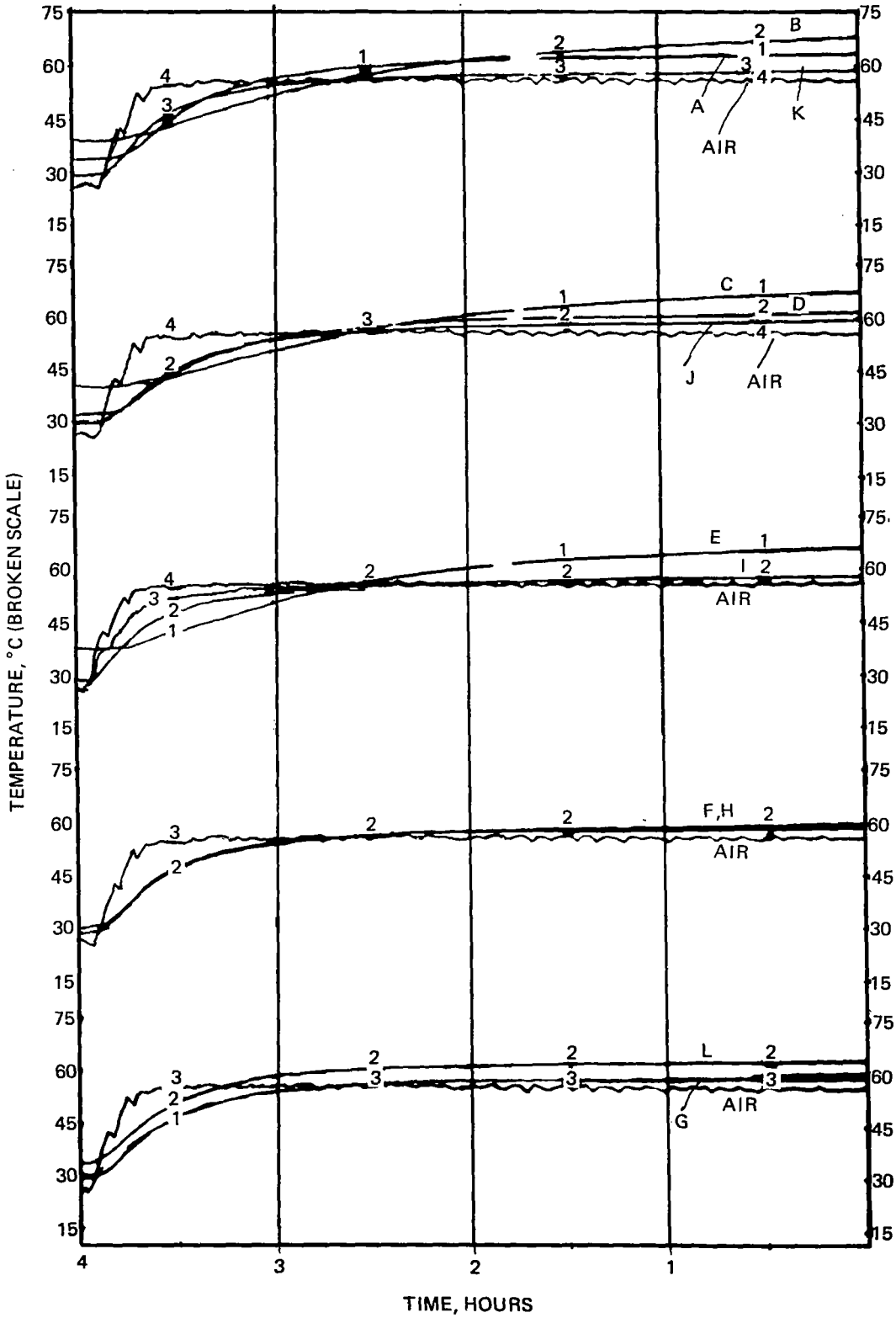


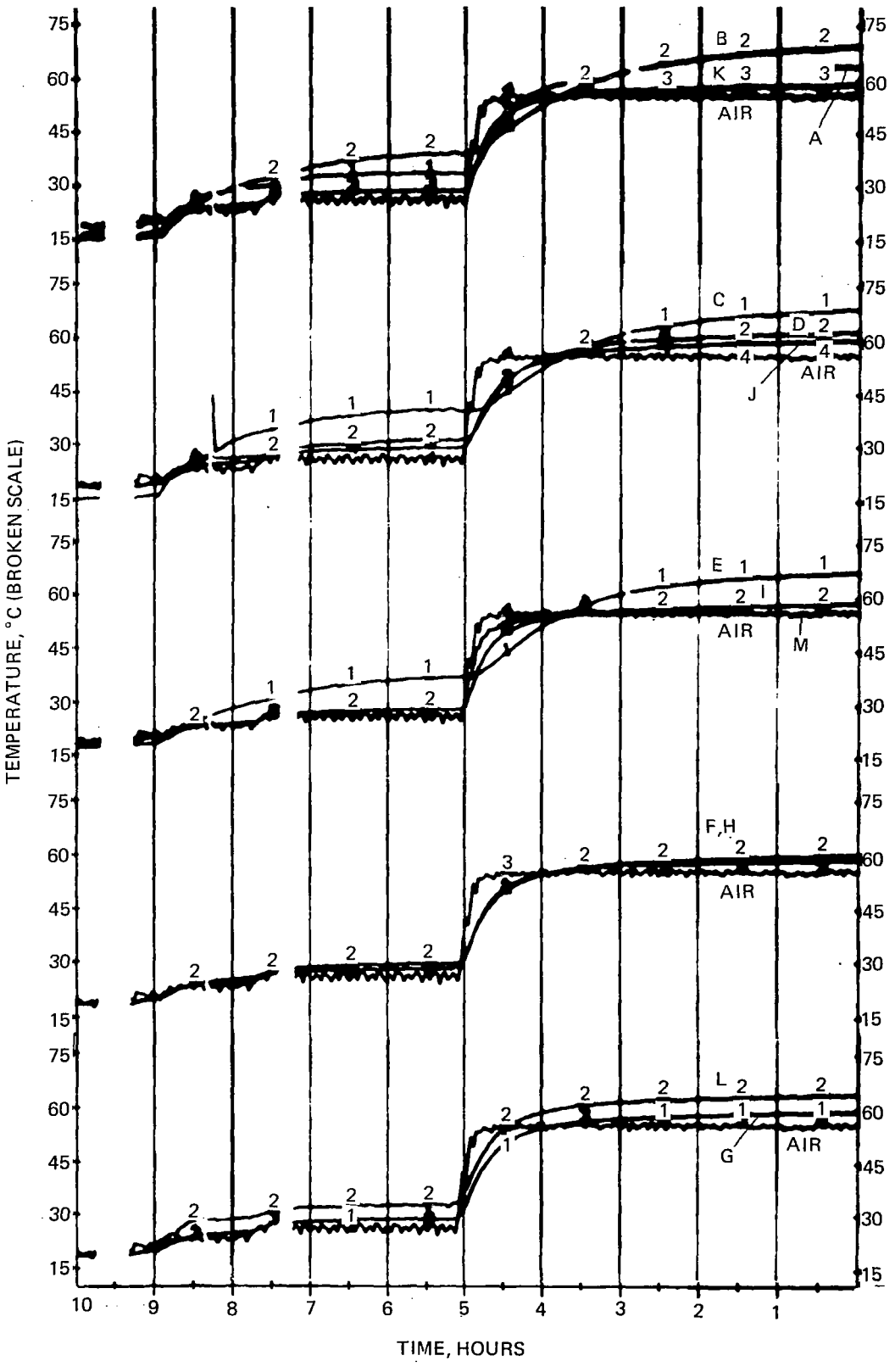
Final Temperatures (All Negative)

A	9.8
B	5.0
C	6.5
D	16.0
E	10.6
F	38.3
G	31.5
H	21.6
I	23.6
J	14.3
K	24.4
L	19.3
M	48.3

Temperature Vs. Time

+55°C, 1 ATM Ambient


TEMPERATURE, °C (BROKEN SCALE)
TIME, HOURS
AIR
A
B
C
D
E
F,H
G
J
K
L

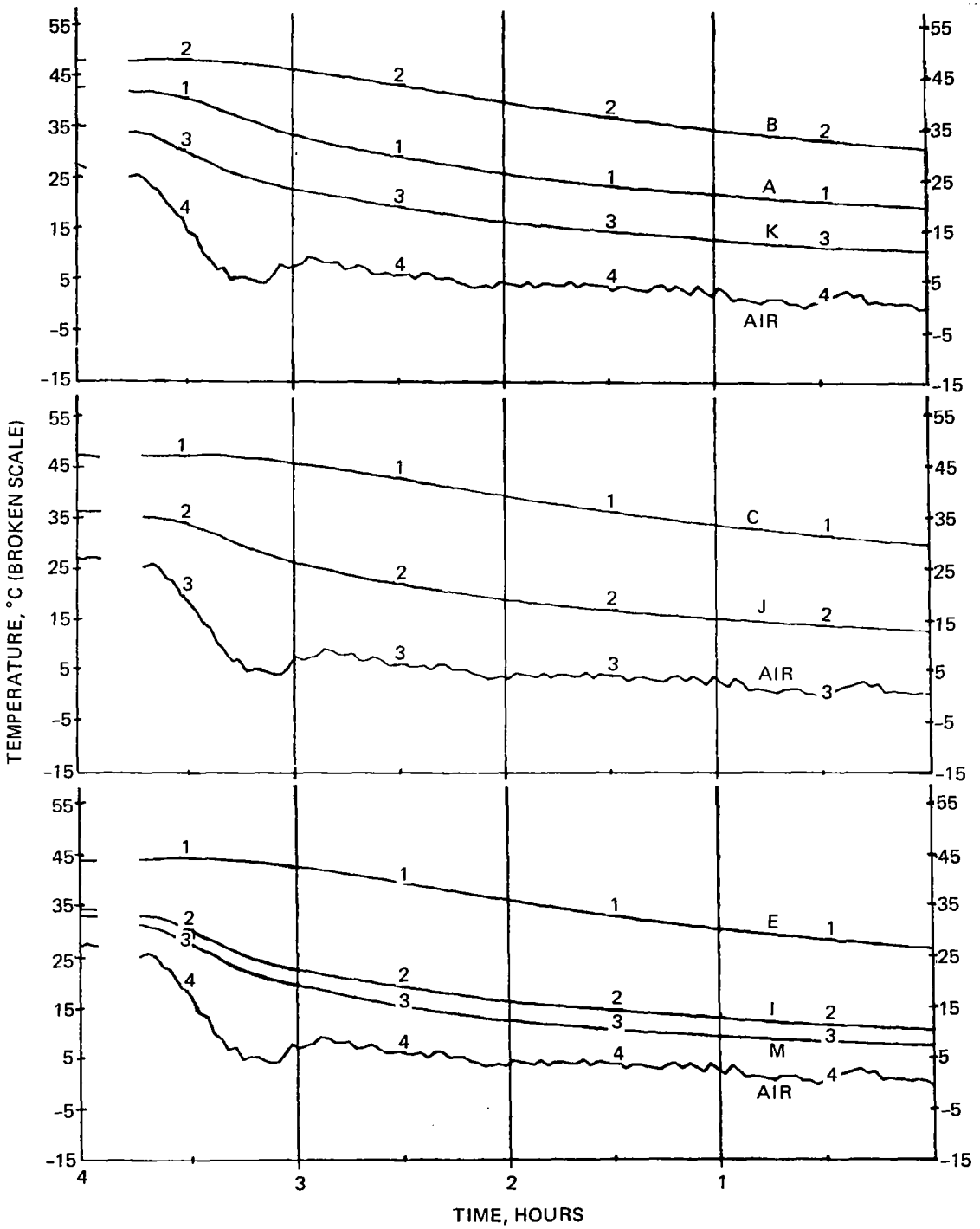

TEMPERATURE, °C (BROKEN SCALE)
TIME, HOURS
AIR
A
B
K
C
D
J
E
M
F,H
L
G

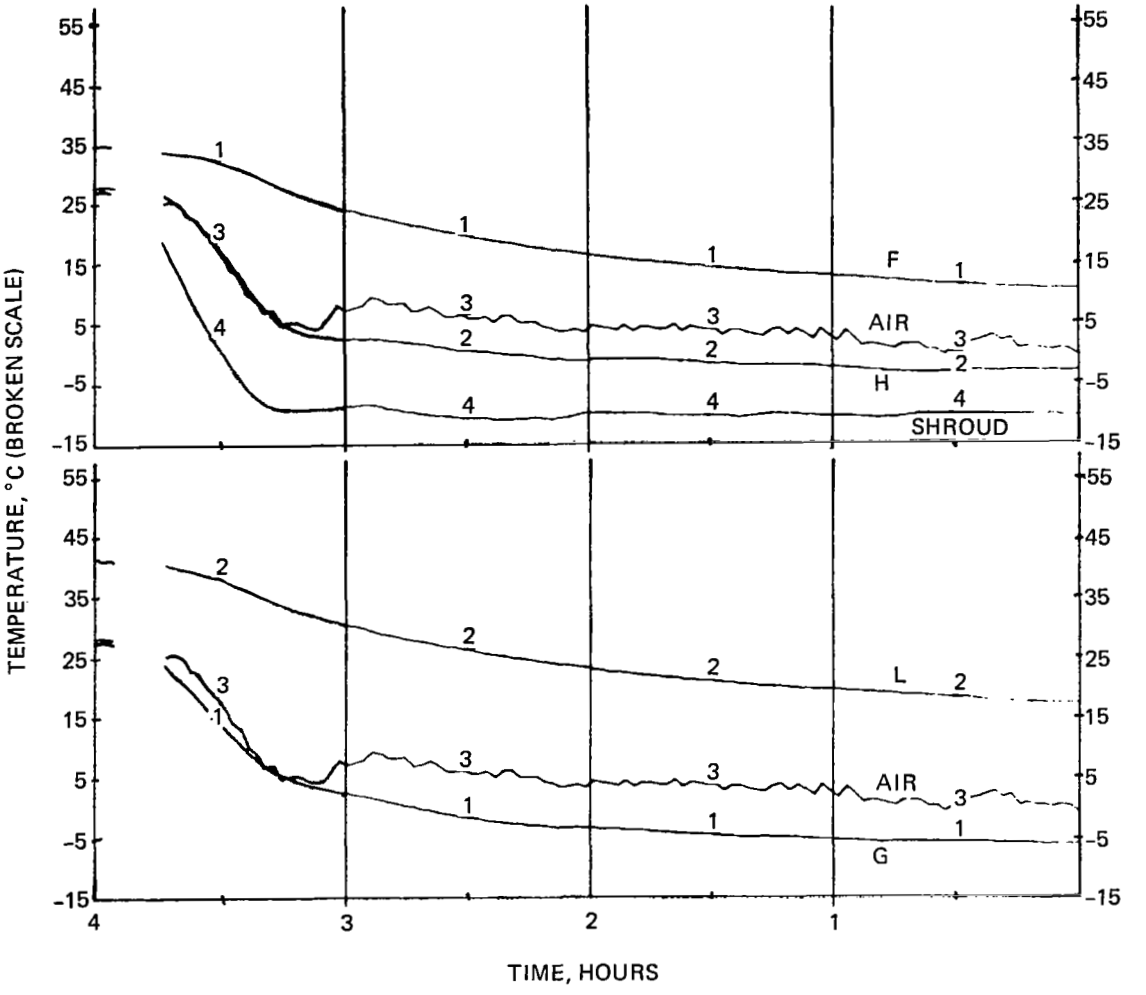
Final Temperatures

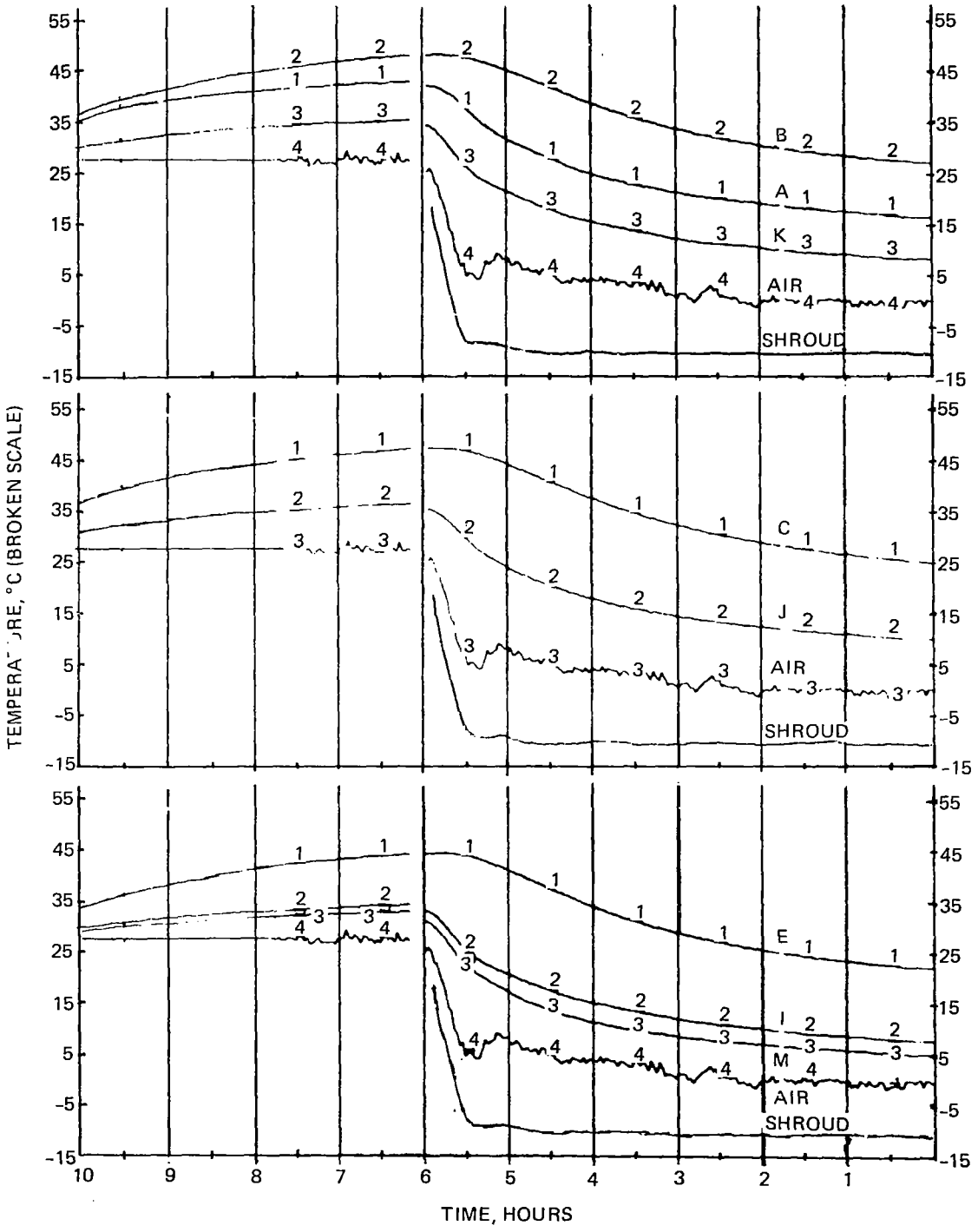
A	64.1
B	69.6
C	68.7
D	62.4
E	67.3
F	59.1
G	59.5
H	60.4
I	58.6
J	60.2
K	59.1
L	64.2
M	55.6

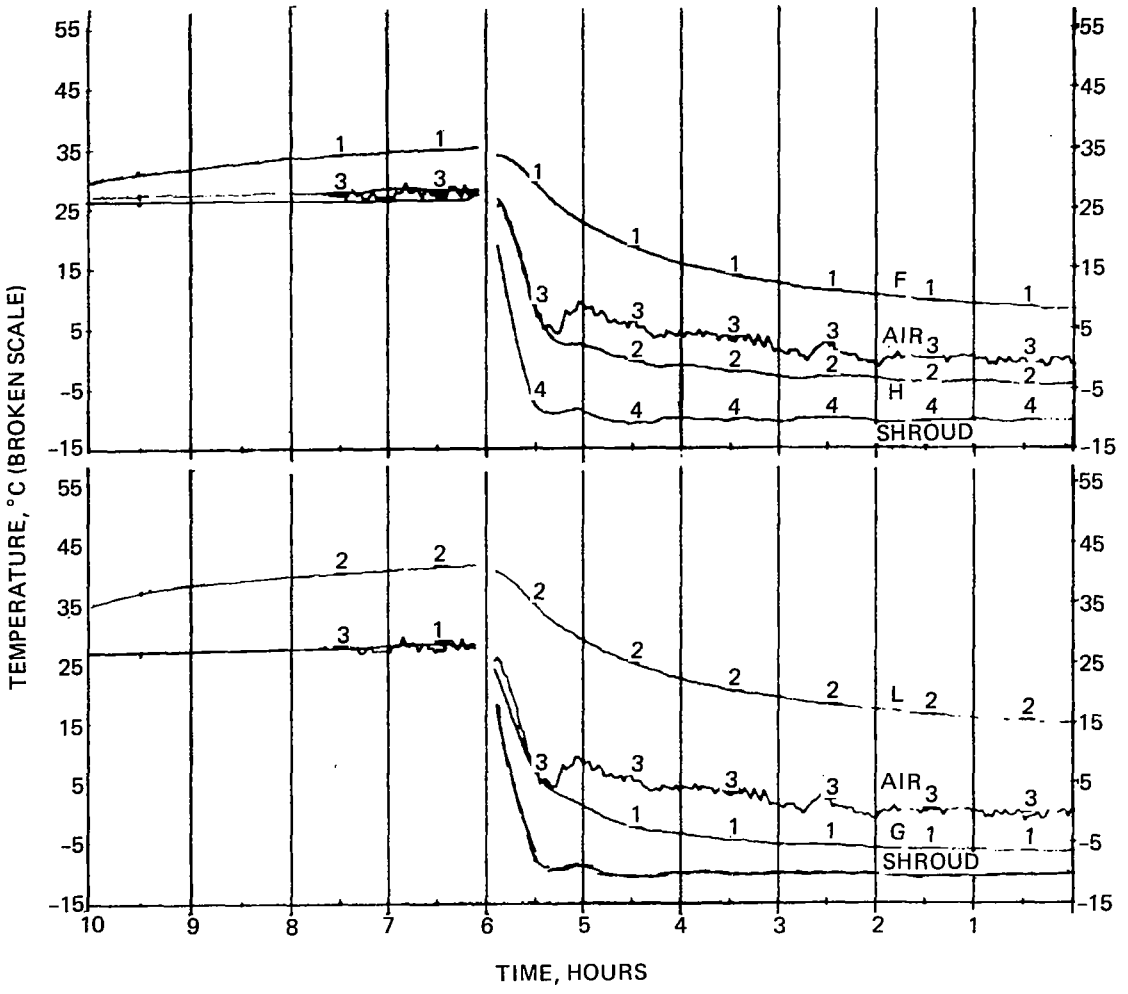
Temperature Vs. Time

-10°C, 75000′ (28 mm) Ambient


TEMPERATURE, °C (BROKEN SCALE)
TIME, HOURS
55
45
35
25
15
5
-5
-15
4
3
2
1
B
A
K
C
J
E
I
M
AIR


TEMPERATURE, °C (BROKEN SCALE)
55
45
35
25
15
5
-5
-15
F
AIR
H
SHROUD
L
AIR
G
4
3
2
1
TIME, HOURS


TEMPERATURE, °C (BROKEN SCALE)
TIME, HOURS
B
A
K
AIR
SHROUD
C
J
AIR
SHROUD
E
I
M
AIR
SHROUD



Final Temperatures

A	16.6
B	27.2
C	25.1
D	22.2
E	8.0
F	6.5
G	-4.1
H	7.9
I	10.3
J	8.3
K	14.9
L	5.3
M	-0.4

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15. Supplementary Notes

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