Report 1903

NOMINAL 9,000-BTU/HR, COMPACT, HORIZONTAL, AIR-CONDITIONING UNITS

by

Roy Peterson

July 1967

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U. S. ARMY ENGINEER RESEARCH AND DEVELOPMENT LABORATORIES
FORT BELVOIR, VIRGINIA

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Task 1M643303D54503

July 1967

Distributed by

The Commanding Officer
U. S. Army Engineer Research and Development Laboratories

Prepared by

Roy Peterson
Environmental Equipment Laboratory
Mechanical Technology Department

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SUMMARY

This final report covers the engineering design testing of four nominal 9,000-Btu/hr, compact, horizontal, air-conditioning models. These are through the wall-mounted, air-cooled, monochlorodifluoromethane refrigerant (R-22)-charged, electric-motor-driven units. The electric characteristics are as follows: 115-volt, 1-phase, 60-cycle, (Military Model MC11HAL6-115); 230-volt, 1-phase, 60-cycle (Military Model MC11HAL6-230); 208-volt, 3-phase, 60-cycle (Military Model MC11HAL16-208); and 208-volt, 3-phase, 400-cycle (Military Model MC11HAL4-208). Environmental tests as well as extensive performance-type tests were accomplished on the air conditioners.

The report concludes:

a. The nominal 9,000-Btu/hr compact, horizontal, air conditioners meet the design objectives of lightweight construction.

b. All test models meet the environmental, physical, operational, and electrical requirements of the tests covered in this report.

c. The units have high cooling capacities and highly advantageous airflow characteristics.

d. The dual-speed fan motors provide the advantage of noise control.

e. The units are safe and provide simple operation.

f. The units are suitable for applications which require great cooling capacities in a small, compact space envelope.

FORFWORD

Authority for the design, development, and testing of the four air conditioners covered by this report is contained in Task 1M643303D54503, "Environmental Control Equipment." Coordinated Military and Technical Characteristics titled "Air Conditioner, 9,000 BTUH Compact Horizontal - Performance Characteristics; Physical Characteristics; and Maintenance Characteristics," 30 June 1966, are outlined in Section II of this report.

This air conditioner project was the responsibility of the Environmental Equipment Laboratory, R. F. Bartelmes, Chief. The development and tests were accomplished under the supervision of Darald C. Frink, Chief, Development Branch; Charles W. Lester, Chief, Evaluation Engineering Branch; and Jerry L. Wilson, Senior Project Engineer, Development Branch. Roy Peterson, Project Engineer, wrote the report.

The air-conditioning units used for the engineering design tests described in this report were developed under Contract DA-44-009-AMC-833(T), 30 September 1964, with the Stratos Division of Fairchild Hiller Corporation, Bay Shore, Long Island, New York, in coordination with the Environmental Equipment Laboratory, Mechanical Technology Department, USAERDL.

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NOMINAL 9,000-BTU/HR, COMPACT, HORIZONTAL, AIR-CONDITIONING UNITS

I. INTRODUCTION

1. Subject. This final report covers the engineering design testing of four compact, horizontal, air-conditioning units each with a nominal cooling capacity of 9,000 Btu/hr. These four models comprise the smallest size units of the family of compact, horizontal air conditioners being developed by the Environmental Control Laboratory, Mechanical Technology Department, USAERDL, Fort Belvoir, Virginia. The objective of this task is to develop compact air conditioners which provide simple operation, durability, reliability, maximum interchangeability of parts with minimum weight and bulk, and which have ability to operate satisfactorily in world-wide climates for extended periods with a minimum amount of maintenance.

2. Background and Previous Investigation. The success of military agencies in providing miniature and smaller categories of portable electronic systems resulted in the requirement for lightweight, compact air conditioners capable of being easily transported and operated in extreme climatic conditions. A study was made to determine the best general design and configuration to satisfy the overall military requirements. The study concluded that lightweight, compact air conditioners could be developed by using aluminum-alloy cabinets, dual-speed fans, and lightweight components.

II. DEVELOPMENT REQUIREMENTS

3. Coordinated Military and Technical Characteristics. These requirements are set forth for the 9,000-Btu/hr-capacity models in the compact, horizontal family of air conditioners.

a. Performance Characteristics.

(1) Total cooling capacity of 9,000-Btu/hr unit (with dehumidification).

(2) Heating capacity of 6,000 Btu/hr.

(3) Minimum conditioner airflow of 270 cfm when unit is operating against zero external resistance

(4) Temperature-sensing device to respond within $\pm 4^{\circ}$ of any preset temperature between 60° and 90° F.

(5) Provisions for introducing at least 35 cfm of fresh air for personnel.

(6) Maximum total power requirement not greater than 3.5 kw.

(7) Automatic safety controls to protect against overpressure, overheating, and electrical overcurrent.

(8) Compatibility in operation with external chemical-biological (CB) protection devices.

(9) Life expectancy of 4,000 hours before overhauling unit, as is shown in the list in paragraph 3c of this report.

(10) Continue operation mission reliability of not less than 0.95 for a mission time of 24 hours, as is shown in the aforementioned list.

(11) Combat ready rate of 95 percent, as is shown in the same list.

(12) Capability of withstanding storage and transit conditions specified in paragraphs 7.1: 7.1.a; 7.1.b; and 7.1.d; of AR 705-15 (2)*.

(13) Operation satisfactory under conditions specified in paragraphs 7.a.(1)(a)1 and 7.d.(1)(a)2 of AR 705-15.

(14) Operation in the cooling mode in outdoor temperatures to a low of 0° F and in the heating mode to a low of -50° F.

(15) Environmental conditions of rain, humidity, fungus, salt fog, sand and dust, shock, and vibration met as specified in U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia, Standard Test Procedures.

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* Numbers in parentheses refer to entries in Literature Cited.

(16) Separate units for operation on the following power sources:

115 volts, 1 phase, 60 cycles
230 volts, 1 phase, 60 cycles
208 volts, 3 phase, 60 cycles
208 volts, 3 phase, 400 cycles

(17) Operation of the 60-cycle units on 50-cycle current at rated voltage with a capacity reduction of not more than 30 percent.

(18) Operation from a power source ranging from 95 percent to 110 percent of the rated voltage.

(19) Degradation of reliability per year of depot or field storage not more than 4 percent.

(20) Provisions for minimizing electrical surges while the unit is operating on thermostatic control.

(21) Noise level in conditioned area of a properly engineered installation not to exceed Curve NC-60 as indicated in ASHRAE Guide and Data Book (2) when used in conjunction with proper external sound treatment.

(22) Condenser side noise level not to exceed the maximum steady state noise level for Army Materiel Command equipment as specified in Table 2 of HEL Standard S-1-63B, June 1965.

(23) Radio frequency interference requirements of Specification MIL-E-55301 for tactical noncommunication electronic (CE) equipment met with exemptions stated in paragraph 3.4.

b. Physical Characteristics.

(1) Units suitable for starting, stopping, and temperature control by one man. Operator maintenance will be limited to minor tasks of lubrication, cleaning, replacement of filters, replacement of power cable, and cleaning condenser and evaporator coils.

(2) Units to be designed toward meeting a maximum volume requirement of 6 cubic feet and a maximum weight requirement of 200 pounds.

(3) Access panels or removable covers for ease of maintenance.

(4) Compliance with safety requirements of applicable ASA, UL, and Military Standards.

(5) Components and parts same as those used in other military air-conditioning units to the extent practicable.

c. <u>Maintenance Characteristics.</u>

(1) Requirement for a minimum of operational and in-storage maintenance. Repair by replacement-type components will be used to the maximum extent practicable.

(2) Requirement for the minimum of man-hours and skill to accomplish maintenance.

(3) Utilization, to the maximum extent practical, of major components that are maintenance free throughout the service life.

(4) Ease of accessibility and restricted use of components that require special skills or tools for maintenance will be stressed.

A list of the air-conditioning components and parts maintenance required on the basis of 24-hour-day operation for 30 days follows:

<u>Maintenance Requirements</u>

Mission Time (t) (hr)	24
Reliability for (t) (%)	95
Mean Time between Failures (predicted) (hr)	480
Mean Time between Failures (90% confidence)	1,104
Combat Ready Rate (%)	95
Mean Time to Repair (hr)	
Operator-Crew and Organizational	4
Direct Support	[illegible]
General Support	24
Mean Time between Maintenance (hr)	
Operator-Crew and Organizational	250
Direct Support	1,000
General Support	4,000

III. INVESTIGATION

4. Description. The 9,000-Btu/hr, compact, horizontal, air-conditioning unit (Figs. 1 through 3) is 23-3/4 inches wide, 26-3/8 inches deep, and 16-1/16 inches high. The maximum weight of the unit, charged and ready to operate, is 200 pounds. The unit is an integral package divided into sections. The condenser is at the rear, and the control panel, electrical controls, and evaporator compartments are at the front. Sealing and thermal insulation are provided as required to minimize heat transfer and air leakage between the sections. The condenser section contains a hermetically sealed motor-compressor with integral suction line filter and intercooler, a condenser with an integral subcooling coil, a condenser air-discharge opening with refrigerant pressure-controlled louver, a shrouded condenser (Centrax) fan with a propeller fan wheel driven by a dual-speed motor, a quench valve (thermal expansion), a receiver, a suction pressure-regulating valve or a hot-gas bypass valve, fresh-air or CB-air opening, electrical power receptacles, refrigerant piping, a sight glass, a filter-drier, a heat-pressure control actuator, service valves, solenoid valves (liquid line and equalization), a high-pressure relief valve, and high-pressure and low-pressure safety cutout devices. The evaporator compartment contains an evaporator coil, a shrouded evaporator fan wheel (double forward curved centrifugal) driven by a dual-speed motor, a discharge-air grille, a return-air grille, an air filter, a condensate drain pan assembly, refrigerant piping, a main thermostatic expansion valve, electrical heaters, a heater high-temperature cutout, and a fresh-air opening and filter. The fresh-air filter, which is held in place by a wire-formed retainer, is located at the lower right rear corner of the evaporator section.* For fresh-air filter service, the return-air grille-filter assembly must be removed, the fresh-air filter retainer screw released, and the retainer pulled free. The fresh-air filter can then be removed.

A separate compartment on the evaporator side of the unit contains the control module, time delay relay, transformer, rectifier, control circuit breaker, contactors, high- and low-pressure cutouts, terminal strips, phase-sensing relay, and the main power receptacle. The control module, which can be remote mounted (Fig. 2), contains the mode selector

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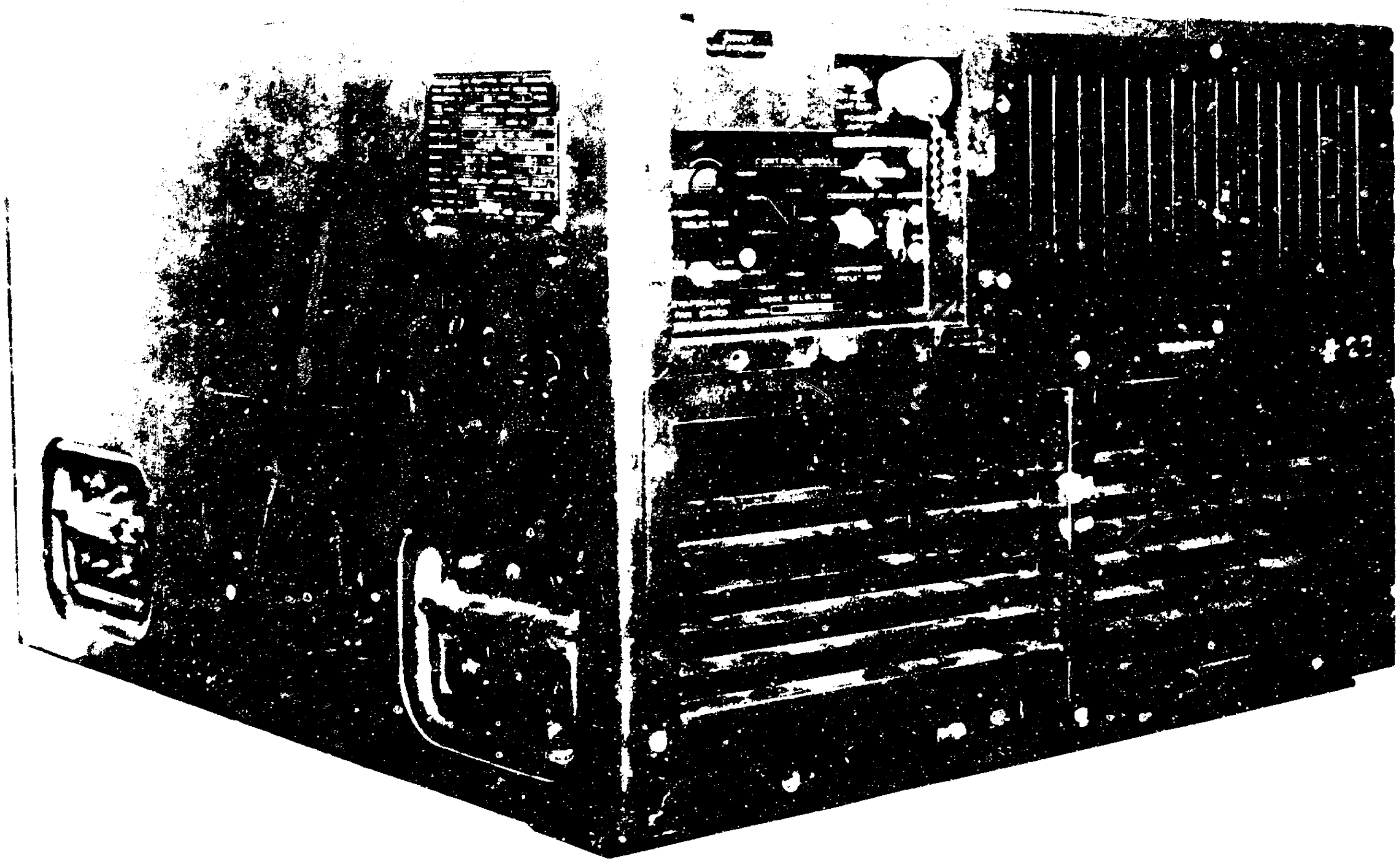
* The final design is to have the filter on the rear of the unit in an integral frame behind the ventilation air inlet screen. The filter will be accessible for servicing by removal of the inlet screen.



P1231

Fig. 1. Front and left side of 9,000-Btu/hr, compact, horizontal, air-conditioning unit, Model MC11HA[illegible]6-115.

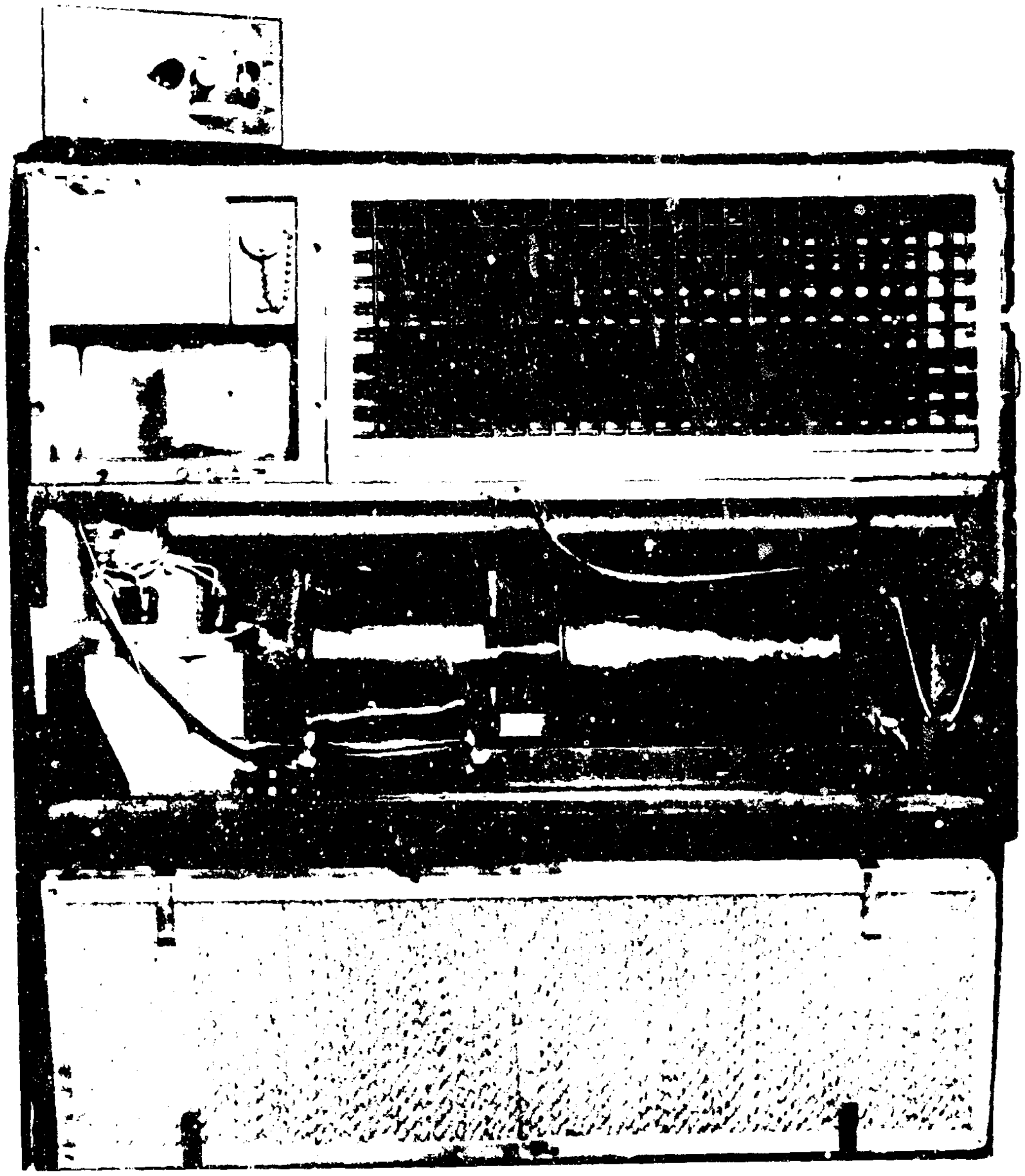


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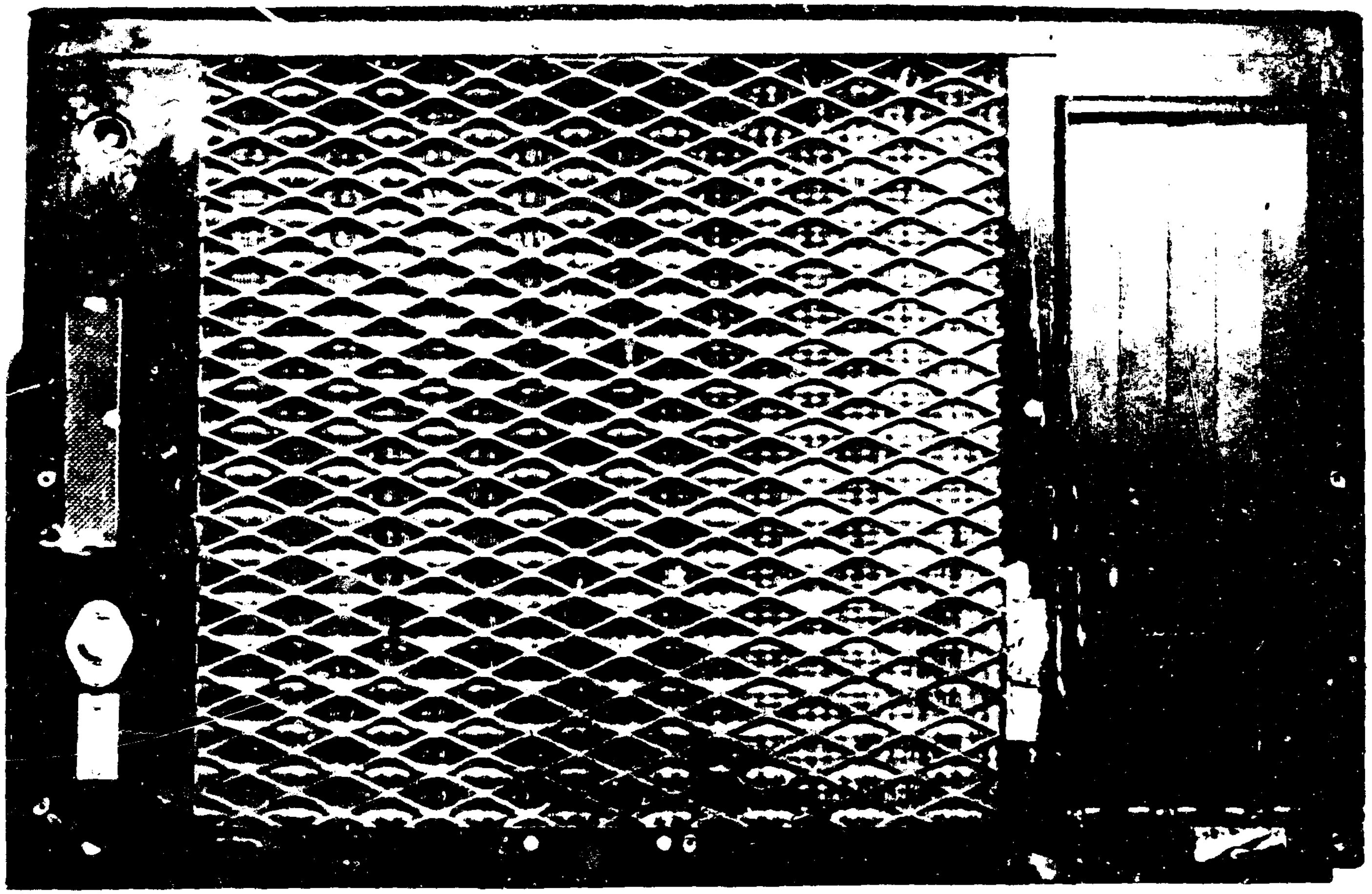
Fig. 2. Front of 9,000-Btu/hr, compact, horizontal, air-conditioning unit, Model MC11HAL6-115, with return air grille and control box removed.



P1238

Fig. 3. Rear of 9,000-Btu/hr, compact, horizontal, air-conditioning unit, Model MC11HAL6-115.

switch, the evaporator fan speed selector switch, the thermostat, and the compressor circuit breaker.

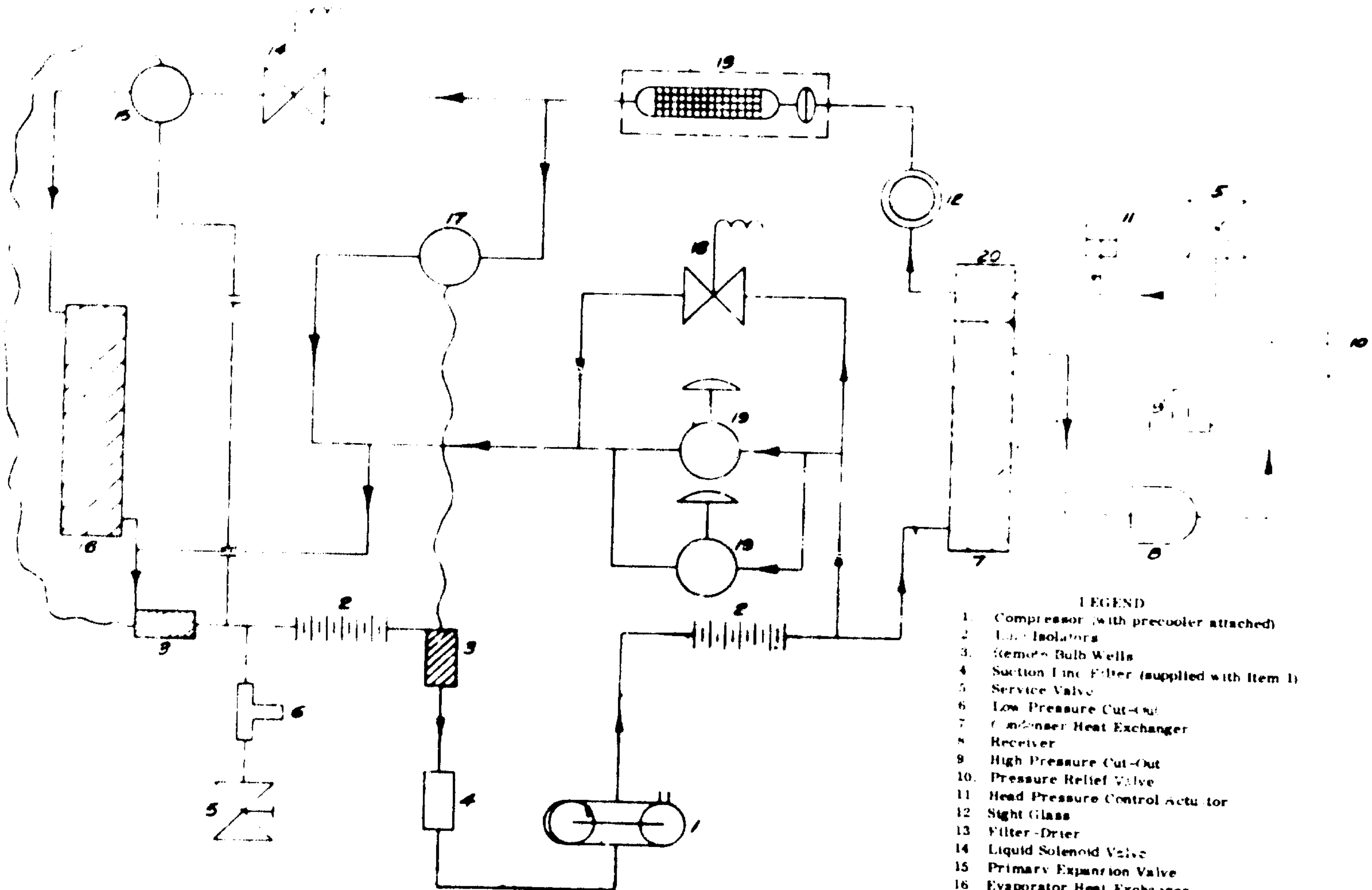
The external casing is a structurally rigid, block-shaped aluminum shell with suitable openings, panels, recessed handles, and rounded corners. Internal panels, separators, supports, and brackets are also aluminum, and their arrangement provides for maximum increased strength when components such as heat exchanger coils are installed. The motors and compressor are provided with suitable elastomer mounts to minimize shock, vibration, and noise. The top is a three-piece cover. The center cover is approximately 3 inches wide (to accommodate the wall thickness of a standard shelter). The purpose of this strip is to allow the front (evaporator) cover, the rear (condenser) cover, or both to be removed while the unit remains mounted in the wall of a shelter. Access for inspection and service is thus provided. The return-air grille and filter are at the front. These can be removed simultaneously and the filter can be separated for servicing.

The evaporator fan motor and the condenser fan motor are identical. The evaporator air impeller is a double forward curved centrifugal wheel mounted on the motor shaft and inclosed in a fiberglass-lined shroud. The return airflow is controlled by thumb latches on the return-air grilles, and the ventilation air damper is controlled by a thumb knob to the right of the discharge-air opening. The evaporator fan motor speed (high or low) is controlled by a toggle switch on the control panel. The fan pulls air through the return-air grille-filter combination, the fresh air filter, or both and pushes this air over the heaters, through the evaporator coil, and from the unit through the discharge-air grille. The filters are a permanent type which can be cleaned with hot water or steam. Application of a filter fluid after each cleaning is indicated.

Condenser airflow is controlled by a louver which, in turn, is controlled by the head-pressure controller in the high-pressure refrigerant line. A link-cable mechanism between the controller and the louver causes increased louver opening as pressure rises, and decreases louver opening as pressure falls. The head-pressure controller is fully extended (louvers full open) at head pressures at or above 250 psig and is completely retracted (louvers closed) at pressures at or below 165 psig. Varying the air delivery controls the output of the condenser heat exchanger which, in turn, controls the head pressure. An outdoor thermostat supplements this control by automatically choosing the condenser fan motor speed. This motor is in high speed at ambients above 100° F and is at low speed at ambients below 100° F. The condenser fan pulls air through the rear guard and condenser coil, and then pushes this air through the shroud and louvers and from the unit. The fan motors have single shafts, two speeds, sealed bearings, and require no lubrication.

A transformer and rectifier provide for the electrical control components of the unit to operate on 24-volt direct current. The direct-current control system is used for either the 60-cycle or the 400-cycle unit. Major portions of the control components are interchangeable among units of different electrical characteristics as well as other units of the compact, horizontal family. The electrical controls consist of the following components: Wiring, selector switch, thermostat, electric heater contactor, compressor contactor, condenser fan motor contactors, compressor circuit breaker, control circuit breaker, transformer, rectifier, time delay relay, temperature protectors, pressure protectors, a phase sequence protector, and an evaporator fan motor speed selector switch. Each wire is number coded and can be traced by reference to the wiring diagram. The selector switch, located in the control panel with a knob extending through the front access panel, has five modes or positions: HI-HEAT, LO-HEAT, OFF, VENTILATE or VENT, and COOL. The OFF mode electrically disconnects all power from the control circuit. The LO-HEAT mode provides thermostatic operation of one-half the heaters and continuous evaporator fan operation. The HI-HEAT mode provides constant operation of the remaining heaters in addition to the LO-HEAT functions. The VENT mode provides continuous evaporator fan operation without any cooling or heating. The COOL mode provides continuous compressor, evaporator fan, and condenser fan operation. The cooling function of the unit is controlled by the adjustable thermostat, located in the control panel next to the selector switch. The thermostat controls the refrigerant liquid line solenoid valve in response to the return-air temperature. This causes the refrigerant system to be either in the cooling cycle or in the bypass cycle of operation. When the compressor stops operating (for any reason), a normally open solenoid valve allows the suction and head pressures to equalize. The thermostat, which has an adjustment range of 60° F to 90° F, has a remote sensing bulb located in the evaporator return-air plenum. In the COOL mode, higher return-air temperatures than the thermostat setting will cause the unit to cool the air by the normal cooling cycle. Lower return-air temperatures than the thermostat setting will cause the unit to be in the bypass cycle and therefore not perform any cooling function.

The refrigerant cycle of the unit employs the vapor cycle principle which uses monochlorodifluoromethane refrigerant (R-22). The refrigerant system (Fig. 4, consists of the following components: Piping, a hermetically sealed compressor with an integral suction line filter and



LEGEND

1. Compressor (with precooler attached)
2. Line Isolators
3. Remote Bulb Wells
4. Suction Line Filter (supplied with Item 1)
5. Service Valve
6. Low Pressure Cut-Out
7. Condenser Heat Exchanger
8. Receiver
9. High Pressure Cut-Out
10. Pressure Relief Valve
11. Head Pressure Control Actuator
12. Sight Glass
13. Filter-Drier
14. Liquid Solenoid Valve
15. Primary Expansion Valve
16. Evaporator Heat Exchanger
17. Quench Expansion Valve
18. Equalization Solenoid Valve
19. Hot-Gas Bypass Valve
20. Subcooling Heat Exchanger

Fig. 4. Refrigerant system schematic.

intercooler, condenser coil with integral subcooler, filter-drier, suction-line service valve, discharge-line service valve, pressure-relief valve, liquid-line solenoid valve, liquid sight glass, main thermal expansion valve (TEV), evaporator coil, pressure-regulating (hot-gas bypass) valve, liquid quench expansion valve, high-pressure safety cutout, low-pressure cutout, receiver, head-pressure control actuator, and equalization solenoid valve. During the normal cooling cycle of operation, the liquid solenoid valve and evaporator TEV are open, and the quench expansion valve and pressure-regulating valve are closed. The compressor pumps the refrigerant through the condenser coil, receiver, subcooler, sight glass, filter-drier, liquid solenoid valve, TEV, and evaporator coil to the suction side of the compressor. During the bypass cycle of operation, the liquid solenoid valve is closed and the pressure-regulating valve and quench valve are open as the pressure and superheat of the suction gas reaches 58 psig and 25° F, respectively. During the bypass mode of operation, the refrigerant is pumped by the compressor and is split into two piping circuits. Most of the refrigerant is forced through the pressure-regulating valve, mixed with the liquid from the quench valve, and drawn into the suction side of the compressor. The remaining refrigerant, the quantity depending upon the liquid quench expansion valve, is forced through the condenser coil, receiver, subcooler, sight glass, filter-drier, and liquid quench expansion valve; mixed with the hot gas; and drawn into the suction side of the compressor. The pressure-regulating valve is preset to maintain a sufficiently high suction pressure (55 to 58 psig) to prevent evaporator coil freezeup. Suction pressure is inherently low under low cooling load conditions and at low ambient temperatures. The quench expansion valve feeler bulb (located just before the suction line filter) senses refrigerant temperature and the pressure-regulating valve senses suction pressure. These functions are coordinated with the condenser head-pressure controls to assure sufficient head pressure under low ambient temperatures. After shutdown of the compressor, the equalization solenoid valve opens and the system pressure equalizes. This permits the compressor to start under unloaded conditions, which reduces the starting current.

5. Test Objectives, Methods, and Results. Tests were initiated in January 1966 on the initial prototype unit. Tests not conducted at USAERDL by USAERDL personnel were supervised or monitored by the Senior Project Engineer. During initial testing all deficiencies were corrected. Final testing followed, and the findings in this report represent the tests on the final prototype air conditioners.

a. Cooling Capacity. The cooling capacity tests were conducted to determine the net cooling capacities at specific test conditions

Table I. Cooling Capacity Test Conditions

Test Condition	Fan Speed, Evaporator-Condenser	Air Temperature on Condenser (°F)	Air Temperature on Evaporator (°F)		Sensible Heat Factor (%)	External Static Pressure (in. of water)
			Dry Bulb	Wet Bulb		
1*	HI/HI	120	90.0	75.0	65-80	0
2**	HI/HI	120	90.0	75.0	65-80	0
3	HI/HI	120	90.0	67.5(max)	100	0
4	HI/HI	120	90.0	67.5(max)	100	0.125
5	HI/HI	120	90.0	67.5(max)	100	0.250
6	HI/HI	95	80.0	67.0	65-80	0
7	HI/LO	95	80.0	67.0	65-80	0
8	LO/LO	95	80.0	67.0	65-80	0
9	HI/HI	95	80.0	58.0(max)	100	0
10	HI/LO	95	80.0	58.0(max)	100	0

Note: Conditions 1, 2, 4, and 7 are used in the cooling capacity tests described in paragraph 5a.

*Section II, Development Requirement cited in paragraph 3a(1) in this report.

**For 60-cycle units only (50-cycle input frequency), Models MC11HAL6-215, -230, and -208.

(Table I). The Technical Characteristics require a cooling capacity of 9,000 Btu/hr under test condition 1, and each model unit was so tested. Because of design similarity, no unit was subjected to all ten test conditions, but sufficient tests were divided among the four models to determine adequacy. The cooling capacity tests were conducted at USAERDL, Fairchild Hiller Corporation, and Electrical Testing Laboratories (ETL), Inc., using the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 16-61, Methods of Testing for Rating Room Air Conditions (3) as a guide. All tests were monitored to assure compliance, and the test rooms and equipment were equivalent to the USAERDL balanced room calorimeter (Fig. 5).

Under a typical test, the sensible heat and latent heat removed from the air in the inside test room by the evaporator section were replaced by the inside calorimeter reconditioner which used electric strip heaters and an electrically heated evaporator tray filled with water. After a stable equilibrium balance was indicated at specific conditions, the total heat input into the inside reconditioner during the test period of 1 hour was then the cooling capacity of the cooling unit under test. As a check, the cooling capacity was again determined from the outside test room, into which was rejected all the heat removed from the inside test room by the unit under test. The sensible heat introduced into the outside room by the air conditioner was removed by the outside calorimeter, which used heat-transfer coils through which chilled water circulated. The cooling capacity used for checking the calorimeter balance was obtained by taking the total heat removed by the outside reconditioner (during the 1-hour test period) and subtracting from it the thermal equivalent of the electrical input to the unit and the reconditioner. The ASHRAE Standard 16-61 specifies that the capacities determined from the two calorimeters shall agree within 4 percent. The quantity of water evaporated in the inside room during test conditions was measured by a calibrated water tube. Condensed water was removed from the evaporator section of the test unit and measured.

For the test, the air conditioner was mounted in the partition separating the inside room from the outside room. Cloth tape and foam rubber insulating strips were used around the panels to prevent leakage between the two rooms. The discharge-air directional louvers and return-air louvers were set to prevent recirculation or "short cycling" of conditioned air. The test unit controls were set for maximum cooling with the ventilation air damper closed. Electrical characteristics were continuously recorded and evaluated during each operational test by use of accurately calibrated instruments. Results of the tests are shown in Tables II through V.

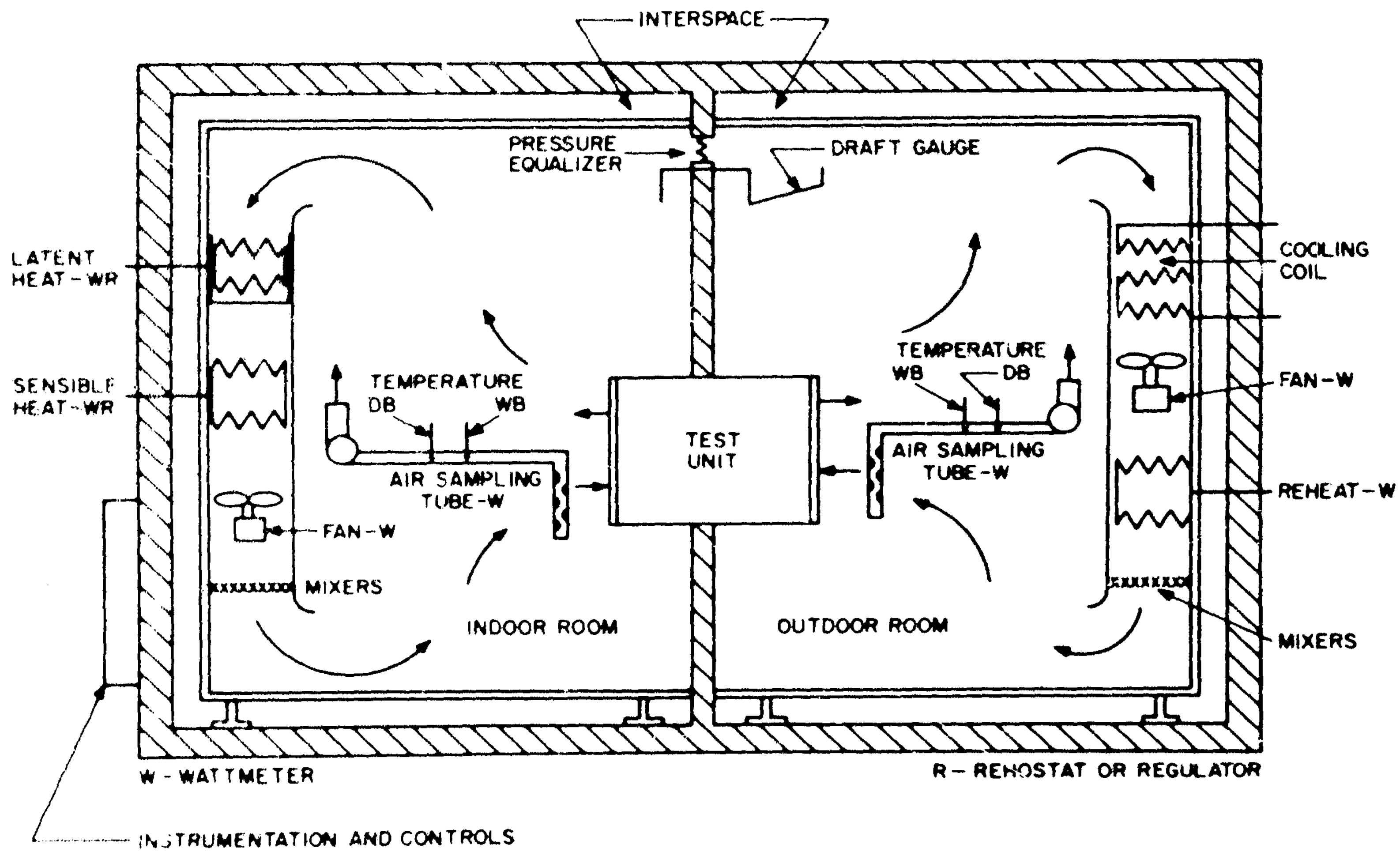


Fig. 5. Balanced room calorimeter.

Table II. Results of Cooling Capacity Test,
Model MC11HAL6-115

Measurement	Test Condition 1	4	7	10
Capacities (Btu/hr)				
Total	10,220	9,881	8,950	8,450
Latent	3,070	0	1,850	0
Sensible	7,150	9,881	7,100	8,450
Sensible Heat Factor (%)	70.0	100	79.0	100
Coefficient of Performance (Btu/hr/watt)	3.46	3.79	3.51	3.40
Air Temperatures (°F)				
Entering Evaporator, Dry Bulb	90.3	90.3	79.9	79.8
Entering Evaporator, Wet Bulb	75.1	66.0	66.9	63.5
Leaving Evaporator, Dry Bulb	70.2	-	61.2	60.4
Outside Room Temperature (°F)	120.1	120.0	95.1	95.2
Airflow (scfm/ton), Evaporator	348	-	353	378
Refrigerant Temperatures (°F)				
Superheat at Bulb	2.0	9.4	1.0	1.0
Subcooling at Condenser	5.0	12.1	11.0	10.0
Discharge Pressure (psig)	378	382	350	340
Suction Pressure (psig)	90	85	76	74
Electrical Characteristics				
Voltage	115	115	115	115
Amperage	26.5	23.8	23.0	22.5
Power (kw)	2.95	2.61	2.55	2.50
Power Factor (%)	96.7	95.3	93.0	96.6

Notes: Test conducted with an external static pressure of 0.125 in. of water on the evaporator.

Hyphens signify that these data were not taken.

Table III. Results of Cooling Capacity Test, Model MC11HAL6-230

Measurement	Test Condition		
	1	2	4
Capacities (Btu/hr)			
Total	10,860	8,160	10,150
Latent	2,540	1,590	0
Sensible	8,320	6,570	10,150
Sensible Heat Factor (%)	77.0	80.5	100
Coefficient of Performance (Btu/hr/watt)	4.16	2.99	3.82
Air Temperatures (°F)			
Entering Evaporator, Dry Bulb	90.1	90.2	90.2
Entering Evaporator, Wet Bulb	74.9	75.0	66.6
Leaving Evaporator, Dry Bulb	-	-	-
Outside Room Temperature (°F)	120.3	120.2	120.0
Airflow (scfm/ton), Evaporator	-	-	-
Refrigerant Temperatures (°F)			
Superheat at Bulb	5.0	6.0	5.0
Subcooling at Condenser	5.5	2.0	4.0
Discharge Pressure (psig)	384	388	386
Suction Pressure (psig)	88.5	95.5	86.0
Electrical Characteristics			
Voltage	230	230	230
Amperage	12.1	18.1	12.2
Power (kw)	2.61	2.73	2.66
Power Factor (%)	94.0	65.5	94.5

Notes: Test conducted by Electrical Testing Laboratories, Inc.

Hyphens signify that these data were not taken.

Table IV. Results of Cooling Capacity Test, Model MC11HAL6-208

Measurement	Test Condition 1	2	4
Capacities (Btu/hr)			
Total	10,640	8,300	9,420
Latent	2,120	1,590	0
Sensible	8,520	6,710	9,420
Sensible Heat Factor (%)	80.0	81.0	100
Coefficient of Performance (Btu/hr/watt)	3.93	3.02	3.51
Air Temperatures (°F)			
Entering Evaporator, Dry Bulb	90.2	90.3	89.8
Entering Evaporator, Wet Bulb	75.0	75.2	65.2
Leaving Evaporator, Dry Bulb	-	-	-
Outside Room Temperature (°F)	119.8	120.4	120.7
Airflow (scfm/ton), Evaporator	-	-	-
Refrigerant Temperatures (°F)			
Superheat at Bulb	3.0	1.0	2.5
Subcooling at Condenser	4.0	2.5	3.4
Discharge Pressure (psig)	379	379	378
Suction Pressure (psig)	89.0	96.0	85.5
Electrical Characteristics			
Voltage	208	208	208
Amperage	10.6	14.0	10.6
Power (kw)	2.710	2.750	2.680
Power Factor (%)	71.0	75.0	71.0

Note: Test conducted by Electrical Testing Laboratories, Inc.

Hyphens signify that these data were not taken.

Table V. Results of Cooling Capacity Test, Model MC11HAL4-208

Measurement	Test Condition 1	Remarks
Capacities (Btu/hr)		Inspection of the air conditioning unit after this test revealed that the cabinet wall thermal insulation had pulled away from the walls and had obstructed the evaporator airflow. This problem has been corrected by modifications made in the design of the unit.
Total	9,560	
Latent	2,650	
Sensible	6,910	
Sensible Heat Factor (%)	66.0	
Coefficient of Performance (Btu/hr/watt)	3.19	
Air Temperatures (°F)		
Entering Evaporator, Dry Bulb	90.2	
Entering Evaporator, Wet Bulb	75	
Leaving Evaporator, Dry Bulb	-	
Outside Room Temperature (°F)	119.7	
Airflow (scfm), Evaporator	-	
Refrigerant Temperatures (°F)		
Superheat at Bulb	8	
Subcooling at Condenser	17	
Discharge Pressure (psig)	371	
Suction Pressure (psig)	78	
Electrical Characteristics		
Voltage	208	
Amperage	16.5	
Power (kw)	3.000	
Power Factor (%)	47.0	

Notes: Test conducted by Electrical Testing Laboratories, Inc.

Hyphens signify that these data were not taken.

b. High-Temperature Cooling Operations. Two different tests were conducted on each of three models (MC11HAL6-230, MC11HAL6-208, and MC11HAL4-208) to determine the effect of high-temperature operation. These two tests were as follows:

(1) Constant High-Temperature Operation. The high-temperature operation test was conducted to determine the ability of the air conditioners to start and operate in the COOL mode under high-temperature conditions (120° F ambient and 120° F return air).

The test was conducted in a calorimeter room with the outside room and inside room stabilized and maintained at 120° F. Each test unit was started in the COOL mode and allowed to operate for 15 minutes with room temperatures maintained at 120° F. The unit was shut off for 5 minutes and then manually restarted. This cycle was repeated twice. During the test, no actuation of any of the safety devices was to take place, and no damage to the motors or components was to occur as a result of operating conditions.

Test results are shown in Tables VI through VIII.

Table VI. Results of High-Temperature Operation Test, Model MC11HAL6-230

Measurement	Test Run		
	1	2	3
Air Temperatures (°F)			
Entering Evaporator	118	118	119
Entering Condenser	120	120	120
Refrigerant Temperatures (°F)			
Condenser Out	149	149	149
Suction at Bulb	76	73	76
Discharge Pressure (psig)	412	411	411
Suction Pressure (psig)	112	112	112
Electrical Characteristics			
Voltage	230	230	230
Amperage	13.0	12.6	13.0
Power (kw)	2.86	2.90	2.84
Power Factor (%)	95.6	100	95.0

Table VII. Results of High-Temperature Operation Test, Model MC11HAL6-208

Measurement	Test Run		
	1	2	3
Air Temperatures (°F)			
Entering Evaporator	121	120	120
Entering Condenser	120	120	120
Refrigerant Temperatures (°F)			
Condenser Out	147	147	147
Suction at Bulb	73	73	71
Discharge Pressure (psig)	407	407	406
Suction Pressure (psig)	114	114	114
Electrical Characteristics			
Voltage	207	208	207
Amperage	10.85	10.85	10.90
Power (kw)	2.87	2.88	2.85
Power Factor (%)	73.9	73.9	73.2

Table VIII. Results of the High-Temperature Operation Test, Model MC11HAL4-208

Measurement	Test Run		
	1	2	3
Air Temperatures (°F)			
Entering Evaporator	120	121	120
Entering Condenser	122	121	120
Refrigerant Temperatures (°F)			
Condenser Out	152	151	148
Suction at Bulb	73	77	72
Discharge Pressure (psig)	407	406	398
Suction Pressure (psig)	103	103	100
Electrical Characteristics			
Voltage	208	208	208
Amperage	16.75	16.80	16.70
Power (kw)	3.15	3.10	3.05
Power Factor (%)	51.4	51.3	50.9

(2) High-Temperature "Pull Down" Operation. Three models (MC11HAL6-230, MC11HAL6-208, and MC11HAL4-208) were tested separately in a shelter located inside the climatic test chamber (Fig. 6). Before each test, a heat soak process, sufficient to establish stable ambients of 155° F inside and 120° F outside, was completed. Then, each unit was started in the COOL mode and data were recorded at intervals. The unit was operated in the COOL mode for 1 hour with the inside room temperature dropping at a controlled rate.

Each unit was shut down for a 5-minute period, restarted in the COOL mode, and after restarting, data were recorded.

Results are listed in Tables IX through XI.

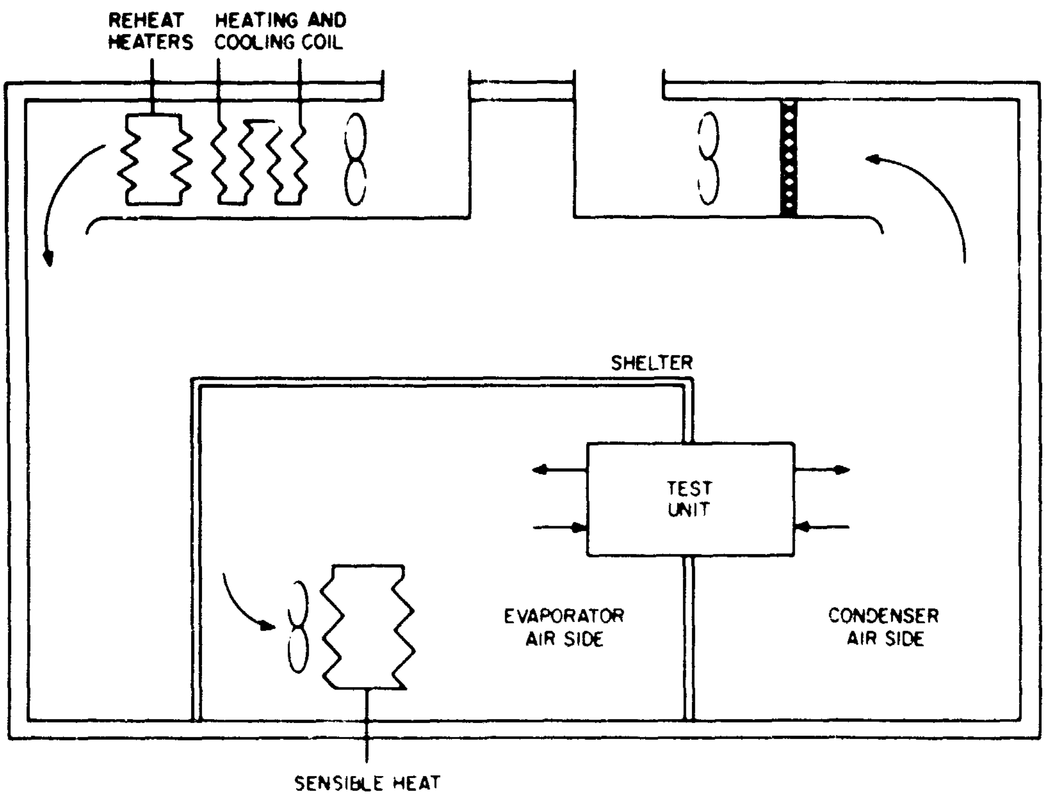


Fig. 6. Climatic test chamber.

Table IX. Results of High-Temperature Pull Down Test, Model MC11HA L6-230

Measurement	Time			
	8 Min after Starting	30 Min after Starting	15 Min after Restarting	45 Min after Restarting
Air Temperatures (°F)				
Entering Evaporator, Dry Bulb	142	105	89	90
Entering Evaporator, Wet Bulb	82	67	57	59
Leaving Evaporator, Dry Bulb	103	79	66	67
Entering Condenser, Dry Bulb	120	120	120	120
Leaving Condenser, Dry Bulb	143	142	140	140
Refrigerant Temperatures (°F)				
Discharge Line	187	205	202	202
Condenser Out	155	152	148	149
Subcooler Out	153	144	139	140
TEV In	151	143	138	139
Suction at TEV Bulb	99	67	60	60
Suction at Compressor	91	72	63	63
Suction Pressure Regulating Valve Out	153	160	156	157
Quench Out	80	61	52	52
Equalization Solenoid Out	157	168	163	164
Precooler In	214	223	223	224
Precooler Out	191	194	190	191
Compressor Skin Temperature (°F)	177	198	194	195
Discharge Pressure (psig)	420	396	378	382
Suction Pressure (psig)	133	92	78	79
Electrical Characteristics				
Voltage	230	230	230	230
Amperage	13.60	12.75	12.35	12.35
Wattage	2.985	2,815	2,680	2,690
Power Factor (%)	95.4	96.0	94.4	94.7

Table X. Results of High-Temperature Pull Down Test, Model MC11HAL6-208

Measurement	Time			
	16 Min after Starting	30 Min after Starting	60 Min after Starting	30 Min after Restarting
Air Temperatures (^oF)				
Entering Evaporator, Dry Bulb	125	103	90	90
Entering Evaporator, Wet Bulb	-	-	62	61
Leaving Evaporator, Dry Bulb	82	71	63	65
Entering Condenser, Dry Bulb	118	121	120	118
Leaving Condenser, Dry Bulb	142	144	140	138
Refrigerant Temperatures (^oF)				
Discharge Line	187	198	194	191
Condenser Out	149	150	144	143
Subcooler Out	144	143	137	137
TEV In	142	142	135	134
Suction at TEV Bulb	70	57	53	53
Suction at Compressor	62	53	52	49
Suction Pressure Regulating Valve Out	148	153	140	137
Quench Out	62	53	48	48
Equalization Solenoid Out	155	160	152	149
Precooler In	208	216	217	213
Precooler Out	182	188	186	182
Compressor Skin Temperature (^oF)	179	190	185	182
Discharge Pressure (psig)	380	379	360	351
Suction Pressure (psig)	100	84	76	75
Electrical Characteristics				
Voltage	208	208	208	208
Amperage	10.46	10.25	10.14	10.08
Wattage	2,730	2,630	2,555	2,540
Power Factor (%)	72.5	71.2	69.9	69.0

Note: Hyphens signify that these data were not taken.

Table XI. Results of High-Temperature Pull Down Test,
Model MC11HAL4-208

Measurement	Time			
	22 Min after Starting	30 Min after Starting	60 Min after Starting	30 Min after Restarting
Air Temperatures (°F)				
Entering Evaporator, Dry Bulb	118	103	91	91
Entering Evaporator, Wet Bulb	85	79	72	71
Leaving Evaporator, Dry Bulb	92	80	71	70
Entering Condenser, Dry Bulb	120	120	120	118
Leaving Condenser, Dry Bulb	139	144	141	139
Refrigerant Temperatures (°F)				
Discharge Line	160	202	198	196
Condenser Out	147	149	146	144
Subcooler Out	145	139	136	133
TEV In	142	138	134	131
Suction at TEV Bulb	95	86	71	75
Suction at Compressor	97	91	79	82
Suction Pressure Regulating Valve Out	138	154	150	147
Quench Out	90	105	87	75
Equalization Solenoid Out	143	162	158	155
Precooler In	198	226	224	223
Precooler Out	178	195	192	190
Compressor Skin Temperature (°F)	151	193	190	187
Discharge Pressure (psig)	382	382	370	362
Suction Pressure (psig)	115	98	85	84
Electrical Characteristics				
Voltage	209.0	209.3	210.0	209.7
Amperage	17.12	16.90	16.80	16.70
Wattage	3,210	3,155	3,105	3,045
Power Factor (%)	51.8	51.7	50.8	50.2

c. Low-Temperature Cooling Operation. The low-temperature cooling operation test was conducted to verify air-conditioner operation in the COOL and bypass modes when outside ambient temperature drops to 0° F, and to determine the cooling capacity at the low ambient conditions.

This test was conducted in the climatic test chamber with the enclosed inside shelter temperature maintained at 70° F ± 3° F dry-bulb dry-coil conditions and with use of electric heaters throughout the test. The unit operation was recorded at 90° F inside room conditions and at 120° F outside room conditions (standard rating point) before and after the test to provide a means of evaluating the change(s), if any, in the unit's performance as a result of the test conditions. As the test unit operated in the COOL mode, readings were recorded as the outside ambient temperature was lowered. When the outside temperature dropped to 90° F, and after 30 minutes' operation at this condition, data were recorded as before. Readings were recorded similarly at chamber temperatures of 75° F, 60° F, 45° F, 30° F, 15° F, and 0° F. The test unit was operated at rated voltage and frequency. With all power to the test unit shutoff, chamber temperature was lowered to -10° F and held for 2 hours. The temperature was then raised to 0° F over a 30-minute period. Power was connected to the test unit, and the unit was restarted and operated for 30 minutes while a chamber temperature of 0° F was maintained. This low-temperature start was repeated twice. Chamber temperature was then raised to 90° F as rapidly as possible, and after equilibrium in the chamber was reached, data were recorded. During the entire test, the air conditioner was required to operate without damage to any components.

All models were subjected to this test. The comparative cooling capacity results are shown on Figs. 7 through 10. Cooling operation data are presented in Tables XII through XV, and bypass operation data are given in Tables XVI and XVII.

d. Heating Capacity. The heating capacity test was conducted to determine the total heating capacity and the electrical characteristics of the unit in the HI-HEAT mode of operation. With this design (separate fan and motor for the evaporator air) the evaporator compartment receives all the heat generated by the total unit power input, therefore, the heating capacities were calculated from the total unit power input during the HI-HEAT mode of operation.

Capacities and other results are shown in Table XVIII.

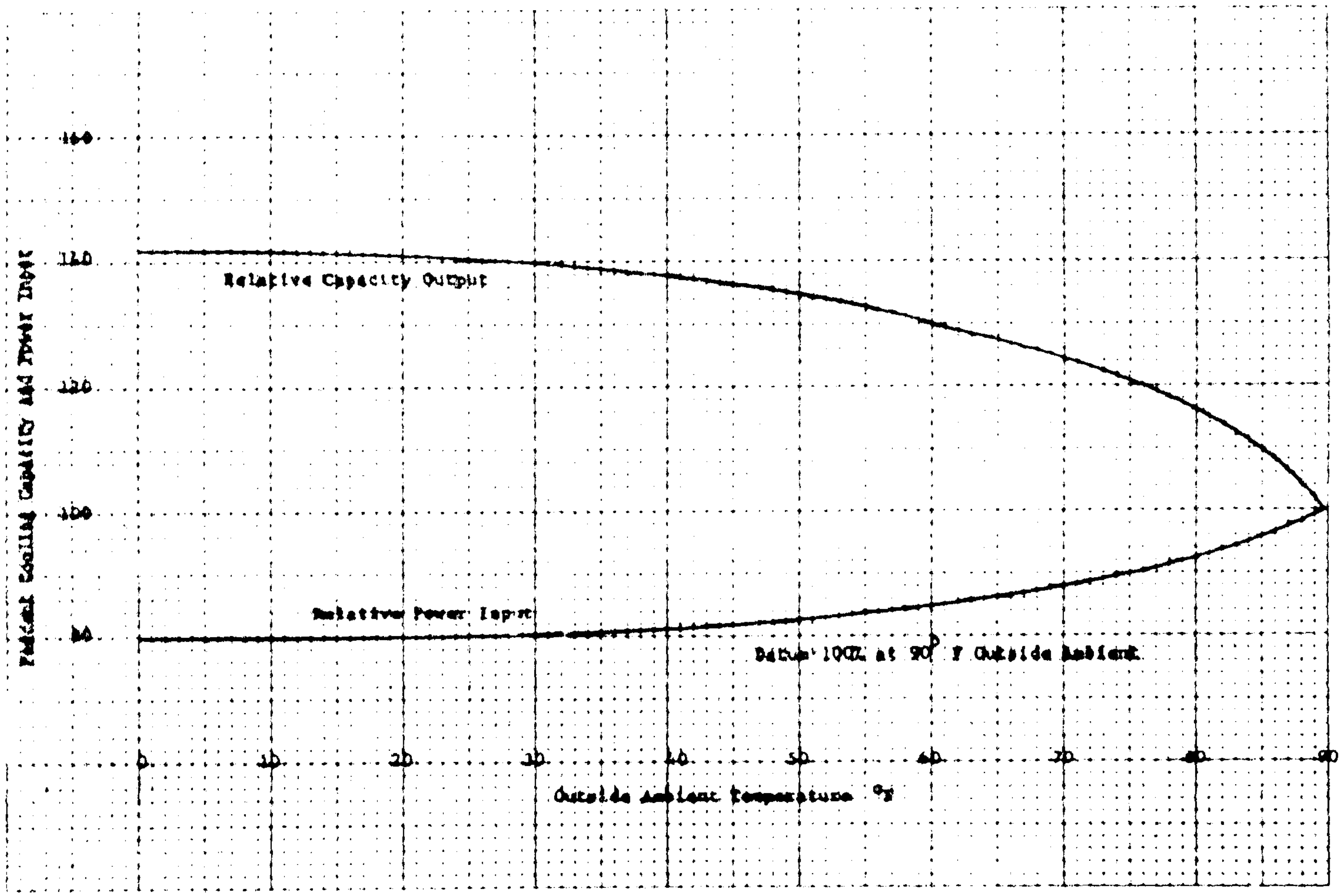


Fig. 7. Relative capacity and power input, 0° F to 90° F outside ambient, Model MC11HAL6-115.

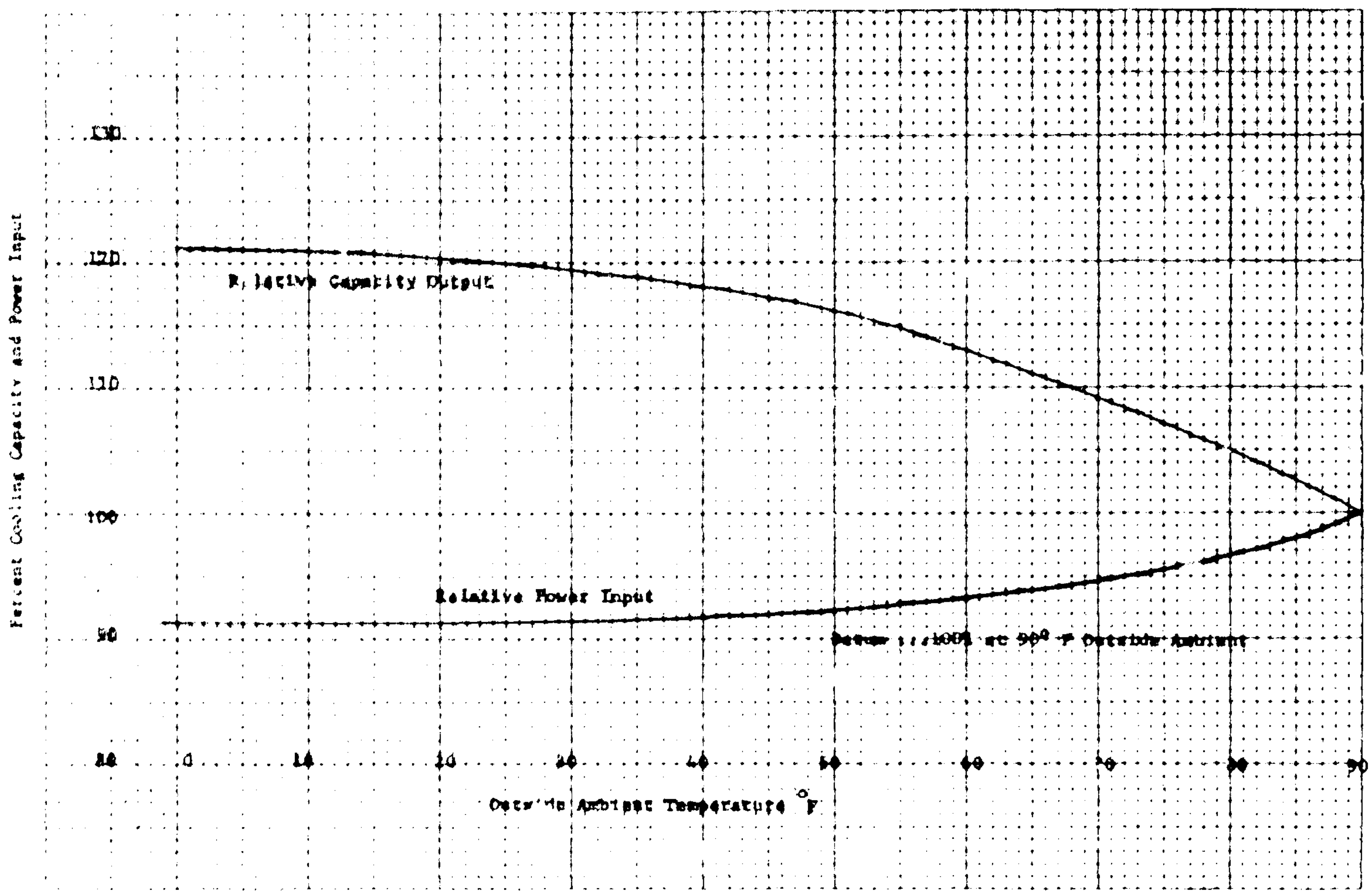


Fig. 8. Relative capacity and power input, 0° F to 90° F outside ambient, Model MC11HAL6-230.

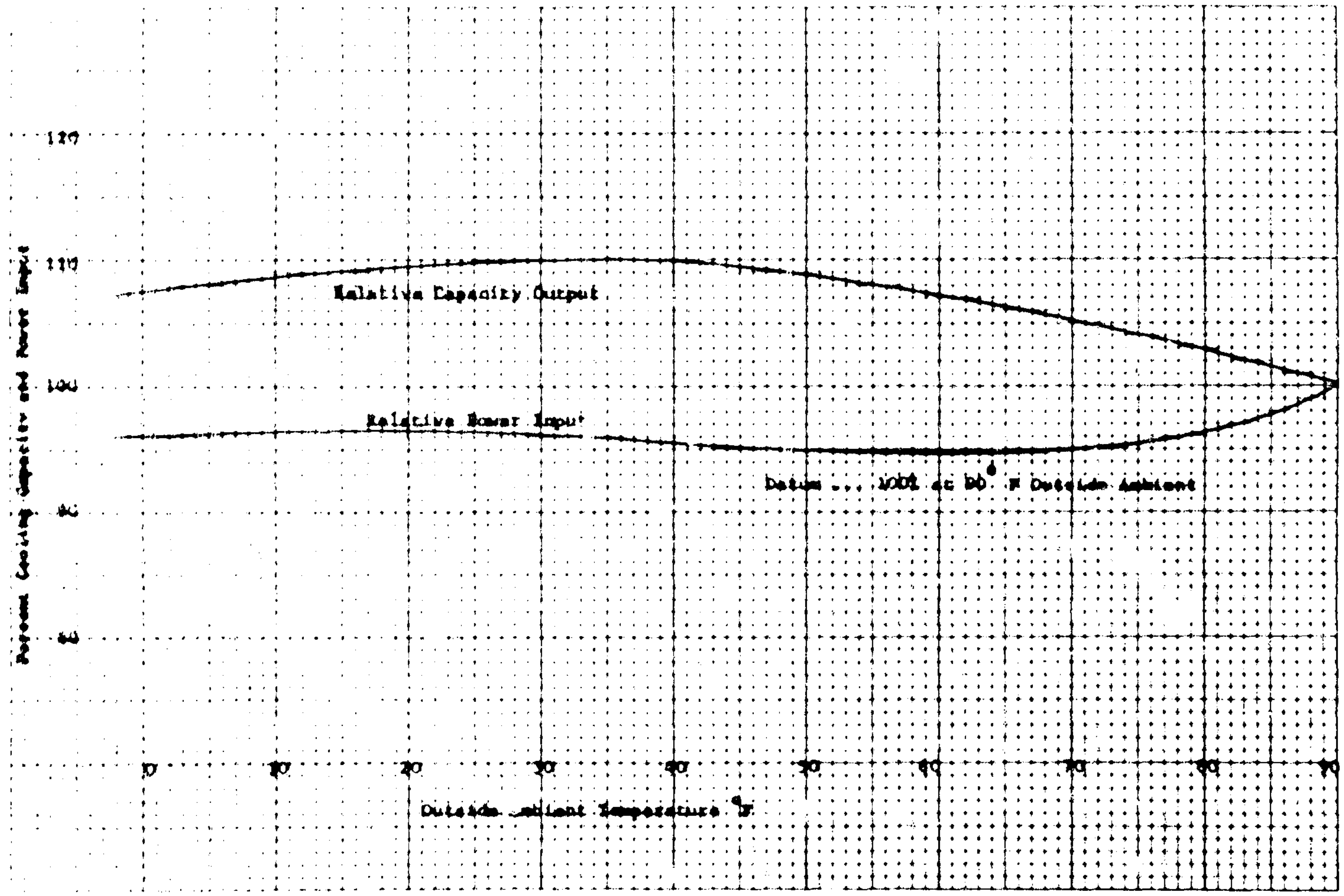


Fig. 9. Relative capacity and power input, 0° F to 90° F outside ambient, Model MC11HAL6-208.

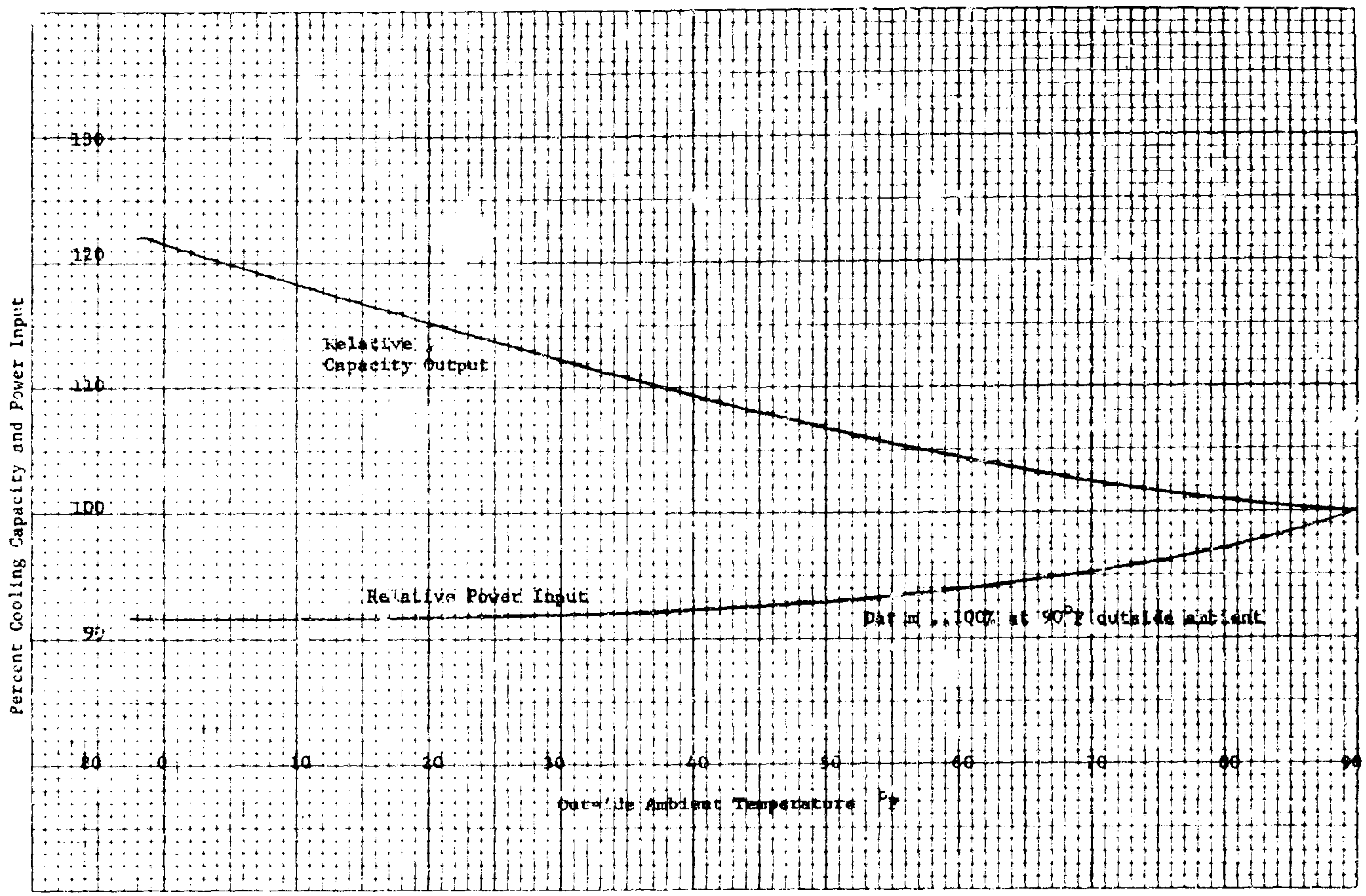


Fig. 10. Relative capacity and power input, 0^{o} F to 90^{o} F outside ambient, Model MC11HA L4-208.

Table XII. Results of Low-Temperature Cooling Operation, COOL Mode, Model MC11HAL6-115

Measurement	Chamber Temperature (°F)										
	120	90	75	60	45	30	15	0	0	90	120
Air Temperatures (°F)											
Entering Condenser, Dry Bulb	121.0	90.5	77.0	62.0	45.0	53.5	14.5	0	2.0	89.5	120.5
Leaving Condenser, Dry Bulb	144.0	121.0	108.0	89.0	61.5	59.0	36.0	24.0	24.0	120.5	142.5
Entering Evaporator, Dry Bulb	96.5	68.0	71.0	70.0	71.5	72.0	71.5	72.0	71.0	70.5	91.0
Entering Evaporator, Wet Bulb	66.0	50.5	51.0	49.0	49.0	48.0	-	-	-	52.0	64.0
Leaving Evaporator Dry Bulb	70.0	56.5	57.0	55.0	55.0	55.0	55.0	55.0	54.5	58.5	70.5
Refrigerant Temperatures (°F)											
Discharge Line	-	155.0	-	149.0	144.0	142.0	138.5	139.0	139.5	176.0	204.0
Condenser Out	148.0	123.5	110.5	98.5	94.0	92.0	86.0	88.5	88.0	123.5	147.0
Subcooler Out	138.0	112.5	99.0	85.5	79.0	75.0	68.0	68.0	69.5	111.0	137.5
TEV In	133.0	106.0	95.0	83.5	77.5	74.5	69.0	68.0	69.5	105.5	132.5
Suction at TEV Bulb	52.5	46.5	43.5	49/42	48/42	42.0	47/41	41.0	41.5	47.5	60.52
Suction at Compressor	65	75/45	71/43	67/41	67/41	67/42	68/40	67/44	67/40	73/45	64.5
Suction Pressure Regulating Valve Out	145.5	[illegible]	127.0	119.0	116.5	116.0	114.0	114.5	115.0	125.0	145.0
Quench Out	69.0	44.0	43.5	41.5	40.5	40.5	39.0	39.0	40.0	44.5	65.0
Equalization Solenoid Out	153.5	143.0	130.0	122.0	120.0	120.0	117.0	115.0	116.5	149.0	153.0
Precooler In	221.0	196.0	177.5	164.0	158.0	156.0	152.0	153.0	153.0	181.5	220.0
Precooler Out	188.5	162.0	145.0	131.0	126.0	124.5	121.5	121.0	122.0	159.5	187.5
Subcooling at Subcooler	10.0	11.0	11.5	13.0	15.0	17.0	18.0	10.5	18.5	12.5	9.5
Superheat at Bulb	2.8	3.5	1.8	-	-	-	-	-	2.2	4.5	10.6.[illegible]
Superheat at Compressor	15.3	32/2	29/1	-	-	-	-	-	28/1	30/2	15.1
Compressor Skin Temperature (°F)	193.0	168.0	150.0	138.0	132.5	130.0	126.5	124.0	125.0	165.0	190.0
Discharge Pressure (psig)	377.5	281.5	240.0	199.0	183.0	180.0	169.5	170/166	171.5	279.0	372.5
Suction Pressure (psig)	83.5	73.0	71.0	68.5	67.5	69.0	67.0	75/65	67.5	73.0	83.0
Electrical Characteristics											
Voltage, Average	115	116	115	115	115	115	115	115	116	115	114
Amperage, Average	24.4	19.3	18.0	16.8	16.0	16.2	16.0	15.8	16.0	19.0	23.8
Wattage, Total	2,720	2,130	1,950	1,795	1,770	1,750	1,770	1,710	1,725	2,080	2,640
Power Factor (%)	96.9	95.1	94.2	92.9	96.2	93.9	96.1	94.1	92.9	95.2	97.3

Note: Hyphens signify that these data were not taken.

Table XIII. Results of Low-Temperature Cooling Operation, COOL Mode, Model MC11HA L6-230

Measurement	Chamber Temperature							
	90	75	60	45	30	15	0	-5
Air Temperatures (°F), Dry Bulb								
Entering Condenser	90.0	75.0	60.1	44.7	30.4	15.6	1.1	-
Leaving Condenser	106.0	92.8	81.6	70.2	60.7	51.5	40.5	31.5
Entering Evaporator	68.4	68.1	68.9	68.5	67.6	67.4	68.4	68.5
Leaving Evaporator	50.1	49.1	48.8	47.5	46.6	46.8	46.4	45.8
Refrigerant Temperatures (°F)								
Discharge Line	155.0	141.5	135.5	133.0	133.0	130.5	125.3	123.0
Condenser Out	109.5	97.5	91.0	87.0	85.5	83.5	79.0	78.0
Subcooler Out	100.0	87.0	78.0	72.5	70.5	67.5	63.5	61.5
TEV In	97.0	85.0	77.0	72.0	70.5	67.5	64.0	62.5
Suction at TEV Bulb	35-48	34-48	33-48	32-46	32-45	32-44	32-46	31-46
Suction at Compressor	45-57	44-55	34-55	34-51	34-51	34-50	33-50	32-48
Suction Pressure Regulating Valve Out	116.0	108.0	106.0	106.0	104.5	102.0	97.5	95.5
Quench Out	38.0	36.5	35-38	35-41	34.5	33-44	34-42	32-36
Equalization Solenoid Out	121.5	112.5	111.0	111.5	105.0	102.0	95.5	93.0
Precooler In	177.0	161.5	154.0	149.5	150.0	145.0	138.5	136.5
Precooler Out	142.0	127.0	120.5	116.5	117.0	114.0	108.5	107.0
Subcooling at TEV Inlet	15.7	16.0	17.2	18.5	19.5	19.5	18.5	18.0
Superheat at Bulb	7.5	12.5	12.5	12.5	12.5	8.5	12.0	12.0
Compressor Skin Temperature (°F)	145.5	131.5	126.0	123.5	123.0	120.0	113.0	111.0
Discharge Pressure (psig)	235	193	181	169	168	160	149	145
Suction Pressure (psig)	66	62	62	59	58	60	59	59
Electrical Characteristics								
Voltage, Average	230	230	230	230	230	230	230	230
Amperage, Average	9.9	9.5	9.3	9.2	9.2	9.2	9.1	9.1
Wattage, Total	2,080	1,970	1,955	1,910	1,920	1,905	1,900	1,890

Note: Hyphen signifies that these data were not taken.

Table XIV. Results of Low-Temperature Cooling Operation, COOL Mode, Model MC11HAL6-208

Measurement	Chamber Temperature (°F)							
	90	75	60	45	30	15	0	-5
Air Temperatures (°F), Dry Bulb								
Entering Condenser	89.9	75.4	60.4	45.7	30.2	15.2	0.9	-
Leaving Condenser	106.4	90.4	73.5	60.2	48.7	41.0	-	-
Entering Evaporator	69.1	69.7	69.7	69.0	69.7	69.0	69.1	68.8
Leaving Evaporator	51.0	51.2	50.4	49.9	50.1	49.5	50.0	49.5
Refrigerant Temperatures (°F)								
Discharge Line	153.5	139.5	136.5	135.5	135.0	133.5	130.0	129.5
Condenser Out	111.0	100.0	96.0	93.5	94.0	91.0	90.5	92.5
Subcooler Out	101.5	90.0	83.0	81.0	79.0	78.0	77.0	79.0
TEV In	98.0	87.0	80.5	78.0	76.5	75.5	74.0	75.5
Suction at TEV Bulb	45.5	40.5	40.5	44.0	44.0	44.0	45.5	46.0
Suction at Compressor	53.5	53.5	51.0	47.5	48.0	47.0	50.0	51.0
Suction Pressure Regulating Valve Out	116.0	107.0	107.0	107.5	106.5	102.0	100.5	100.5
Quench Out	50.0	45.0	42.5	42.5	43.5	43.5	44.5	-
Equalization Solenoid Out	121.0	112.0	113.5	115.5	111.0	103.5	100.5	100.0
Precooler In	176.0	158.0	152.5	150.5	152.0	146.0	145.0	145.5
Precooler Out	140.5	125.5	122.0	121.0	121.5	118.0	115.5	117.5
Subcooling at TEV Inlet	14.0	16.0	17.0	17.5	19.0	19.8	18.0	16.5
Superheat at Bulb	12.0	15.5	16.0	15.0	17.0	16.5	17.0	17.0
Compressor Skin Temperature (°F)	142.0	129.5	127.5	127.0	124.0	121.5	118.0	118.0
Discharge Pressure (psig)	233	205	189	184	184	183	173	173
Suction Pressure (psig)	67	65	64	64	64	64	63	63
Electrical Characteristics								
Voltage, Average	208	208	208	208	208	208	208	208
Amperage, Average	9.4	9.2	9.1	9.2	9.1	9.2	9.2	9.2
Wattage, Total	2,130	2,035	2,025	2,050	2,055	2,025	2,060	2,065

Note: Hyphens signify that these data were not taken.

Table XV. Results of Low-Temperature Cooling Operation, COOL Mode, Model MC11HAL4-208

Measurement	Chamber Temperature (°F)										
	120	90	75	60	45	30	15	0	0	90	120
Air Temperatures (°F)											
Entering Condenser, Dry Bulb	123.5	91.0	81.5	64.5	45.4	31.0	16.5	0	1.5	92.0	120.0
Leaving Condenser, Dry Bulb	146.0	118.5	113.0	93.0	71.0	56.0	40.0	25.5	28.5	122.0	140.5
Entering Evaporator, Dry Bulb	90.5	69.0	71.0	71.0	70.0	71.0	71.0	70.0	70.5	91.0	89.5
Entering Evaporator, Wet Bulb	68.0	52.5	52.0	50.0	49.5	49.0	49.0	48.0	-	54.0	67.0
Leaving Evaporator, Dry Bulb	72.5	55.0	57.0	56.9	55.5	55.0	55.0	55.0	55.0	59.0	71.0
Refrigerant Temperatures (°F)											
Discharge Line	205.0	200.5	169.0	150.0	144.0	143.0	146.5	147.0	153.5	186.0	201.0
Condenser Out	150.0	126.0	116.5	100.5	94.0	91.5	92.5	91.0	96.0	127.5	147.0
Subcooler Out	144.5	109.5	103.5	[illegible]	78.0	73.0	73.5	71.0	75.5	115.0	140.0
TEV In	142.5	108.5	101.0	85.5	77.0	73.5	74.0	72.0	76.0	112.0	138.0
Suction at TEV Bulb	75.0	65/40	61.5	60.0	59.0	58.5	60.0	60.0	62.0	63.0	72.0
Suction at Compressor	83.0	93/46	77.5	76/46	75/42	74/50	76/48	76/54	78/43	82/49	80.0
Suction Pressure Regulating Valve Out	157.0	149.5	135.0	123.0	120.0	120.0	123.0	119.5	129.5	148.0	153.0
Quench Out	88.0	149.0	67/42	63/41	62/40	61/40	62/40	62/39	63/40	68/45	80.0
Equalization Solenoid Out	163.0	128/46	140.0	126.5	125.0	126.0	130.0	131.0	135.5	154.0	160.0
Precooler In	230.0	134.5	194.5	174.0	166.5	164.5	167.0	166.0	172.0	211.5	227.0
Precooler Out	197.5	218.0	159.0	138.0	131.0	130.0	132.5	132.0	139.0	176.0	194.0
Subcooling at Subcooler	5.5	16.5	13.0	14.0	16.0	18.5	19.0	20.0	20.5	12.5	7.0
Superheat at Bulb	22.6	22/-3	19.1	20.4	20.7	20.2	-	-	-	20.0	23.0
Superheat at Compressor	30.6	50/4	35.1	36/6	37/4	36/12	-	-	-	39/6	29.0
Compressor Skin Temperature (°F)	195.0	185.0	161.0	142.0	137.0	136.0	138.5	138.0	144.0	177.5	192.0
Discharge Pressure (psig)	384	307	258	204	182	179	181	176	189	292	393
Suction Pressure (psig)	88.0	73.5	72.0	68.0	66.0	66.0	74/63	74/63	74/64	73.0	66/83
Electrical Characteristics											
Voltage, Average	208.0	209.7	210.7	210.0	210.0	210.0	209.0	208.0	208.0	208.0	208.0
Amperage, Average	17.0	14.7	14.5	14.0	13.9	13.8	13.8	13.8	13.8	14.6	17.0
Wattage, Total	3,170	2,630	2,430	2,220	2,137	2,120	2,120	2,170	2,140	2,560	3,150
Power Factor (%)	51.5	48.5	45.9	43.6	41.9	42.3	42.5	43.7	43.1	48.7	51.5

Note: Hyphens signify that these data were not taken.

Table XVI. Results of Low-Temperature Cooling Operation, Bypass Mode, Model MC11HA L6-115

Measurement	Chamber Temperature (^{o}F)										
	120	90	75	60	45	30	15	0	0	90	120
Air Temperatures (^{o}F)											
Entering Condenser, Dry Bulb	119.0	89.0	75.0	60.0	43.5	29.0	13.5	0	1.0	88.0	121.5
Leaving Condenser, Dry Bulb	125.0	98.5	81.0	70.0	53.5	38.0	23.0	7.0	12.0	98.5	128.0
Entering Evaporator, Dry Bulb	87.0	68.5	70.0	78.0	72.0	71.0	73.5	68.0	70.0	70.0	79.0
Entering Evaporator, Wet Bulb	65.0	50.0	50.0	52.0	48.0	47.5	-	-	-	52.0	59.0
Leaving Evaporator, Dry Bulb	90.5	72.0	73.5	80.0	74.5	72.5	74.5	69.0	70.0	74.0	83.0
Refrigerant Temperatures (^{o}F)											
Discharge Line	-	153.0	150.0	159.0	143.0	132.0	118.0	116.0	111.5	166.0	194.0
Condenser Out	122.0	93.5	87.0	84.5	64.0	46.0	30.0	16.0	15.0	94.0	125.5
Subcooler Out	123.0	94.0	85.5	82.5	66.0	51.0	31.5	22.5	20.5	93.5	126.0
TE	103.0	81.0	79.0	82.0	73.0	67.5	62.5	56.5	55.5	82.0	99.0
Suction at TEV Bulb	90.5	72.0	74.0	80.5	74.5	72.5	74.0	69.0	68.5	75.0	83.5
Suction at Compressor	75.0	71.0	65/30	66/28	52/17	54/5	40/-9	31/-20	20.5	69/31	77.5
Suction Pressure Regulating Valve Out	140.0	142.5	126.5	135.5	124.0	108.5	99.0	91.0	89.0	138.0	152.0
Quench Out	36.0	29.0	27.5	26.0	14.0	1.0	-7/-14	18/-22	14/-24	29.5	37.0
Equalization Solenoid Out	142.5	142.0	128.0	133.5	120.0	108.0	90.5	80.5	78.5	139.0	152.0
Precooler In	212.0	195.0	176.5	180.0	165.0	148.5	133.0	120.0	120.5	187.5	224.5
Precooler Out	169.5	149.0	139.0	140.5	119.0	100.0	78.0	60.5	59.0	145.6	177.5
Subcooling at Subcooler	-	-	-	-	-	-	-	-	-	-	-
Superheat at Bulb	55.4	43.5	48.0	55.6	-	-	-	-	-	45.7	47.8
Superheat at Compressor	40.4	42.5	39/4	41.1/3.1	-	-	-	-	-	39.7/1.7	41.8
Compressor Skin Temperature (^{o}F)	166.5	154.0	133.0	137.5	120.5	108.0	88.5	83.0	80.0	151.0	177.0
Discharge Pressure (psig)	271.0	187.5	164.5	159.0	117.5	89.0	66/54	46/40	39.0	188.5	282.0
Suction Pressure (psig)	61.0	53.0	50.0	48.5	36.0	27/23	19/11	4.0	12/4	54.0	62.5
Electrical Characteristics											
Voltage, Average	116	116	115	115	115	115	115	115	116	115	116
Amperage, Average	19.9	16.0	15.3	15.2	13.9	13.0	12.3	12.0	12.1	15.9	19.6
Wattage, Total	2,210	1,730	1,620	1,620	1,450	1,310	1,265	1,185	1,185	1,710	2,130
Power Factor (%)	95.8	93.[illegible]	92.1	92.6	90.7	87.6	89.5	85.9	84.9	93.5	93.7

Note Hyphens signify that these data were not taken.

Table XVII. Results of Low-Temperature Cooling Operation, Bypass Mode, Model MC11HAL4-208

Measurement	Chamber Temperature										
	120	90	75	60	45	30	15	0	0	90	120
Air Temperatures (°F)											
Entering Condenser, Dry Bulb	122.5	92.0	78.5	61.5	46.0	32.0	14.0	0	1.0	90.0	120.0
Leaving Condenser, Dry Bulb	130.0	103.0	88.0	74.5	63.5	50.5	33.0	15.5	18.5	100.0	127.0
Entering Evaporator, Dry Bulb	79.0	67.5	81.0	71.5	71.0	71.0	70.0	70.0	70.5	69.0	78.0
Entering Evaporator, Wet Bulb	62.0	52.0	57.5	51.0	50.0	50.0	38.0	48.5	-	53.5	63.0
Leaving Evaporator, Dry Bulb	84.0	73.0	85.0	75.5	75.0	75.0	71.5	72.0	72.0	73.5	82.0
Refrigerant Temperatures (°F)											
Discharge Line	185.0	165.0	102.5	163.0	153.0	141.0	123.0	110.5	114.5	164.5	184.0
Condenser Out	126.5	97.0	86.0	85.0	75.0	61.0	41.0	22.0	29.5	95.0	124.0
Subcooler Out	127.0	98.5	88.5	90.0	83.5	67.5	47.0	29.0	39.5	97.0	125.0
TEV In	100.0	83.5	88.0	82.0	79.0	74.5	66.0	61.5	63.5	82.5	97.5
Suction at TEV Bulb	85.0	74.0	85.0	75.5	75.5	75.5	71.0	71.5	71.5	74.0	83.0
Suction at Compressor	90/80	80/46	77/60	78/70	75/58	64.42	49/12	40/0	41/-8	80/48	87/78
Suction Pressure Regulating Valve Out	148.0	141.0	142.0	141.5	134.0	124.0	108.0	94.5	98.5	141.0	148.0
Quench Out	36.0	26.0	23.0	24.0	20.5	11/6	-9/-14	1/-20	-16.5	27/25	35.0
Equalization Solenoid Out	150.0	141.0	144.0	137.5	128.5	116.0	98.0	82.5	87.0	141.0	149.0
Precooler In	221.0	196.0	191.0	191.5	181.0	167.0	149.0	131.0	135.5	195.5	220.0
Precooler Out	178.5	150.5	146.0	150.5	140.5	120.5	95.0	72.5	78.5	150.0	177.0
Subcooling at Subcooler	-	-	-	-	-	-	-	-	-	-	-
Superheat at Bulb	-	-	-	-	-	-	-	-	-	-	-
Superheat at Compressor	56/46	56/22	56/39	56/48	56/39	?	?	?	?	56/24	54/45
Compressor Skin Temperature (°F)	174.0	155.0	152.5	150.5	141.0	128.0	110.0	96.0	101.0	154.0	173.0
Discharge Pressure (psig)	283.0	192.0	170.0	168.5	149.5	112.0	74.0	58/43	60/53	189.0	276.5
Suction Pressure (psig)	60.0	48.0	44.5	45.0	41.5	28/32	11.5	13/6	15/7	48.0	59.0
Electrical Characteristics											
Voltage, Average	208	210	209	211	210	210	208	208	208	208	208
Amperage, Average	15.9	13.9	13.7	13.5	13.6	13.4	13.0	13.1	13.0	13.8	15.9
Wattage, Total	2,710	2,160	2,020	2,060	1,970	1,822	1,614	1,565	1,575	2,115	2,722
Power Factor (%)	47.4	43.2	40.8	41.8	39.8	38.6	34.5	33.2	33.7	42.5	47.5

Note: Hyphens signify that these data were not taken.

Table XVIII. Results of Heating Capacity Tests

Measurement	Model			
	MC11HAL6-115	MC11HAL6-230	MC11HAL6-208	MC11HAL4-208
Capacity (Btu/hr)	7,150	7,500	8,450	8,550
Air Temperatures (°F), Dry Bulb				
Entering Evaporator	86	85	85	80
Leaving Evaporator	103	103	104	98
Electrical Characteristics				
Voltage	115	230	208	207
Amperage	18.60	9.72	7.34	8.08
Total Power (kw)	2.090	2.200	2.480	2.502
Power Factor (%)	97.7	99.3	91.4	86.3
Fan Speed (rpm)	3,520	3,550	3,550	3,890

Note: External static pressure (in. of water) has 0 for all air-conditioning models.

e. Low-Temperature Heating Operation. The low-temperature heating operation test was performed to determine heater operation at low temperatures, and the effects of low temperatures on the evaporator fan motor.

Each unit was placed in the climatic test chamber. The chamber temperature was then lowered to -50° F. After a minimum 2-hour cool soak period, power was applied to the unit. The unit was switched to the VENT mode for approximately 5 minutes, and data were recorded. The unit was switched to the HI-HEAT mode and operated for 1 hour during which time data were recorded at 10-minute intervals. The switch was returned to the VENT mode for final data recording.

The units met the test requirements, and results are shown in Tables XIX through XXII.

Table XIX. Results of Low-Temperature Heating Operation, Model MC11HAL6-115

Measurement	Interval			
	Preperformance	After 3 min Low Temperature	Finish Low Temperature	Postperformance
a. VENT				
Air Temperatures (^{o}F), Dry Bulb				
Entering	80	-54	-	81
Leaving	82	-52	-	83
Electrical Characteristics				
Voltage	115	115	115	116
Amperage	2.72	3.50	3.20	2.80
Wattage	294.0	375.0	335.0	302.0
Power Factor (%)	93.9	93.3	91.0	92.9
b. HI-HEAT				
	Preperformance	Start Low Temperature	Average Low Temperature	Postperformance
Air Temperatures (^{o}F), Dry Bulb				
Entering	80	-55	-52	84
Leaving	97	-42	-38	101
Electrical Characteristics				
Voltage	114	115	115	115
Amperage	18.45	19.50	19.20	18.75
Wattage	2,080	2,240	2,192	2,140
Power Factor (%)	98.9	99.9	99.3	99.2

Note: Hyphens signify that these data were not taken.

Table XX. Results of Low-Temperature Heating Operation, Model MC11HAL6-230

Measurement	Interval			
	Preperformance	Start Low Temperature	Finish Low Temperature	Postperformance
a. VENT				
Air Temperatures (^{o}F), Dry Bulb				
Entering	78	-51	-	79
Leaving	80	-48	-	80
Electrical Characteristics				
Voltage	230	230	230	232
Amperage	1.75	1.94	2.10	1.86
Wattage	310.0	404.0	306*	350
Power Factor (%)	77.1	90.60	63.5	81.2

b. HI-HEAT

Measurement	Preperformance	Start Low Temperature	Average Low Temperature	Postperformance
Air Temperatures (^{o}F), Dry Bulb				
Entering	79	-51	-50	81
Leaving	96	-39	-36	98
Electrical Characteristics				
Voltage	229	230	230	230
Amperage	9.65	10.20	10.02	9.82
Wattage	2,210	2,335	2,303	2,245
Power Factor (%)	100.0	99.5	99.9	99.4

Note: Hyphens signify that these data were not taken.

* Instrument reading questionable.

Table XXI. Results of Low-Temperature Heating Operation, Model MC11HAL6-208

Measurement	Interval			
	Preperformance	Start Low Temperature	Finish Low Temperature	Postperformance
a. VENT				
Air Temperatures (°F), Dry Bulb				
Entering	79	-49	-	80
Leaving	85	-48	-	83
Electrical Characteristics				
Voltage	209.0	208.7	208.7	209.0
Amperage	2.71	2.81	2.74	2.59
Wattage	392	538	460	378
Power Factor (%)	40.0	53.0	46.5	40.3
b. HI-HEAT				
	Preperformance	Start Low Temperature	Average Low Temperature	Postperformance
Air Temperatures (°F), Dry Bulb				
Entering	83	-49	-49	79
Leaving	104	-36	-33	97
Electrical Characteristics				
Voltage	208.0	208.3	208.3	208.0
Amperage	7.21	7.56	7.32	7.15
Wattage	2,440	2,590	2,504	2,455
Power Factor (%)	93.9	95.0	95.0	95.3

Note: Hyphens signify that these data were not taken.

Table XXII. Results of Low-Temperature Heating Operation, Model MC11HA1A-208

Measurement	Interval			
	Preperformance	Start Low Temperature	Finish Low Temperature	Postperformance
a. VENT				
Air Temperatures (°F), Dry Bulb				
Entering	87	-50	-	79
Leaving	88.0	-49.0	-	83.0
Electrical Characteristics				
Voltage	209.0	208.3	208.3	210.3
Amperage	4.27	4.36	4.27	4.17
Wattage	538	596	592	516
Power Factor (%)	34.8	37.9	38.2	34.1

b. HI-HEAT

Measurement	Preperformance	Start Low Temperature	Average Low Temperature	Postperformance
Air Temperatures (°F), Dry Bulb				
Entering	85	-50	-49	78
Leaving	105	-49	-35	95
Electrical Characteristics				
Voltage	209.7	209.0	208.3	211.3
Amperage	8.32	8.36	8.22	8.10
Wattage	2,620	2,645	2,615	2,580
Power Factor (%)	87.0	87.4	88.2	87.3

Note: Hyphens signify that these data were not taken.

f. Evaporator Airflow. The evaporator airflow test was conducted to determine the standard airflow (scfm) rate of the evaporator fan when operating at external static pressures ranging from 0 to 1.0 inch of water.

Airflow tests were conducted and flow rates were calculated in accordance with ASHRAE Standard 37-60, Method of Testing for Rating Unitary Air Conditioning Equipment (4), modified to incorporate military test requirements.

The airflow measuring apparatus (code tester) consisted of a mixing section, a sampling tree section, a nozzle section, a fan discharge section, and an adjustable damper section fitted into an insulated duct. The mixing section consisted of a series of vanes arranged to divide the airflow into a number of small streams and then divert the streams across each other. The condition of the air was determined by wet-bulb and dry-bulb temperature readings as recorded through the sampling tree section. Static-pressure taps were located before and after the nozzles for determinations of pressure drop across the nozzles. The damper section consisted of an adjustable iris which could be closed to increase static pressure. The test was conducted with a dry evaporator coil and return air entering the evaporator at zero static pressure or atmospheric conditions. The test was started with an external static pressure of 0 inch of water at the evaporator discharge and then varied from 0 to 1.0 inch of water. The test results are shown in Tables XXIII through XXVI.

g. Condenser Airflow. The condenser airflow test was conducted to determine the airflow (cfm) rate of the condenser fan during operation at external static pressures that ranged from 0 to 0.5 inch of water.

Airflow tests were conducted and flow rates were calculated in accordance with ASHRAE Standard 37-60 modified to incorporate military test requirements.

The airflow measuring apparatus (code tester) consisted of a mixing section, a sampling tree section, a nozzle section, a fan discharge section, and an adjustable damper section fitted into an insulated duct. The mixing section consisted of a series of vanes arranged to divide the airflow into a number of small streams and then divert the streams across each other. The condition of the air was determined by wet-bulb and dry-bulb temperature readings as recorded through the sampling tree section. Static-pressure taps were located before and after the nozzles for determinations of pressure drop across the nozzles. The adjustable damper

Table XXIII. Results of Evaporator Airflow Test, Model MC11HAL6-115

Measurement	External Static Pressure (in. of water)				
	0	0.25	0.5	0.75	1.0
Nozzle Pressure Drop (in. of water)	1.3	1.11	0.93	-	-
Airflow (scfm)	398	368	336	-	-
Filter Face Velocity (fpm)	371	340	319	-	-
Air Temperatures (°F)					
Entering Nozzles, Dry Bulb	84	82.8	81.6	-	-
Entering Nozzles, Wet Bulb	54	54	53	-	-
Electrical Characteristics					
Voltage	115	115	115	-	-
Amperage	2.9	2.8	2.8	-	-
Power (kw)	0.400	0.375	0.375	-	-
Fan Speed (rpm)	-	-	-	-	-

Note: Hyphens signify that these data were not taken.

Table XXIV. Results of Evaporator Airflow Test, Model MC11HAL6-230

Measurement	External Static Pressure (in. of water)				
	0	0.25	0.5	0.75	1.0
Nozzle Pressure Drop (in. of water)	0.32	1.04	0.82	0.60	0.34
Airflow (scfm)	380	363	319	263	198
Filter Face Velocity (fpm)	355	340	299	0.75	1.0
Air Temperatures (°F)					
Entering Nozzles, Dry Bulb	85.0	85.2	85.7	84.7	87.1
Entering Nozzles, Wet Bulb	66.6	66.7	66.8	66.5	68.1
Electrical Characteristics					
Voltage	230	230	230	230	230
Amperage	1.96	1.95	1.94	1.93	1.92
Power (kw)	0.356	0.348	0.348	0.332	0.312
Fan Speed (rpm)	3,560	3,560	3,560	3,565	3,565

Note: Hyphens signify that these data were not taken.

Table XXV. Results of Evaporator Airflow Test, Model MC11HAL6-208

Measurement	External Static Pressure (in. of water)				
	0	0.25	0.5	0.75	1.0
Nozzle Pressure Drop (in. of water)	0.34	0.24	0.39	0.56	0.30
Airflow (scfm)	398	335	296	262	191
Filter Face Velocity (fpm)	371	310	274	242	177
Air Temperatures (°F)					
Entering Nozzles, Dry Bulb	81.5	81.7	82.0	79.8	77.0
Entering Nozzles, Wet Bulb	60.7	60.4	60.7	59.3	58.7
Electrical Characteristics					
Voltage	209	208	208	209	209
Amperage	2.82	2.76	2.78	2.85	2.88
Power (kw)	0.531	0.488	0.484	0.492	0.496
Fan Speed (rpm)	3,560	3,560	3,575	3,580	3,580

Note: Hyphens signify that these data were not taken.

Table XXVI. Results of Evaporator Airflow Test, Model MC11HAL4-208

Measurement	External Static Pressure (in. of water)				
	0	0.25	0.5	0.75	1.0
Nozzle Pressure Drop (in. of water)	0.23	0.67	0.60	2.9	0.94
Airflow (scfm)	329	286	271	167	128
Filter Face Velocity (fpm)	300	280	265	163	125
Air Temperatures (°F)					
Entering Nozzles, Dry Bulb	77.8	78.4	78.1	78.7	79.8
Entering Nozzles, Wet Bulb	63.0	63.6	63.4	64.9	65.2
Electrical Characteristics					
Voltage	207	207	207	208	208
Amperage	4.2	4.2	4.2	4.2	4.2
Power (kw)	0.4[illegible]	0.485	0.487	0.509	0.501
Fan Speed (rpm)	4,020	4,025	4,015	4,010	4,020

Notes: Hyphens signify that these data were not taken.

Later inspection of the unit after cooling capacity tests revealed that the cabinet wall thermal insulation had pulled away from the cabinet wall and had obstructed the evaporator airflow. Design changes have eliminated this problem (Table V). The airflow test data in Tables XXIII through XXVI reflect the effects of this problem on the original EDT units.

section consisted of an iris which could be closed to increase static pressure. The test was conducted with a dry condenser coil and cooling air entering the condenser section at zero static pressure or atmospheric conditions. The test was started with an external static pressure of 0 inch of water at the condenser discharge and then varied from 0 to 0.5 inch of water. The test unit was operated in the COOL mode during the test. Both total electrical power input and condenser fan power input were recorded. The test results are presented in Tables XXVII and XXVII.

Table XXVII. Results of Condenser Airflow Test, Model MC11HAL6-230

Measurement	External Static Pressure (in. of water)				
	0.0	0.125	0.25	0.375	0.5
Airflow (scfm)	706.5	675.5	643.0	610.0	577.5
Air Temperatures (^{o}F), Dry Bulb					
Entering Condenser	119.2	119.0	119.3	119.4	119.3
Entering Nozzles	137.8	138.2	138.7	140.0	140.2
Condenser Ambient	119.2	119.0	119.3	119.4	119.3
Electrical Characteristics					
Condenser Fan Motor Voltage	230				
Condenser Fan Motor Amperage	1.75				
Condenser Fan Motor Power (kw)	0.358				
Discharge Pressure (psig)	371	375	380	385	392
Suction Pressure (psig)	76.0	76.5	77.0	80.0	82.5
Fan Speed (rpm)	3,540	3,545	3,545	3,545	3,545

Note: Blank spaces signify not applicable.

Table XXVIII. Results of Condenser Airflow Test, Model MC11HAL6-208

Measurement	External Static Pressure (in. of water)				
	0.0	0.125	0.25	0.375	0.5
Airflow (scfm)	700.5	667.0	635.5	596.5	553.5
Air Temperatures (°F), Dry Bulb					
Entering Condenser	118.3	119.0	118.8	119.5	121.0
Entering Nozzles	137.9	139.0	141.0	143.0	147.0
Condenser Ambient	118.3	119.0	118.8	119.5	121.0
Electrical Characteristics					
Condenser Fan Motor Voltage	208				
Condenser Fan Motor Amperage	2.32				
Condenser Fan Motor Power (kw)	0.418				
Discharge Pressure (psig)	374	379	383	392	402
Suction Pressure (psig)	79	80	80	81	82
Fan Speed (rpm)	3,560	3,565	3,565	3,565	3,565

Note: Blank spaces signify not applicable.

h. Ventilation. The ventilation test was conducted to determine the quantity of fresh air in standard cubic feet per minute supplied through the fresh-air inlet.

The entire evaporator face of each test unit was connected to the receiving end of a portable code tester via a short length of duct. Readings of velocity pressures across the nozzles and wet- and dry-bulb temperatures of the air were recorded at different combinations of box-static pressures and return-air damper positions. Ventilating rates were computed from these data, and the results are shown in Tables XXIX through XXXII.

Table XXIX. Results of Ventilation Airflow Test, Model MC11HAL6-115

Measurement	Fresh-Air Damper Full Open Return-Air-Grille Position	
	Open	Closed
Airflow (scfm)	27.3	43.8
Chamber Pressure (in. of water)	0	0
Nozzle Pressure Drop (in. of water)	0.26	0.67
Air Temperatures (°F)		
Entering Nozzles, Dry Bulb	75.0	74.5
Entering Nozzles, Wet Bulb	55.0	55.0

Table XXX. Results of Ventilation Airflow Test, Model MC11HAL6-230

Measurement	Fresh-Air Damper Full Open Return-Air-Grille Position	
	Open	Closed
Airflow (scfm)	21.5	56.5
Chamber Pressure (in. of water)	0	0
Nozzle Pressure Drop (in. of water)	1.06	0.17
Air Temperatures (°F)		
Entering Nozzles, Dry Bulb	73.9	73.9
Entering Nozzles, Wet Bulb	61.6	61.6

Table XXXI. Results of Ventilation Airflow Test, Model MC11HAL6-208

Measurement	Fresh-Air Damper Full Open Return-Air-Grille Position	
	Open	Closed
Airflow (scfm)	26.5	61.5
Chamber Pressure (in. of water)	0	0
Nozzle Pressure Drop (in. of water)	1.61	0.22
Air Temperatures (°F)		
Entering Nozzles, Dry Bulb	73.3	73.3
Entering Nozzles, Wet Bulb	61.5	61.5

Table XXXII. Results of Ventilation Airflow Test, Model MC11HA L4-208

Measurement	Fresh-Air Damper Full Open Return-Air-Grille Position	
	Open	Closed
Airflow (scfm)	19.5	38.5
Chamber Pressure (in. of water)	0	0
Nozzle Pressure Drop (in. of water)	0.88	0.09
Air Temperatures (°F)		
Entering Nozzles, Dry Bulb	80.6	80.6
Entering Nozzles, Wet Bulb	67.3	67.3

i. Air Recirculation. The air recirculation test was conducted to determine the effect of air recirculated or short cycled between the evaporator air discharge and the evaporator air return and between the condenser air discharge and the condenser air intake.

This test was conducted in the balanced-room calorimeter with the outside room temperature at 120° F and the inside room temperature at 90° F dry conditions. After stable thermal equilibrium was reached in the cells with the air conditioner in the maximum COOL mode, temperature and pressure readings were recorded. A baffle plate was then placed between the condenser air-intake and air-discharge openings. Three sets of readings were taken at 10-minute intervals. This baffle plate was removed, and the unit was allowed to operate for 30 minutes before temperatures and pressures at this condition were recorded. A baffle plate was then placed between the air-return and air-discharge openings on the evaporator side in order to discourage short cycling. Three sets of readings were taken at 10-minute intervals. The test results are shown in Tables XXXIII through XXXVI.

j. Operating Controls and Operational Results. The operating controls tests were conducted to verify thermostat and selector switch operation in each position or mode.

(1) Thermostat. The thermostat test was conducted to determine if the thermostat functioned properly and in accordance with design specifications. This test was conducted by the Instrumentation Division, USAERDL. The thermostat was tested by submerging

Table XXXIII. Results of Air Recirculation Test, Model MC11HAL6-115

Measurement	No Baffle	Evaporator Side Baffled	Condenser Side Baffled
Air Temperatures (°F)			
Inside Room, Dry Bulb	91	90	90
Inside Room, Wet Bulb	57	57	59
Outside Room, Dry Bulb	119.0	119.0	117.5
Refrigerant Temperatures (°F)			
Compressor Discharge	195.0	194.0	190.5
Liquid Line Entering TEV	141.0	141.0	139.0
Suction Line at TEV Bulb	61.0	60.0	60.0
Discharge Pressure (psig)	376	376	367
Suction Pressure (psig)	84	84	84
Electrical Characteristics			
Voltage	115.5	115.5	115.3
Amperage	26.17	26.15	25.60
Power (kw)	2.852	2.848	2.792

Table XXXIV. Results of Air Recirculation Test, Model MC11HAL6-230

Measurement	No Baffle	Evaporator Side Baffled	Condenser Side Baffled
Air Temperatures (°F)			
Inside Room, Dry Bulb	89.3	89.5	88.5
Inside Room, Wet Bulb	67.8	66.9	66.0
Outside Room, Dry Bulb	120.8	120.4	120.4
Refrigerant Temperatures (°F)			
Compressor Discharge	201.0	200.9	200.2
Liquid Line Entering TEV	141.8	141.9	141.5
Suction Line at TEV Bulb	51.5-59.5	52.6-60.6	52.0-59.0
Discharge Pressure (psig)	387.7	387.7	385.0
Suction Pressure (psig)	85.5	85.7	84.8
Electrical Characteristics			
Voltage	230	230	230
Amperage	12.1	12.1	12.1
Power (kw)	2.655	2.640	2.640

Table XXXV. Results of Air Recirculation Test,
Model MC11HAL6-208

Measurement	No Baffle	Evaporator Side Baffled	Condenser Side Baffled
Air Temperatures (^oF)			
Inside Room, Dry Bulb	89.9	89.9	90.4
Inside Room, Wet Bulb	64.8	65.4	66.0
Outside Room, Dry Bulb	119.9	120.1	120.2
Refrigerant Temperatures (^oF)			
Compressor Discharge	201.0	201.7	201.2
Liquid Line Entering TEV	141.0	141.0	141.2
Suction Line at TEV Bulb	54.2	53.8	54.2
Discharge Pressure (psig)	376.0	376.3	374.7
Suction Pressure (psig)	85.0	85.5	85.2
Electrical Characteristics			
Voltage	208	208	208
Amperage	10.57	10.57	10.63
Power (kw)	2.715	2.705	2.720

Table XXXVI. Results of Air Recirculation Test,
Model MC11HAL4-208

Measurement	No Baffle	Evaporator Side Baffled	Condenser Side Baffled
Air Temperatures (^oF)			
Inside Room, Dry Bulb	90.4	90.2	90.2
Inside Room, Wet Bulb	67.2	67.1	67.0
Outside Room, Dry Bulb	120.4	120.3	119.7
Refrigerant Temperatures (^oF)			
Compressor Discharge	201.0	200.8	200.2
Liquid Line Entering TEV	140.2	139.5	139.0
Suction Line at TEV Bulb	57.7	57.5	57.3
Discharge Pressure (psig)	377.0	377.2	375.4
Suction Pressure (psig)	78.2	78.6	77.0
Electrical Characteristics			
Voltage	208	208	208
Amperage	2.935	2.940	2.935
Power (kw)			

the bulb of the power element assembly into a water bath. The temperature of the water was raised by a submerged electrical heater with variable control. The temperature was lowered with dry ice. Throughout the bath, even temperatures were maintained with a circulating pump. A low direct-current voltage was applied to the electrical terminals of the thermostat in conjunction with a buzzer to determine the making and breaking of the contacts. The technique of the water bath was measured by a calibrated, laboratory-type thermometer. The ambient temperature surrounding the test assembly was controlled as shown in Table XXXVII. The ambient temperature was measured by a calibrated laboratory-type thermometer. Three new thermostats identified as 1, 2, and 3 were employed for Tests A, B, and C. Three old thermostats identified as 302, 303, and 304 were used for Test D.

All phases of the tests were repeated four times, and the data obtained were averaged for report purposes. All tests were conducted at an ambient temperature of 72° F unless indicated otherwise.

Table XXXVII. Results of Thermostat Test

TEST A

Operating Range at +72° F Ambient Temperature

Setting	New Thermostats No. 1	New Thermostats No. 2	New Thermostats No. 3	Average
LO	40.48	36.95	39.9	39.11
HI	89.96	91.46	89.9	90.44

TEST B

Operating Differential at +72° F Ambient Temperature

Thermostat	Setting in °F						Average
	40	50	60	70	80	90	
1	1.80	3.3	2.3	2.0	1.9	2.4	2.3
2	2.38	2.5	2.5	2.9	1.9	2.2	2.4
3	2.87	1.97	2.25	2.32	2.2	3.2	2.5

Table XXXVII (cont'd)

TEST C

Effect of Ambient Temperature on Operating Range

Setting	72° F Ambient	150° F Ambient	150° F Ambient + 160° F Preheat
LO	39.9	38.85	40.6
HI	89.90	86.18	87.75

Effect of Ambient Temperature on Differential

Ambient Temperature	Setting (°F) 40	50	60	70	80	90	Average Total	Average Operating ±
72	2.87	1.97	2.25	2.32	2.20	3.20	2.50	1.25
150	2.50	2.37	2.65	2.57	2.42	3.06	2.50	1.30
150 + 160° F Preheat	2.50	--	--	2.05	--	2.52	2.36	1.18

TEST D

Deterioration - Operating Range at +72° F Ambient Temperature

Setting (°F)	Old Thermostats No. 302	No. 303	No. 304	Average	New Thermostats Average
LO	33.26	49.10	47.40	43.25	39.11
HI	94.80	--	93.04	93.92	90.44

Deterioration - Operating Differential at 72° F Ambient Temperature

Thermostat	Setting (°F) 40	50	60	70	80	90	Average	Total Average
302	7.88	6.90	5.20	6.10	4.90	5.0	5.99	3.60
303	4.10	2.70	1.92	2.12	2.17	2.17	2.53	3.60
304	2.50	2.25	2.15	1.75	1.95	2.27	2.14	3.60

Note: Hyphens signify that these data were not taken.

(a) Test A - Operating Range. The operating range test was conducted in two steps:

Step 1 - Low Setting. The thermostats were set to the maximum decrease temperature position. The water bath temperature was lowered with dry ice, and temperatures were recorded as the thermostats were actuated. The water bath temperature was raised until the thermostat contacts were opened, and the temperatures were recorded.

Step 2 - High Setting. The thermostats were set to the maximum increase temperature position, and the water bath temperature was raised until the thermostats were actuated. Temperatures were recorded, and the operation was reversed and repeated as in Step 1.

(b) Test B - Operating Differential. The thermostats were tested at the following settings: 40°, 50°, 60°, 70°, 80°, and 90° F. The procedure followed was similar to that used in Test A, Step 1.

(c) Test C - Effect of Ambient Temperature on Thermostat. Tests were conducted as follows to determine the effect of ambient temperature on thermostat operating range and differential:

Step 1. The body of the thermostat was maintained at 150° F as compared to 72° F for the preceding tests, and Tests A and B were repeated.

Step 2. The entire thermostat assembly (body and sensing bulb) was subjected to an ambient temperature of 160° F for 2 hours. The sensing bulb was then immersed in the water bath, the body of the thermostat was lowered to 150° F, and Tests A and B were repeated at 40° F, 70° F, and the maximum setting.

(d) Test D - Deterioration. Thermostats 302, 303, and 304 were subjected to Tests A and B and compared with thermostats 1, 2, and 3.

From this comparison, the effects of prolonged operation and rough usage upon the operation of the thermostats can be evaluated in terms of degrees Fahrenheit variation. Thermostats 302, 303, and 304 were removed from air conditioners which had been subjected to a variety of tests including operational, airflow, capacity, refrigerant charge, fungus, shock and vibration, and endurance. Each thermostat had an average of 1,500 hours of operation prior to these tests.

(2) Selector Switch. The selector switch tests were conducted to determine if the controls and components were functioning properly and in accordance with design specifications.

These tests were conducted at ambient temperatures between 79° F and 90° F. The selector switch is a five-position rotary switch, and the control selection modes are: OFF, VENT, COOL, LO-HEAT, and HI-HEAT.

For each test model the selector switch was set in each mode several times to establish proper functioning as follows: In the OFF mode, no component shall operate at any setting of the thermostat. In the VENT mode, the evaporator fan shall operate at any setting of the thermostat. In the COOL mode, with the thermostat set below the return-air temperature, the unit shall operate in the COOL mode with condenser fans, evaporator fans, and compressor running. In the LO-HEAT mode, the evaporator fan shall operate at any thermostat setting. One bank of heaters shall function when the thermostat is set above the return-air temperature. This bank of heaters shall not function when the thermostat is set below the return-air temperature. In the HI-HEAT mode, the evaporator fan and one bank of heaters shall operate at any setting of the thermostat. The other bank of heaters shall function in the same manner as in the LO-HEAT mode.

With the selector switch in the COOL mode, the condenser fan, evaporator fan, and compressor shall operate at any setting of the thermostat. When the thermostat is set above the return-air temperature, the liquid solenoid valve shall be closed, thus forcing the unit into the bypass mode. After several minutes of operation at this condition, the thermostat is reset below the return-air temperature. The liquid solenoid valve shall open, thus returning the unit to operation in the COOL mode. Operation in the COOL mode shall continue successfully for 2 hours. The switch is then set in the OFF mode, and all components shall cease to function.

The results for each selector switch position test and performance and power characteristic data recorded for each model (Tables XXXVIII through XLII) follow.

Switch Position		Results
(a)	OFF	No operation.
(b)	VENT	Evaporator fan operated at any thermostat setting.

Table XXXVIII. Results of VENT Mode Tests

Measurement	Model			
	MC11HAL6-115	MC11HAL6-230	MC11HAL6-208	MC11HAL4-208
Air Temperatures (^{o}F), Dry Bulb				
Entering Evaporator	77	80	85	89
Leaving Evaporator	81	84	89	94
Electrical Characteristics				
Voltage, Average	115	230	209	208
Amperage, Average	2.82	2.19	2.91	4.22
Power (kw)	0.296	0.350	0.424	0.552
Power Factor (%)	91.4	69.5	40.3	36.6
Fan Speed (rpm)	3,500	3,530	3,550	3,880

Switch Position		Results
(c)	COOL, Thermostat Set High.	Condenser fan, evaporator fan, and compressor operated. Unit in bypass mode.

Table XXXIX. Results of Bypass Mode Tests

Measurement	Model			
	MC11HAL6-115	MC11HAL6-230	MC11HAL6-208	MC11HAL4-208
Air Temperatures (^oF)				
Entering Evaporator, Dry Bulb	79	89	83	88
Entering Evaporator, Wet Bulb	62	72	64	61
Leaving Evaporator, Dry Bulb	83	93	86	92
Entering Condenser, Dry Bulb	114	120	120	121
Leaving Condenser, Dry Bulb	119.5	126.0	126.0	130.0
Refrigerant Temperatures (^oF)				
Discharge Line	210	212	220	218
Condenser Out	116	125	125	128
Subcooler Out	116	125	126	126
TEV In	102	104	103	108
Suction at TEV Bulb	67	67	68	62
Suction at Compressor	72.5	71.0	80.0	72.0
Suction Pressure Regulating Valve Out	146	140	148	133
Quench Out	35	35	41	54
Equalization Solenoid	145	145	149	111
Precooler In	218	216	226	229
Precooler Out	201	198	208	206
Subcooling at Subcooler	3.2	-1.6	1.2	2.2
Superheat at Compressor	52.5	43.7	48.4	40.4
Compressor Skin Temperature (^oF)	190	194	196	202
Discharge Pressure (psig)	257	272	286	290
Suction Pressure (psig)	43.0	51.5	57.0	57.0
Electrical Characteristics				
Voltage, Average	119.0	227.0	208.0	208.2
Amperage, Average	19.20	10.45	9.65	15.70
Power (kw)	2.050	2.200	2.270	2.720
Power Factor (%)	89.70	91.60	65.30	48.15
Evaporator Fan Speed (rpm)	3,500	3,530	3,550	3,950
Condenser Fan Speed (rpm)	3,440	3,520	3,540	3,940

Switch Position		Results
(d)	COOL, Thermostat Set Low.	**Condenser fan, evaporator fan, and compressor operated. Unit in COOL mode.**

Table XL. Results of COOL Mode Tests

Measurement	Model			
	MC11HAL6-115	MC11HAL6-230	MC11HAL6-208	MC11HAL4-208
Air Temperatures (°F)				
Entering Evaporator, Dry Bulb	90	91	90	90
Entering Evaporator, Wet Bulb	65	72	67	62
Leaving Evaporator, Dry Bulb	68	68	66	69
Entering Condenser, Dry Bulb	120	122	120	120
Leaving Condenser, Dry Bulb	143	144	139	142
Refrigerant Temperatures (°F)				
Discharge Line	230	233	233	228
Condenser Out	149	150	150	146
Subcooler Out	140	144	141	137
TEV In	138	140	137	134
Suction at TEV Bulb	56	56	55	68
Suction at Compressor	72	67	61	74
Suction Pressure Regulating Valve Out	138	146	146	132
Quench Out	110	142	145	124
Equalization Solenoid	140	145	142	147
Precooler In	234	235	232	232
Precooler Out	220	222	220	218
Subcooling at Subcooler	10.2	5.2	5.0	12.9
Subcooling at TEV	11.7	9.2	7.0	15.9
Superheat at TEV Bulb	4.5	10.4	5.6	15.1
Superheat at Compressor	20.5	21.4	13.6	21.1
Compressor Skin Temperature (°F)	220	210	205	210
Discharge Pressure (psig)	380	378	377	372
Suction Pressure (psig)	86.5	77.0	88.0	89.0
Electrical Characteristics				
Voltage, Average	116.0	227.0	208.0	208.0
Amperage, Average	23.50	12.25	10.71	16.50
Power (kw)	2.610	2.628	2.790	3.085
Power Factor (%)	95.7	94.3	72.4	52.0
Evaporator Fan Speed (rpm)	3,520	3,545	3,500	3,960
Condenser Fan Speed (rpm)	3,480	3,530	3,480	3,950

Switch Position		Results
(e)	LO-HEAT, Thermostat Set below Ambient.	Evaporator fan operated; no heaters energized.
(f)	LO-HEAT, Thermostat Set above Ambient.	Evaporator fan operated; one bank (50%) of heaters energized (Table XLI).

Table XLI. Results of LO-HEAT Mode Tests

Measurement	Model			
	MC11HAL6-115	MC11HAL6-230	MC11HAL6-208	MC11HAL4-208
Air Temperatures (°F), Dry Bulb				
Entering Evaporator	79	80	85	82
Leaving Evaporator	92	91	96	93
Electrical Characteristics				
Voltage, Average	119	230	209	207
Amperage, Average	11.0	5.85	4.79	5.86
Power (kw)	1.236	1.304	1.446	1.560
Power Factor (%)	94.4	96.9	83.6	75.3
Evaporator Fan Speed (rpm)	3,500	3,530	3,550	3,890

Switch Position		Results
(g)	HI-HEAT, Thermostat Set above Ambient.	Evaporator fan operated; all heaters energized (Table XLII).
(h)	HI-HEAT, Thermostat Set below Ambient.	Evaporator fan operated; one bank 50% (other than those in (f)) of heaters energized.

Table XLII. Results of HI-HEAT Mode Tests

Measurement	Model			
	MC11HAL6-115	MC11HAL6-230	MC11HAL6-208	MC11HAL4-208
Air Temperatures (°F)				
Entering Evaporator, Dry Bulb	79	83	85	80
Leaving Evaporator, Dry Bulb	100	102	104	98
Electrical Characteristics				
Voltage, Average	119	230	208	207
Amperage, Average	19.8	9.93	7.34	8.08
Power (kw)	2.300	2.295	2.416	2.502
Power Factor (%)	97.6	100	91.4	86.3
Evaporator Fan Speed (rpm)	3,500	3,530	3,550	3,890

k. Coil Frost. The coil frost tests were conducted on three models (MC11HAL6-230, MC11HAL6-208, and MC11HAL4-208) to determine the ability of these air conditioners to operate under low load (high latent conditions) and low ambient conditions without the evaporator coil freezing over.

Each model was tested in accordance with ASHRAE Standard 37-60. Installation was flush with the indoor barrier wall, and a metal duct was attached to the evaporator air outlet opening.

Each test unit was operated for 12 hours with air entering the evaporator at 67° F dry bulb and 57° F wet bulb and air entering the condenser at 55° F dry bulb. To complete this test successfully, sufficient frost or ice shall not form or collect on the cooling coil to decrease the airflow to less than 95 percent of rated delivery.

The evaporator airflow at the outset and completion of each 12-hour test showed no reduction, and inspections indicated no frost. Initial and terminal results are shown in Tables XLIII through XLV.

Table XLIII. Results of Coil Frost Test, Model MC11HAL6-230

Measurement	Start	Finish (12 hr)
Air Temperatures (°F)		
Entering Condenser, Dry Bulb	55.3	54.8
Entering Evaporator, Dry Bulb	63.0	66.4
Entering Evaporator, Wet Bulb	57.1	56.7
Leaving Evaporator, Dry Bulb	49.0	48.6
Air Velocity (fpm)	677	677
Airflow Rate (scfm)	362	363
Refrigerant Temperatures (°F)		
TEV In	76.5	75.0
Suction Pressure Regulating Valve Out	106.5	106.0
Discharge Pressure (psig)	179.5	177.0
Suction Pressure (psig)	61.5	61.0

Table XLIV. Results of Coil Frost Test,
Model MC11HAL6-208

Measurement	Start	Finish (12 hr)
Air Temperatures (^{o}F)		
Entering Condenser, Dry Bulb	55.3	54.9
Entering Evaporator, Dry Bulb	67.5	67.5
Entering Evaporator, Wet Bulb	58.0	57.5
Leaving Evaporator, Dry Bulb	50.2	49.1
Air Velocity (fpm)	809	809
Airflow Rate (scfm)	432	432
Refrigerant Temperatures (^{o}F)		
TEV In	79.0	79.0
Suction Pressure Regulating Valve Out	107.0	109.5
Discharge Pressure (psig)	192	190
Suction Pressure (psig)	65	65

Table XLV. Results of Coil Frost Test,
Model MC11HAL4-208

Measurement	Start	Finish (12 hr)
Air Temperatures (^{o}F)		
Entering Condenser, Dry Bulb	55.3	55.3
Entering Evaporator, Dry Bulb	67.0	66.8
Entering Evaporator, Wet Bulb	57	57
Leaving Evaporator, Dry Bulb	50.3	51.2
Air Velocity (fpm)	749	749
Airflow Rate (scfm)	401	403
Refrigerant Temperatures (^{o}F)		
TEV In	75.5	76.5
Suction Pressure Regulating Valve Out	103.0	105.0
Discharge Pressure (psig)	178	180
Suction Pressure (psig)	58	62

1. High-Temperature Storage. The high-temperature storage test was conducted to determine the effects of high-temperature conditions (155° F) upon the air conditioner with respect to deterioration of components or structure and to determine if the high temperature had any effect on the operational characteristics of the air conditioner.

This test was conducted in the climatic test chamber. The unit was stored in a 155° F ambient for 48 hours and then operated in the VENT, COOL, and HI HEAT modes at 90° F to 120° F ambient. The test units were inspected for any malfunctions or deteriorations. Malfunctions inspected for included rupture of refrigerant piping and control components, binding of motors caused by breakdown of winding insulation or bearing lubrication, and binding of parts or components caused by metal expansion. Deterioration inspected for included discoloration, cracking, shrinking, bulging, checking or crazing of gaskets, insulation sheets and strips, fabrication material, and paint; breakdown of insulation adhesives; and permanent setting of gaskets and packings. A detailed visual examination of the test units after exposure to this test revealed no deterioration or damage as a result of this test. The test results are presented in Table XLVI.

Table XLVI. Results of High-Temperature Storage Test, Model MC11HAL6-208

Measurement	Mode					
	VENT		COOL		HI-HEAT	
	Before	After	Before	After	Before	After
Air Temperatures (°F).						
Dry Bulb						
Entering Evaporator	80	80	90	90	79	88
Leaving Evaporator	83	82	63	69	97	106
Electrical Characteristics						
Voltage	209	209	208	209	208	207
Amperage	2.59	2.57	10.24	10.38	7.15	7.11
Power (kw)	0.38	0.37	2.61	2.75	2.46	2.39
Discharge Pressure (psig)	-	-	367	379	-	-
Suction Pressure (psig)	-	-	77	81	-	-

Note: Hyphens signify that these data were not applicable.

m. Low-Temperature Storage. The low-temperature storage test was conducted to determine the effects of low-temperature conditions (-65° F) upon the air conditioner with respect to deterioration of components or structure and to determine if the aforesaid conditions had any effect on the operational characteristics of the unit.

This test was conducted in the climatic test chamber where the temperature was maintained at -65° F for 48 hours. At the completion of the 48-hour storage period, the test unit was examined visually for any deterioration or damage as a result of differential contraction of dissimilar metal parts; loss of resiliency of insulation and gaskets; congealing of lubricants; breakdown of adhesives; binding of motors caused by breakdown of winding insulation or bearing lubrication; discoloration, cracking, shrinking, bulging, checking, or crazing of gaskets and insulation, fabrication materials and paint, and permanent setting of gaskets and packings.

Operation of the test units in the VENT, COOL, LO-HEAT, and HI-HEAT modes after low-temperature storage indicated no adverse results during storage tests. A visual examination of the test units after exposure to this test revealed no deterioration or damage as a result of this test. The test results are presented in Table XLVII.

Table XLVII. Results of Low-Temperature Storage Test, Model MC11HAL6-208

Measurement	Mode					
	VENT		COOL		HI-HEAT	
	Before	After	Before	After	Before	After
Air Temperatures (°F), Dry Bulb						
Entering Evaporator	80	81	90	90	86	83
Leaving Evaporator	82	84	69	69	106	100
Electrical Characteristics						
Voltage	209	208	209	208	207	206
Amperage	2.58	2.55	10.4	10.8	7.11	7.05
Power (kw)	0.37	0.37	2.75	2.81	2.39	2.37
Discharge Pressure (psig)	-	-	379	396	-	-
Suction Pressure (psig)	-	-	81	82	-	-

Note: Hyphens signify that these data were not applicable.

n. Humidity. The humidity test was conducted on Model MC11HAL6-115 to determine the resistance of the air conditioner to a warm, highly humid tropical atmosphere.

The test was conducted by the Development and Proof Services Department, Test and Evaluation Command (TECOM), Aberdeen, Maryland. Prior to this test, the following operational data were recorded:

(1) Compressor suction and discharge pressures.

(2) Evaporator air intake and discharge temperatures.

(3) Condenser air intake and discharge temperatures.

(4) Voltage input, current draw, and power input.

The test item was placed in a humidity chamber where the chamber temperature ranged between 68° F and 100° F. In 2 hours, the chamber temperature and relative humidity were raised to 155° F and 95^{+5}_{-0} percent, respectively. These conditions were maintained for 6 hours. Then, in 16 hours, the temperature was lowered to 100° F, while the humidity was kept at 95^{+5}_{-0} percent. This cycle was repeated ten times for a total exposure of 240 hours. Before and after the exposure, the unit was given a detailed inspection. All covers and grilles (except the condenser grille) were removed, and all evidences of damage or corrosion were noted. In addition, after each inspection, the unit was given an operational test. The unit was turned on, all controls were checked, and any evidence of improper operation was noted. With the unit in the COOL mode and the thermostat set for cooling, measurements of power, temperature, and pressures were made.

The results and findings of this test are covered in Report No. DPS-2173 (5), October 1966, under TECOM Project Nos. 7-4-0492-02 and 7-4-0493-02. The summary of the humidity test results follows:

The inspection and operation after the exposure to humidity revealed the following discrepancies:

(1) The adjusting screw on the back pressure-regulating valve was rusty.

(2) The three pieces of plastic tubing (condensate drain) had pulled off the copper T-connector.

(3) The black foam insulating material used to wrap the quench valve temperature bulb and the hot-gas line had shrunk and lost its resiliency.

(4) The auxiliary contacts on the compressor circuit breaker would not close; hence, the compressor and condenser rendered the fan inoperative.

(5) The coil bracket on the evaporator blower relay had rusted.

(6) The automatic opening louvers at the condenser air discharge would open to no more than 45° and would close to no more than 30°.

Items (1) and (5) above were considered a design improvement problem area; items (2), (3), and (6) were considered design shortcomings; and item (4) was considered a design deficiency.

The action taken and opinions of the project personnel at USAERDL on the just mentioned possible problem areas follow:

Item (1) - The proper setting for this valve has been determined during recent EDT testing, and in all future units the adjusting screw will be properly preset at the factory and then soldered in place to prevent a change in setting. Therefore, no change in adjustment will be necessary or possible after a possible rust buildup in the field.

Item (2) - The plastic drain tubing now has metal spring-type clips at the slip-on copper joints to preclude this problem. Results of subsequent high-temperature tests show that the plastic tubing stays in place.

Item (3) - The final design units will have temperature bulbs inside the refrigerant lines in bulb wells and therefore will not require a protective insulation covering.

Item (4) - The subject item was removed from the test unit and sent to the manufacturer for a failure analysis. A tooling change was sufficient to preclude future failures. No further action appears necessary at this time.

Item (5) - In the subject test unit, another identical coil bracket next to the subject coil bracket had no rust or corrosion whatsoever. The manufacturer has shown that the bracket material is a well-known corrosion-resistant material and could not believe the results. Their only explanation is that filings, shavings, and the like, could have collected on one of the brackets and caused the external corrosion. Anyway, as no operational problems have resulted, no design changes are believed necessary.

Item (6) - A similar result was witnessed after the Category II Salt Fog Test on the 18,000-Btu/hr horizontal unit (MC20HAL6-230). This item is covered in paragraph 5 o of this report.

Operational comparison tests were made in the following order:

(1) At USAERDL before shipment to TECOM.
(2) At TECOM immediately before the humidity test.
(3) At TECOM immediately after the humidity test.
(4) At USAERDL upon return of the unit.

The condenser fan operated at high speed during the USAERDL tests and at slow speed during the tests conducted at TECOM.

The USAERDL test results are given in Table XLVIII, and the USATECOM test results are listed here.

Table XLVIII. Results of Humidity Test, USAERDL

Measurement	Before Shipment	After Return
Air Temperatures (^oF)		
Entering Evaporator, Dry Bulb	90	91
Leaving Evaporator, Wet Bulb	70	71
Condenser Air In	120.5	119.0
Subcooling at Subcooler	10	11
Electrical Characteristics		
Voltage	118	115
Amperage	23.8	24.5
Wattage, Total	2,630	2,660
Discharge Pressure (psig)	382	388
Suction Pressure (psig)	80	81

Results of prehumidity operational characteristics test follow:

Measurement	Result
Evaporator Intake Air Temperature (^{o}F)	82.0
Evaporator Discharge Air Temperature (^{o}F)	62.5
Condenser Intake Air Temperature (^{o}F)	83.5
Condenser Discharge Air Temperature (^{o}F)	131.0
Compressor Discharge Pressure (psig)	315
Compressor Suction Pressure (psig)	79
Input Voltage (a-c volts)	113.5
Amperage	20.5
Power Consumption (kw)	2.27

Results of posthumidity operational characteristics test follow:

Measurement	Result
Evaporator Intake Air Temperature (^{o}F)	86.0
Evaporator Discharge Air Temperature (^{o}F)	65.5
Condenser Intake Air Temperature (^{o}F)	87.0
Condenser Discharge Air Temperature (^{o}F)	146.0
Compressor Discharge Pressure (psig)	380
Compressor Suction Pressure (psig)	79
Input Voltage (a-c volts)	113.5
Amperage	22.6
Power Consumption (kw)	2.55

o Salt Fog. The salt fog test was conducted on Model MC20HAL6-230 to determine the resistance of the air conditioner to the effects of a salt atmosphere.

The test was performed under RDT&E Project 1M643303-D545 and under USATECOM Projects Nos. 7-4-0494-02 and 7-4-0495-02 by the Development and Proof Services according to the "USATECOM Plan of Test for Integrated Engineering." Report No. DPS-2187 (6) gives results of USATECOM test on the 18,000-Btu/hr air conditioner. According to test personnel, the 18,000-Btu/hr and 9,000-Btu/hr capacity units are similar in mechanical construction and identical in material and finish. Here, the test findings are sufficient for both air conditioners.

Prior to the salt fog storage, the unit was subjected to an operational test, and data were recorded. The test item with the evaporator end covered was placed in a salt fog chamber. The chamber nozzles were adjusted to produce a fine mist of 5 $\pm$ 1 percent (by weight) sodium chloride solution, and the air conditioner was exposed to this mist for 48 hours with the chamber temperature ranging between 92° F and 97° F. The test item was inspected and operated after the exposure. During these operations, the unit air temperatures were measured in the COOL mode, and the power characteristics were measured in all switch positions.

Inspection after the salt fog test revealed no deficiencies in the unit; a problem, however, was revealed during the operational phase. The automatic louvres at the condenser air discharge would open no more than 30°, even after the condenser air intake was blocked off, until the high-pressure cutout operated. The cable, piston rod, and louvre pivot points were all oiled. The louvres still would not open or close without manual help. After the cable was disconnected at both ends, the cable and piston seemed to work freely, but the louvres were binding at the nylon bushings. These bushings would not rotate freely in the holes in the frame. The USAERDL Materials Research Laboratory was consulted on the expansion properties of nylon, and the louvre pivot mechanism tolerances were adjusted accordingly. A new component parts test in the USAERDL salt fog facility showed no binding or restrictions to the linkage cable, the nylon bushings, or the damper actuator. The entire assembly was operated manually with minimum effort.

The pretest and posttest operational results are presented in the two following lists and in Tables XLIX and L. Presalt fog operational temperatures were as follows:

Measurement	Results
Evaporator Intake Air Temperature*	75.5
Evaporator Discharge Air Temperature*	57.0
Condenser Intake Air Temperature	80.5
Condenser Discharge Air Temperature	125.5

Postsalt fog operational temperatures were as follows:

Measurement	Results
Evaporator Intake Air Temperature*	70.0
Evaporator Discharge Air Temperature*	56.0
Condenser Intake Air Temperature	73.0
Condenser Discharge Air Temperature	114.0

* Wet coil conditions.

Table XLIX. Presalt Fog Operational Power Measurements

Switch Position	Current (amp) Line A	Current (amp) Line B	Line-to-Line Volts	Power (kw)
VENT	1.0*	1.0*	235	0.60
COOL	19.5	19.3	228	4.05
LO-HEAT	11.0	11.0	232	2.45
HI-HEAT	19.3	19.2	230	4.30

Table L. Postsalt Fog Operational Power Measurements

Switch Position	Current (amp) Line A	Current (amp) Line B	Line-to-Line Volts	Power (kw)
VENT	1.0*	1.0*	235	0.60
COOL	18.0	17.8	228	3.80
LO-HEAT	11.0	10.9	233	2.45
HI-HEAT	19.5	19.5	231	4.30

* The nonlinear scale on this meter could lead to inaccuracies of 2 or 3 amp when currents below 5 amp are read

p. Sand and Dust. The sand and dust test was performed on Model MC20HAL6-230 (6) to determine the ability of the test unit to withstand an atmosphere of blowing sand and dust.

The test was conducted by the Development and Proof Services Department, USATECOM.

The test item was installed in the rear of a van with the condenser section outside and the evaporator section 10 inches inside the van. The unit was caulked and sealed at the wall of the van. A mixture of sand and dust containing particle sizes from very fine earth up to the largest size listed in AR 705-15, Cl, par. 7a(8) was blown at the condenser end at a wind speed of 15 mph. The air conditioner was exposed to these conditions for 4 hours with the unit operating in the COOL mode, the condenser fan speed switch on automatic (speed was low), the thermostat set for cooling, the fresh-air damper closed, and the evaporator fan speed high.

Prior to the exposure the unit was inspected, operated, and the evaporator and condenser air temperatures were measured. During exposure, the inside of the van and the unit was observed, and no evidences of sand and dust particles passing through the unit into the van were found. After 3½ hours of exposure, the air temperatures were measured again, and after the exposure, the unit was inspected for detrimental effects.

Inspection of the Model MC20HAL6-230 air conditioner after the sand and dust exposure revealed the following:

(1) Sand and dust were piled up in the fins at the bottom of the condenser coil to a height varying from 1½ to 2½ inches.

(2) Sand and dust covered the bottom of the condenser section to a height varying from 2 to 3 inches.

(3) No sand or dust passed through the unit.

The unit operated satisfactorily during the sand and dust exposure, and no detrimental effects were found afterward. The pretest and posttest results are shown in Table LI.

Table LI. Results of Sand and Dust Test

Measurement	Temperature (°F)	
	Pretest	Posttest
Evaporator Intake Air Temperature*	+ 67	+ 68
Evaporator Discharge Air Temperature*	+ 51	+ 52
Condenser Intake Air Temperature	+ 84	+ 82
Condenser Discharge Air Temperature	+116	+115

* Wet coil conditions.

q. Chemical Biological. The fresh-air opening at the rear of each unit is provided with means of connecting external chemical-biological (CB) protection devices to the evaporator section. The simplest method is to connect ductwork from an external CB filtering device to the fresh-air duct opening. The configurations of the air passage and the basic unit design are compatible with CB cycle operation. The unit has a blow-through evaporator coil which reduces the negative pressure at the suction of the air conditioner evaporator fan. Also, the CB air is introduced near the suction of the air conditioner evaporator fan. This arrangement requires the least output from the CB filter fan to maintain sufficient positive pressure at the suction of the air conditioner evaporator fan.

r. Starting Current. The starting current test was conducted to determine the maximum starting and steady-state running current of the air conditioner in the COOL mode of operation.

The test was conducted at nameplate rated voltage and frequency, and the unit was charged with the optimum refrigerant charge. Specific test conditions of 120° F dry-bulb outside room and 90° F dry-bulb dry-coil inside room were maintained throughout the test. A stable thermal equilibrium balance was obtained in the test cells at the specific test conditions with the unit operating in the maximum cooling cycle before testing. An oscilloscope was connected to the electrical power input leads of the test unit. A camera was attached to the oscilloscope to photograph the readouts on the oscilloscope graph. The following transients were recorded:

(1) OFF to COOL (fans only).
(2) OFF to COOL (compressor).
(3) OFF to VENT.
(4) OFF to LO-HEAT.
(5) OFF to HI-HEAT.
(6) VENT to COOL (fans only).
(7) VENT to COOL (compressors).
(8) Bypass to COOL (thermostat operation).
(9) COOL to Bypass (thermostat operation).

When current or voltage spikes of short duration, of large amplitude, or both were apparent, the scale size and selected time of the oscilloscope were adjusted to record and photograph the spikes properly so that accurate amplitude and time duration of the spikes could be determined.

Current transients were observed in the functions (1) through (7) just listed. No change in current occurred during the functions (8) and (9).

The results of this test are presented in Table LII and in Figs. 11 through 13.

Table LII. Results of Starting Current Test

Switch Position Changes	Test Model: MC11HAL6-230		MC11HAL6-208		MC11HAL4-208	
	Transient Current (calculated in rms, amp)	Duration of Transient (calculated in msec)	Transient Current (calculated in rms, amp)	Duration of Transient (calculated in msec)	Transient Current (calculated in rms, amp)	Duration of Transient (calculated in msec)
(1) OFF to COOL (fans only)	13.8	940.0	15.4	752.0	26.6	635.0
(2) OFF to COOL (compressor)	38.6	235.0	14.8	118.0	32.4	235.0
(3) OFF to VENT	12.7	382.0	12.5	341.0	13.9	552.0
(4) OFF to LO-HEAT	16.7	470.0	15.2	376.0	16.1	552.0
(5) OFF to HI-HEAT	16.1	588.0	15.2	317.0	17.6	552.0
(6) VENT to COOL (fans only)	-	-	14.6	423.0	18.3	635.0
(7) VENT to COOL (compressor)	38.6	235.0	14.8	103.0	32.4	235.0

Note: Hyphens signify that these data were not taken.

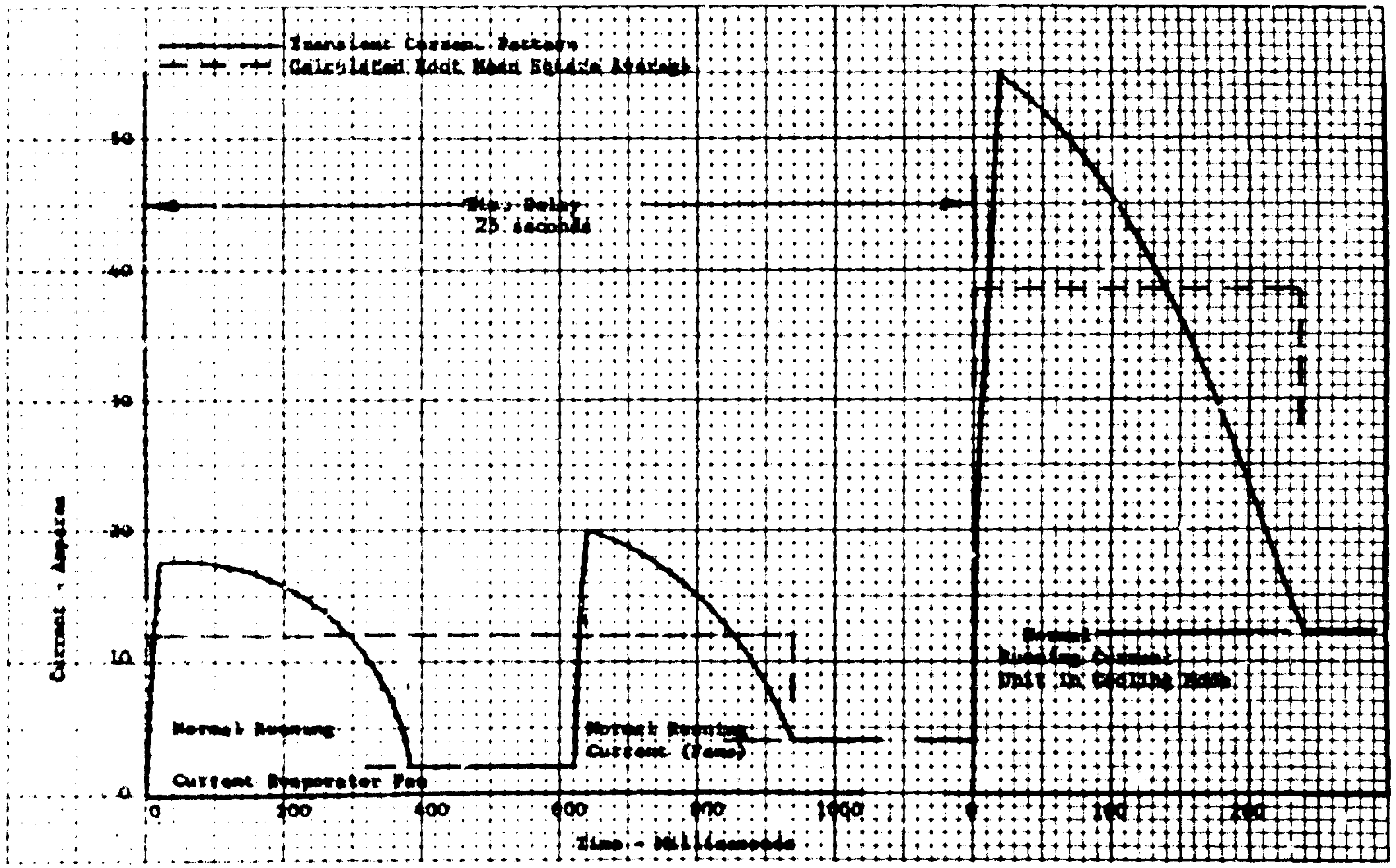


Fig. 11. Results of starting current test, Model MC11HAL6-230.

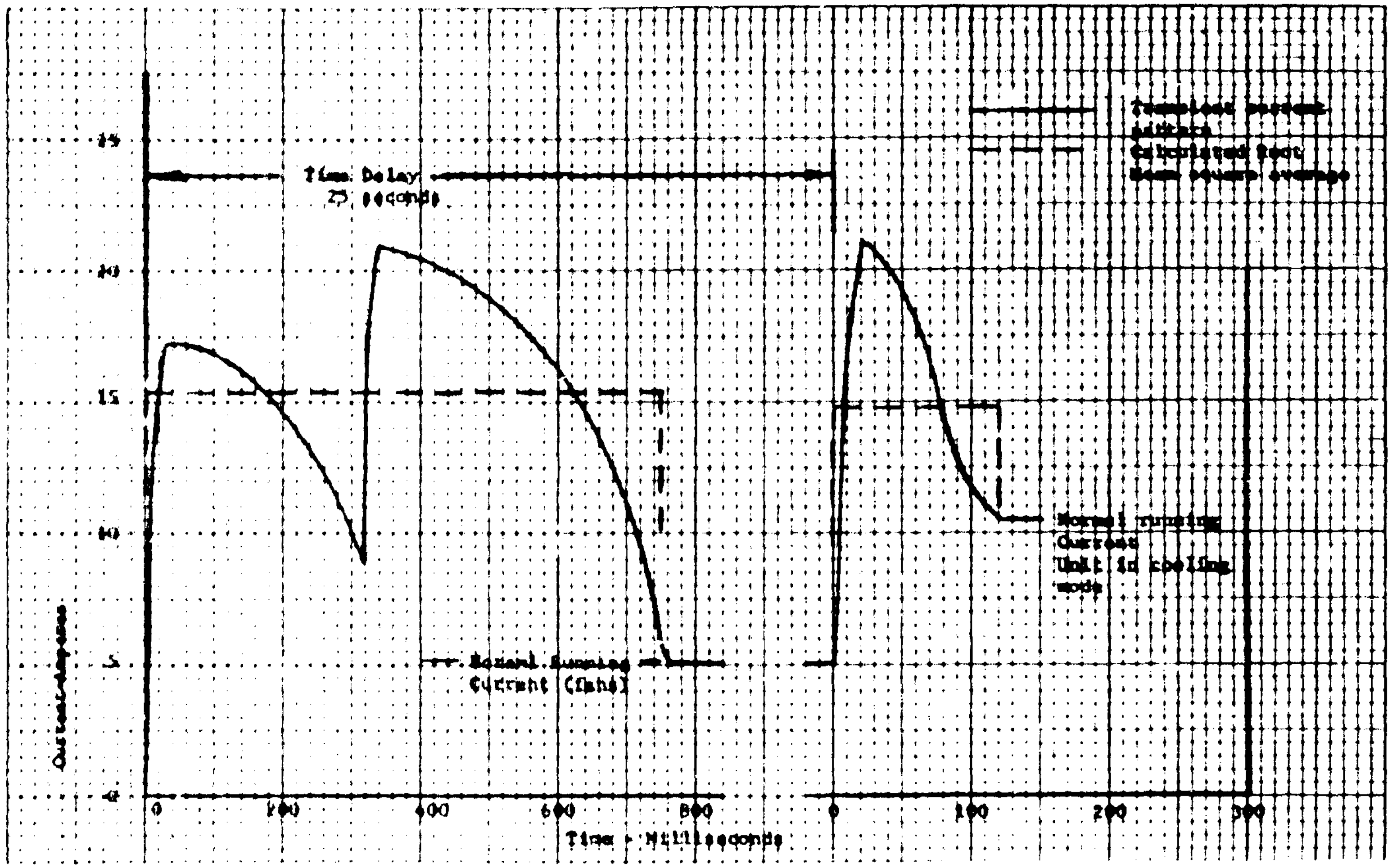


Fig. 12. Results of starting current test, Model MC11HAL6-208.

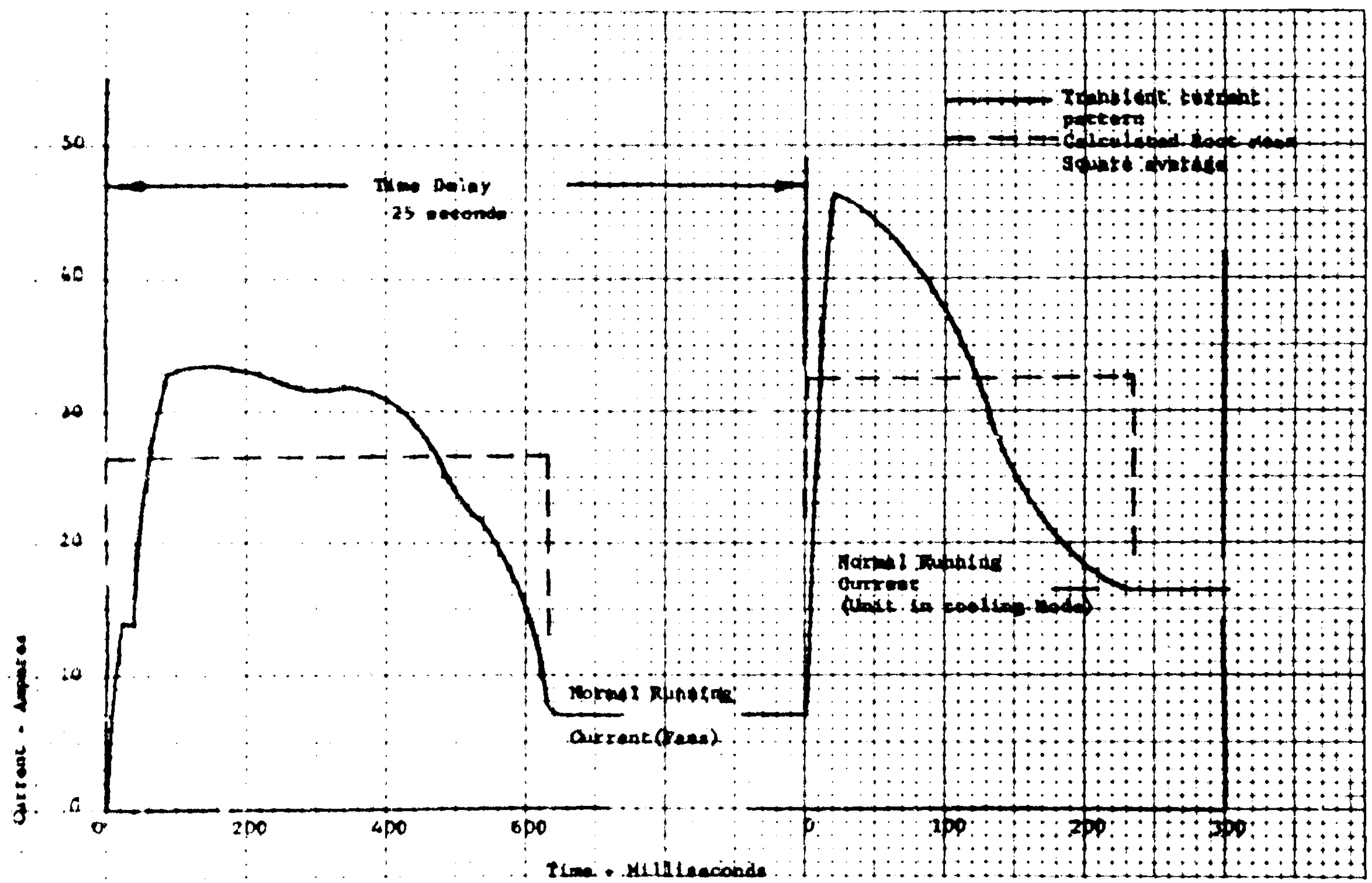


Fig. 13. Results of starting test. Model MC11HA L4-208.

s. <u>Radio Frequency Interference (RFI)</u>. The radio frequency interference tests were conducted to determine if the test items (MC11HAL6-230, MC11HAL6-208, and MC11HAL4-208) were adequately suppressed to prevent electrical disturbances (radiated, conducted, or both) that may be detrimental to operation of electronic equipment. The criteria used were as follows:

(1) The items should not radiate electromagnetic energy beyond the broadband limits specified in Table I of Specification MIL-E-55301, with Amendment No. 1.

(2) The items should not emit conducted energy beyond the broadband limits specified in Table III of Specification MIL-E-55301, with Amendment No. 1.

These tests were performed by the USATECOM at the Aberdeen Proving Ground.

The air conditioners and test equipment were set up in an area with low ambient noise. The air conditioners were positioned on an earth-grounded metal ground plane. A filtron-type FSR-702SC line impedance stabilization network was inserted in each power lead to the air conditioners. Each network was bonded to the ground plane and was loaded with a 50-ohm resistive termination at the type-N connector.

Tests for radiated interference were made over the frequency range of 0.15 through 1,000 megacycles with the antenna of the test equipment being located 5 feet from the front of the air conditioners.

Tests for conducted interference were made on each of the input lines to the impedance stabilization network over the frequency range of 1.5 through 65.0 megacycles.

Orientation of the test equipment, condition of units, test site, and permissible limits of interference for these tests were in accordance with the requirements outlined in Specification MIL-E-55301.

Radio interference measuring set, AN/URM-85, was used throughout the investigation. In addition to measuring radio interference at predetermined frequencies, the frequency spectrum between them was scanned for peaks of interference.

The radiated measurements at 0.15 and 0.35 megacycle were not made of any of the units because the ambient levels were too high.

As far as could be determined, all three units were within the levels for radiated and conducted energy outlined in Specification MIL-E-55301, with Amendment No. 1.

Data sheets of RFI tests on Models MC11HAL6-230, MC11HAL6-208, and MC11HAL4-208 are given in Report No. DPS-2173.

These results are presented in Tables LIII through LVIII.

t. Vibration. The mechanical vibration test was conducted to determine the ability of the air conditioner to withstand dynamic stresses which result from extremely hard usage in military service.

Vibration tests were conducted in accordance with USAERDL Vibration Test No. 514. This test procedure consists of a table vibration at a 1.6-g level for a minimum of 80 minutes in each of three mutually perpendicular planes. This 80-minute test period in each plane is equivalent to 4,000 miles of vehicular transport. One-sixth the total vibration time was at each of four points of resonance in each plane. The remaining time was spent sinusoidally cycling from 5 cps to 295 cps.

The three mutually perpendicular directions for the air conditioner were designated and defined as:

Vertical
Perpendicular to the top and bottom surfaces.

Transverse (side to side)
Perpendicular to the side surfaces on which the handles were mounted.

Longitudinal (front to back)
Perpendicular to the front panel.

As the vibration test phase progressed, several failures occurred. Some deficiencies required substantial repair design modification, or both. This report covers the final test for the design model MC11HAL6-115, and these findings obtain for all models in the 9,000-Btu/hr capacity.

Table LIII. Results of Radio Frequency Interference Test, Broadband, Radiated, Model MC11HAL6-230

Frequency (mc)	Interference (db > 1.0 μ v/mc) Ambient Noise Level	Passing Limit MIL-E-55301(EL)	Measurement COOL	LO HEAT	HI HEAT
0.15	*	86			
0.35	*	86	*	*	*
1.5	62	66	a	a	a
3	52	66	↓	↓	↓
5	54	60			
8	55	60			
12	50	60			
16	45	60			
20	37	54			
24	32				
28	29				
30	27				
35	25				
38	26				
40	23				
1,000	37	54	a	a	a

Note: Letter a indicates interference level at or below ambient level.
Test was continued as follows:
40 to 100 in increment of 5
100 to 200 in increments of 10
200 to 300 in increments of 20
300 to 1,000 in increments of 50.
Ambient remained below specification requirement.

* Ambient background was above specification limit; valid reading could not be obtained.

Table LIV. Results of Radio Frequency Interference Test,
Broadband, Radiated, Model MC11HA L6-208

	Interference (db > 1.0 μv/mc)				
Frequency	Ambient	Passing Limit	Measurement		
(mc)	Noise Level	MIL-E-55301(EL)	COOL	LO HEAT	HI HEAT
0.15	*	86	*	*	*
0.35	*	86	*	*	*
1.5	61	66	a	a	a
3	54	66			
5	55	60			
8	55	60			
12	55	60			
16	52	60			
20	38	54			
24	27				
28	28				
30	29				
35	24				
38	26				
40	25				
1,000	38	54	a	a	a

Note: Letter a indicates interference level at or below ambient level.
Test was continued as follows:
40 to 100 in increments of 5
100 to 200 in increments of 10
200 to 300 in increments of 20
300 to 1,000 in increments of 50
Ambient remained below specification requirement.

* Ambient background was above specification limit; valid reading could not be obtained.

Table LV. Results of Radio Frequency Interference Test, Broadband, Radiated, Model MC11HAL4-208

	Interference (db > 1.0 μ v/mc)				
Frequency (mc)	Ambient Noise Level	Passing Limit MIL-E-55301(EL)	Measurement COOL	LO HEAT	HI HEAT
0.15	*	86	*	*	*
0.35	*	86	*	*	*
1.5	62	66	a	a	a
3	52	66			
5	54	60			
8	55	60			
12	50	60			
16	45	60			
20	34	54			
24	31				
28	32				
30	30				
35	28				
38	26				
40	22				
1,000	39	54	a	a	a

Note: Letter a indicates interference level at or below ambient level.
Test was continued as follows:
40 to 100 in increments of 5
100 to 200 in increments of 10
200 to 300 in increments of 20
300 to 1,000 in increments of 50
Ambient remained below specification requirement.

* Ambient background was above specification limit; valid reading could not be obtained.

Table LVI. Results of Radio Frequency Interference Test, Broadband, Conducted, Model MC11HAL6-230

Frequency (mc)	Ambient Noise Level	Passing Limit MIL-E-55301	Interference (db > 1.0 μ v/mc) Line A COOL	Line A LO HEAT	Line A HI HEAT	Line B COOL	Line B LO HEAT	Line B HI HEAT	Neutral COOL	Neutral LO HEAT	Neutral HI HEAT
1.5	35	83	80	66	67	a	a	a	58	52	54
3	40	83	67	59	60	↓	↓	↓	a	a	47
5	35	80	49	41	40				↓	↓	a
8	36	80	a	a	a						↓
12	38	74	↓	↓	↓						
16	37										
20	34										
24	36										
28	36										
30	35										
35	30										
38	30										
40	32										
45	31										
50	32										
55	31										
60	32										
65	32	74									

Note: Letter a indicates interference level at or below ambient level.

Table LVII. Results of Radio Frequency Interference Test, Broadband, Conducted, Model MC11HAL6-208

Frequency (mc)	Ambient Noise Level	Passing Limit MIL-E-55301	Interference (db > 1.0 μ v/mc) Line A COOL	Line A LO HEAT	Line A HI HEAT	Line B COOL	Line B LO HEAT	Line B HI HEAT	Line C COOL	Line C LO HEAT	Line C HI HEAT	Line D COOL	Line D LO HEAT	Line D HI HEAT
1.5	35	83	a	a	a	a	a	a	a	a	a	a	a	a
3	40	83												
5	38	80												
8	37	80												
12	39	74												
16	37													
20	29													
24	30													
28	30													
30	29													
35	31													
38	31													
40	30													
45	31													
50	32													
55	32													
60	32													
65	31	74	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓

Note: Letter a indicates interference level at or below ambient level.

Table LVIII Results of Radio Frequency Interference Test, Broadband, Conducted, Model MC11HA L4-208

Frequency (mc)	Ambient Noise Limit	Passing Limit MIL-E-55301	Interference (db > 1.0 μ v/mc)											
			Line A			Line B			Line C			Line D		
			COOL	LO HEAT	HI HEAT	COOL	LO HEAT	HI HEAT	COOL	LO HEAT	HI HEAT	COOL	LO HEAT	HI HEAT
1.5	37	83	75	75	76	83	75	76	75	74	74	52	44	44
3	38	83	67	63	63	76	64	64	79	63	62	57	43	42
5	38	80	46	46	46	47	45	45	52	47	46	38	39	38
8	37	80	39	41	40	38	38	40	42	38	39	38	38	38
12	36	74	a	a	a	a	a	a	37	a	a	47	a	a
16	38								a			a		
20	35													
24	36													
28	37													
30	37													
35	31													
38	31													
40	33													
45	32													
50	32													
55	33													
60	31													
65	31	74	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓

Note: Letter a indicates interference level at or below ambient level.

The air conditioner was bolted to a 2-inch-thick aluminum plate supplied by USAERDL. This plate was bolted to a magnesium "slippery" plate and driven by a horizontally positioned Ling Model A300 B vibration exciter for transverse and longitudinal direction tests. For testing in the vertical direction, the aluminum plate was bolted directly to the test surface of a vertically positioned Ling Model A300B vibration exciter.

For determining resonances, piezoelectric accelerometers were cemented to the major components of the air conditioners as selected by the USAERDL representatives. Before proceeding to the next direction, the test operator realigned the sensitive axis of each accelerometer so that it would coincide with the direction of excitation.

A piezoelectric accelerometer was mounted near each of the four corners of the unit for monitoring the input acceleration level. The outputs of these accelerometers were connected into an electronic network which averaged the four inputs into a single reading on a direct current vacuum tube voltmeter; thus, the operator could control the unit from indications on one meter.

The outputs of all accelerometers were connected through cathode followers and amplifiers to a Consolidated Electrodynamics oscillograph. Oscillograms of the accelerations transduced by each accelerometer were recorded during each resonance search. The paper speed was 0.25 inch per second.

The air conditioner and fixture were observed under frequency-synchronized stroboscopic light to assist in determining resonances. Transparent Plexiglas covers permitted observation of the internal components.

A resonance search was performed with the use of a logarithmic frequency sweep with the time regulated to traverse the frequency range from 5 Hz to 295 Hz in 7.5 minutes. Oscillograms were recorded during the search.

After the oscillograms were evaluated, major resonances were selected with the assistance of the USAERDL representatives. A 13-1/3-minute resonant dwell period was performed at each major resonance selected. The input acceleration level for each resonant dwell period was 1.6 g's (average).

The remainder of the specified 80 minutes of vibration time for each direction was devoted to cycling from 5 Hz to 295 Hz and returning to 5 Hz at the same sweep rate and input level employed during the resonance search.

Test results in each of the three planes follow:

(1) Vertical Direction. Major resonances were selected from the evaluation of the oscillograms recorded during the resonance search. The resonant frequencies are presented in Table LIX.

Table LIX. Resonant Frequencies of Model MC11HAL6-115, Vertical Direction

Location	Frequency (Hz)	Acceleration (g)
Condenser Fan Motor	112	32.0
Liquid Line Solenoid Valve	90	44.0
Compressor and Precooler Lines	45	6.0
Evaporator Fan Motor	33	12.0

A 13-1/3-minute resonant dwell period was performed at each of these frequencies just given. The visual examination after completion of the vibration test in this direction did not disclose any apparent defects of the unit.

(2) Transverse Direction. Major resonances were selected from the evaluation of the oscillograms recorded during the resonance search. The resonant frequencies are given in Table LX.

Table LX. Resonant Frequencies of Model MC11HAL6-115, Transverse Direction

Location	Frequency (Hz)	Acceleration (g)
Equalizer Solenoid Valve	92	36.0
Condenser Fan Motor	38	40.0
Evaporator Fan Motor	32	22.0
Compressor	22	7.5

A 13-1/3-minute resonant dwell period was performed at each of the frequencies just given. After approximately 8 minutes of the fourth dwell (22 Hz) period, a change in noise level was noticeable. Further investigation disclosed that the stainless steel bracket attaching the top of the compressor to the partition had fractured at the bend nearest the partition. The bracket was repaired at USAERDL, Fort Belvoir, and a gusset was added where the break had occurred. The dwell period at 22 Hz was repeated. One cycle from 5 to 295 Hz was also completed before the setup for the next direction was begun.

(3) Postrepair Tests.

(a) Transverse Direction. Testing in this direction was repeated to subject the repaired compressor tiedown bracket to testing in all three directions. The evaluation of the oscillograms disclosed the same major resonances; therefore, the dwell periods were performed at the same frequencies as listed in the preceding paragraph of this report except that the 22 Hz dwell period was not repeated. The visual examination after completion of the vibration test in this direction did not disclose any electrical or mechanical defects.

(b) Vertical Direction. The evaluation of the oscillograms recorded during the resonance search disclosed that the major resonances were at the same frequencies as previously observed. The dwell periods were performed at the frequencies listed in paragraph t(1) of this report. The visual examination after completion of the vibration test did not disclose any apparent defects.

(4) Longitudinal Direction. Major resonances were selected from the evaluation of the oscillograms recorded during the resonance search. The resonant frequencies are shown in Table LXI.

Table LXI. Resonant Frequencies of Model MC1.HAL6-115, Longitudinal Direction

Location	Frequency (Hz)	Acceleration (g)
Condenser Fan Motor	83	17.0
Equalizer Solenoid Valve	47	44.0
Compressor	22	7.6
Evaporator Fan Motor	19	8.0

A 13-1/3-minute resonant dwell period was completed at each of the frequencies just given. The visual examination after completion of the vibration test in this direction did not disclose any electrical or mechanical defects.

Operational tests were performed before and after the vibration tests. These operational results are presented in Tables LXII through LXIV.

u. Acoustical Noise (Sound). The acoustical noise tests were conducted to determine the air conditioner sound pressure levels and to compare these levels with standard sound criteria.

These tests were conducted at USAERDL. Each test unit was installed in an S-141 shelter (MIL STD 52059) as shown in Fig. 14. The test enclosure was located outdoors for conductance of all sound tests and contained only the necessary equipment for these tests. The ceiling was covered with 3/4-inch acoustical tile. The evaporator section of the air conditioner protruded 10 inches inside the test enclosure and was mounted as rigidly as possible. The microphone was located 46 inches from the floor and 48 inches from the evaporator section of the air conditioner for the three inside positions, and 68 inches from the ground and 48 inches from the condenser section for the three outside positions. The readings were made in accordance with the manufacturer's recommendations, and no more than one person was inside the test enclosure during the conductance of any sound test. The background noise level was at least 10 db below the minimum recorded sound pressure level in any of the specified octave bands.

The arithmetical averages for each condition were used to plot Figs. 15 and 16. Criteria for the inside position average noise levels are Curves NC-60 and NC-65 (ASHRAE Guide - 1963 Edition). These are plotted here for comparison.

All octave band pressure level measurements were taken with the air conditioner operating in both VENT and COOL modes. Each octave band analysis of eight octave bands was made using instruments built in accordance with the requirement of either ASA-Z24. 10-1953 or ASA-S1. 6-1960.

The three sound pressure levels for each condition are recorded in Tables LXV through LXXIV.

Table LXII. Cooling Operation Test Results, Pre and Postvibrational, Model MC11HAL6-115

Measurement	COOL Previbrational Operation	COOL Postvibrational Operation
Air Temperatures (°F)		
Entering Evaporator, Dry Bulb	91	91
Entering Evaporator, Wet Bulb	71	68
Leaving Evaporator, Dry Bulb	68	68
Entering Condenser, Dry Bulb	119	120
Leaving Condenser, Dry Bulb	142	141
Refrigerant Temperatures (°F)		
Discharge Line	232	231
Condenser Out	148	149
Subcooler Out	135	136
TEV In	134	135
Suction at TEV Bulb	53	57
Suction at Compressor	62	65
Suction Pressure Regulating Valve Out	136	139
Quench Out	135	138
Equalization Solenoid Out	144	142
Precooler In	230	224
Precooler Out	223	221
Subcooling at Subcooler	16.4	13.2
Subcooling at TEV	17.4	14.2
Superheat at TEV Bulb	2.4	8.2
Superheat at Compressor	11.4	17.2
Compressor Skin Temperature (°F)	209	206
Discharge Pressure (psig)	389	378
Suction Pressure (psig)	85	82
Electrical Characteristics		
Voltage, Average	115	115
Amperage, Average	24.50	23.40
Wattage, Total	2,660	2,600
Power Factor (%)	94.4	96.6
Evaporator Fan Speed (rpm)	3,510	3,520
Condenser Fan Speed (rpm)	3,470	3,480

Table LXIII. Heater Test Results, Pre and Postvibrational, Model MC11HAL6-115

Measurement	LO HEAT		HI HEAT	
	Previbrational Operation	Postvibrational Operation	Previbrational Operation	Postvibrational Operation
Air Temperatures (°F), Dry Bulb				
Entering Evaporator	78	83	79	80
Leaving Evaporator	89	94	96	103
Electrical Characteristics				
Voltage, Average	115	115	115	115
Amperage, Average	10.50	10.75	18.10	18.60
Wattage, Total	1,175	1,225	2,010	2,090
Power Factor (%)	96.86	99.1	96.58	97.7
Evaporator Fan Speed (rpm)	3,510	3,520	3,510	3,520

Table LXIV. Ventilation Test Results, Pre and Postvibrational, Model MC11HAL6-115

Measurement	VENT	
	Previbrational Operation	Postvibrational Operation
Air Temperatures (°F), Dry Bulb		
Entering Evaporator	77	92
Leaving Evaporator	81	93
Electrical Characteristics		
Voltage, Average	116	115
Amperage, Average	2.68	2.60
Wattage, Total	288	284
Power Factor (%)	92.6	95.0
Evaporator Fan Speed (rpm)	3,520	3,520

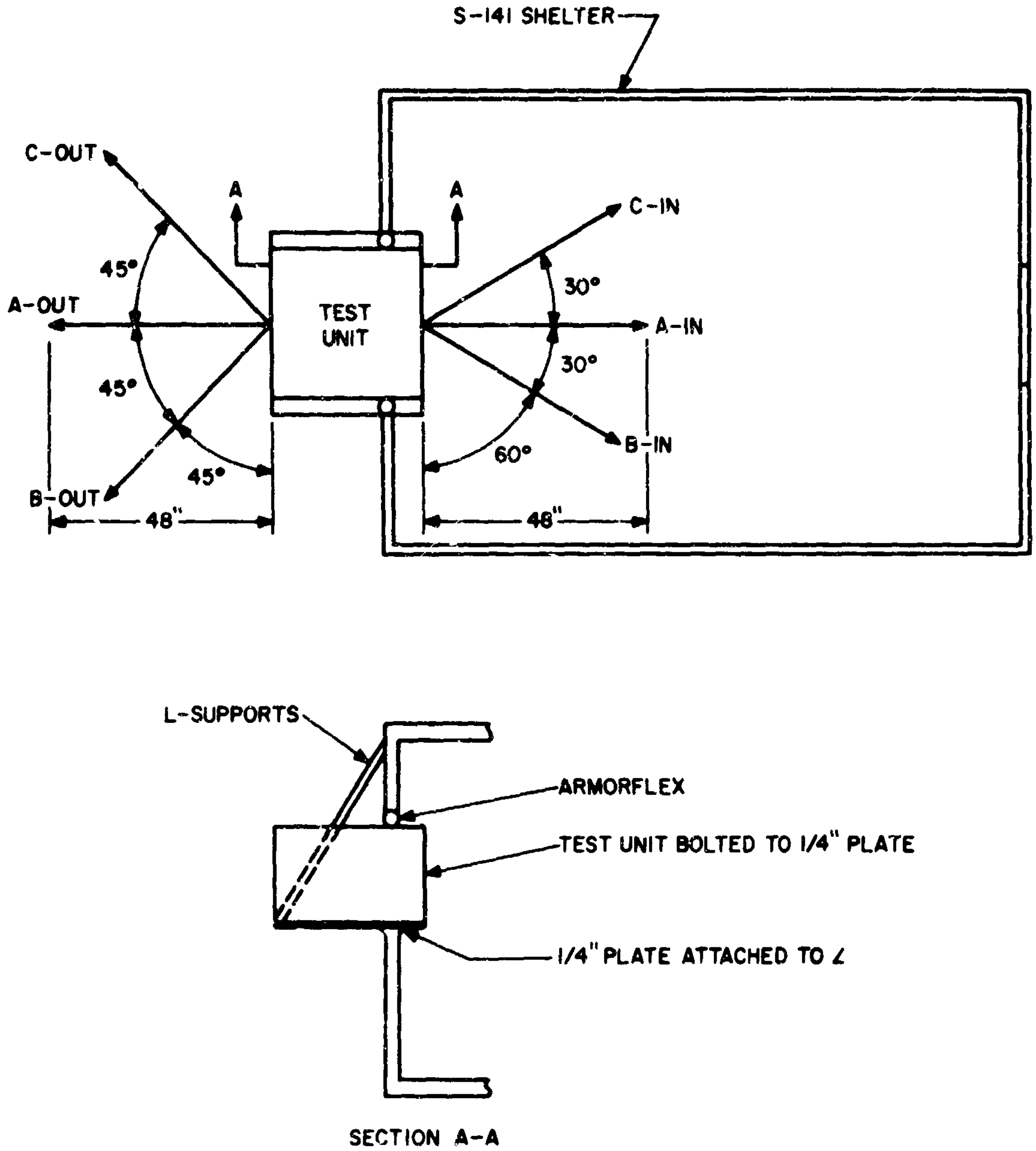


Fig. 14. Simulated application, sound test setup.

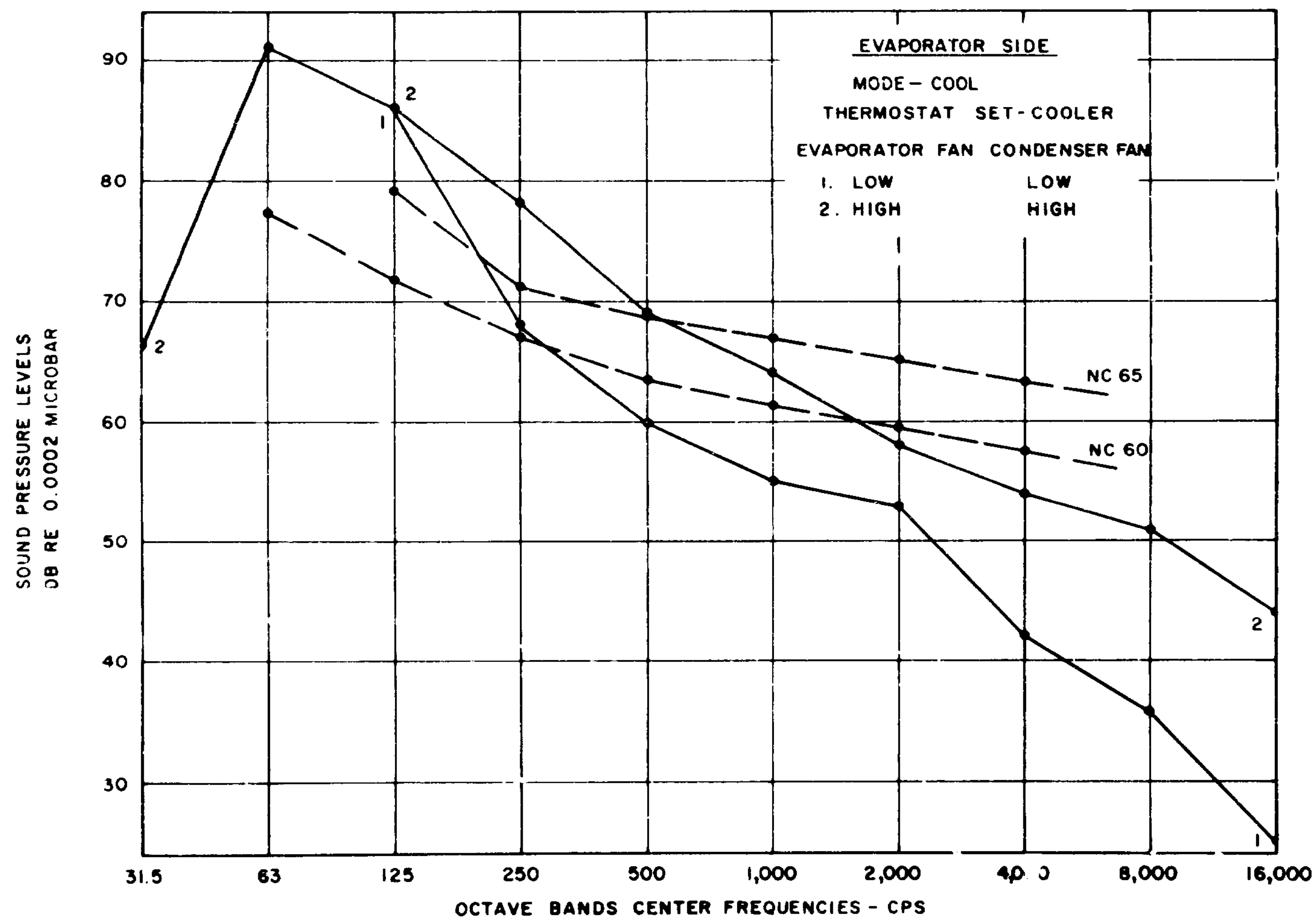


Fig. 15. Results of sound test, Model MC11HAL6-115.

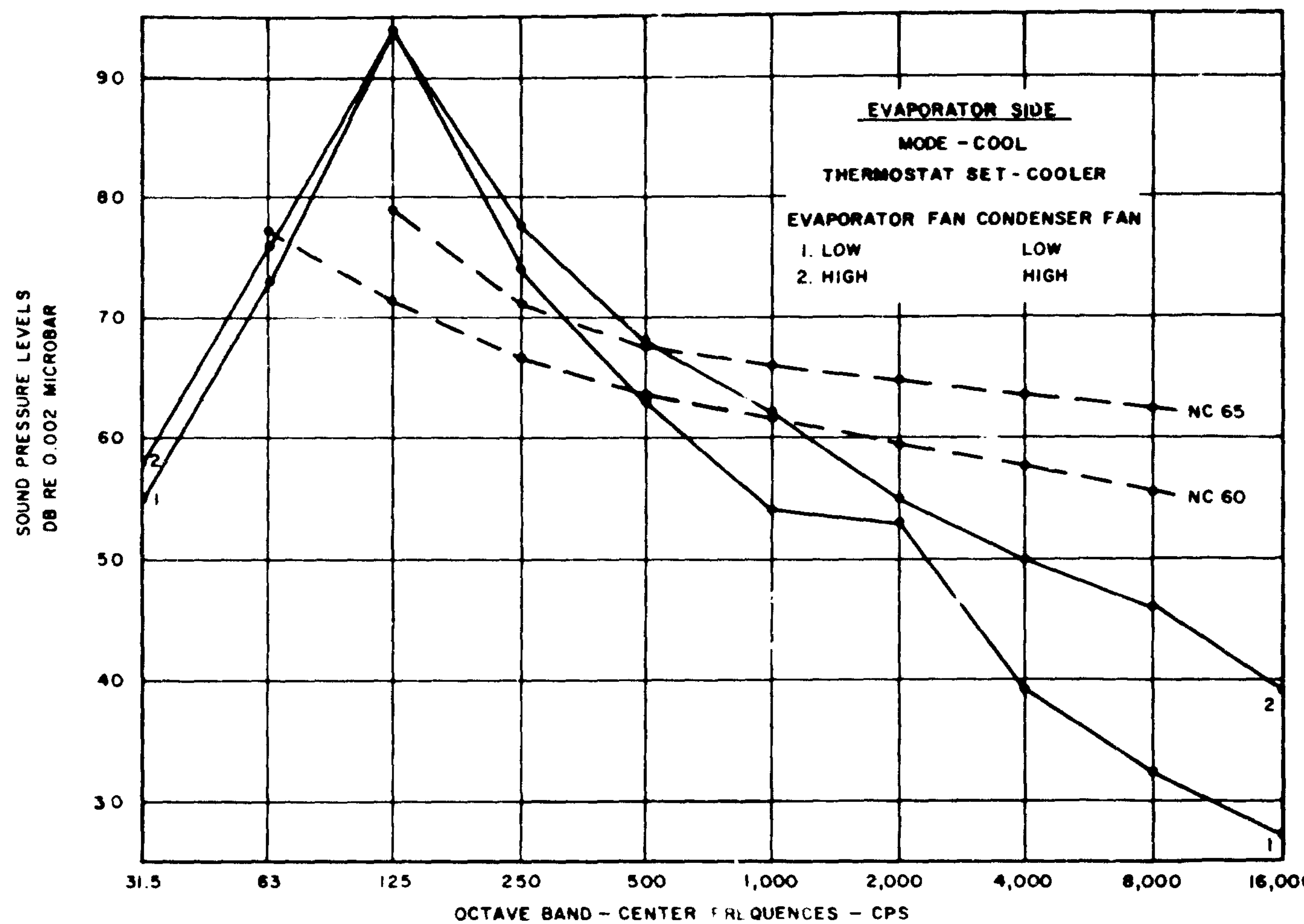


Fig. 16. Results of sound test, Model MC11HAL4-208.

Table LXV. Results of Acoustical Noise, Simulated Application Test, Model MC11HAL6-115 Air-Conditioning Unit (VENT; Evaporator Side)

Measurement	Corrected Sound Pressure Level (db Re 0.0002 microbar)					
	Evaporator Fan High Microphone Position			Evaporator Fan Low Microphone Position		
	A	B	C	A	B	C
Weighted Scales						
A	65.5	64.0	65.0	64.0	59.0	60.0
B	72.5	70.0	71.0	75.0	69.0	71.0
C	76.0	74.0	74.0	79.0	73.0	75.0
LIN	76.0	74.0	74.0	79.0	73.0	75.5
Octave Band Center Frequency (cps)						
31.5	50.0	51.0	47.8	54.5	52.2	61.5
63	70.5	70.5	67.6	60.5	--	--
125	74.0	69.5	71.0	79.5	73.0	75.0
250	66.0	66.5	67.5	56.5	59.0	61.0
500	63.0	62.5	62.5	52.5	48.0	50.0
1,000	60.5	59.0	60.0	53.5	48.0	45.5
2,000	55.0	54.5	54.5	59.5	54.0	45.5
4,000	51.5	52.0	51.0	37.0	36.5	36.0
8,000	47.5	48.5	46.5	30.0	29.5	29.0
16,000	39.0	42.5	40.0	25.0	22.5	23.5

Note: Hyphens signify that these data were not taken.

Table LXVI. Results of Acoustical Noise, Simulated Application Test, Model MC11HAL6-115
(COOL; Evaporator Side, Condenser Side)

Measurement	Corrected Sound Pressure Level (db Re 0.0002 microbar)						
	Evaporator Fan High Microphone Position			Condenser Fan High Microphone Position			Condenser Side (Average SPL, db)
	A	B	C	D	E	F	
Weighted Scales							
A	77.0	76.5	79.0	80.0	81.0	79.5	80.0
B	90.0	89.0	92.5	83.0	84.5	82.5	83.0
C	93.5	93.0	96.5	85.0	86.0	84.0	85.0
LIN	93.5	93.0	96.5	85.0	86.0	84.0	85.0
Octave Band Center Frequencies (cps)							
31.5	57.5	58.0	59.0	--	--	--	--
63	77.0	73.0	77.0	69.0	70.0	67.2	69.0
125	94.0	93.0	96.5	82.5	83.5	81.0	82.0
250	77.0	79.0	80	73.0	75.0	73.0	74.0
500	68.5	67.0	72	78.5	81.0	78.5	79.0
1,000	61.0	62.0	62.5	75.0	74.5	73.5	74.0
2,000	54.5	55.0	55	72.0	70.5	71.0	71.0
4,000	50.5	52.0	49	68.0	68.5	68.0	68.0
8,000	46.0	48.5	44.5	64.5	67.0	61.5	64.0
16,000	37.5	42.5	38.0	55.5	62.0	52.0	56.0

Note: Hyphens signify that these data were not taken.

Table LXVII. Results of Acoustical Noise, Simulated Application Test, Model MC11HAL6-115 (COOL; Evaporator Side, Condenser Side)

Measurement	Corrected Sound Pressure Level (db Re 0.0002 microbar)					
	Evaporator Fan High Microphone Position			Condenser Fan Low Microphone Position		
	A	B	C	D	E	F
Weighted Scales						
A	76.5	76.0	78.0	69.5	68.5	65.5
B	89.0	89.0	91.0	80.5	86.5	76.0
C	93.5	93.0	95.0	84.5	84.5	80.0
LIN	93.5	93.0	95.5	85.0	84.5	80.0
Octave Band Center Frequencies (cps)						
31.5	54.5	55.5	58.0	59.8	--	--
63	74.0	73.5	75.0	68.5	69.0	66.0
125	93.0	93.5	95.0	85.0	85.5	80.0
250	72.0	73.5	76.0	62.5	63.5	61.5
500	63.5	65.0	68.0	63.5	62.0	62.0
1,000	60.0	60.0	60.5	60.0	58.0	57.5
2,000	55.0	54.0	54.0	57.0	56.0	55.0
4,000	50.5	51.0	49.5	53.5	52.0	52.5
8,000	46.0	42.5	44.5	52.5	51.0	47.5
16,000	37.5	41.5	38.0	50.5	51.0	44.0

Note: Hyphens signify that these data were not taken.

Table LXVIII. Results of Acoustical Noise, Simulated Application Test, Model MC11HAL6-115 (COOL: Evaporator Side, Condenser Side)

Measurement	Corrected Sound Pressure Level (db Re 0.0002 microbar)					
	Evaporator Fan Low Microphone Position			Condenser Fan High Microphone Position		
	A	B	C	D	E	F
Weighted Scales						
A	75.5	76.5	79.0	85.0	80.5	79.5
B	90	89.0	92.5	83.0	84.0	82.5
C	93.5	93.0	96.5	86.0	85.5	84.0
LIN	93.5	93.0	97.0	86.0	85.5	84.0
Octave Band Center Frequencies (cps)						
31.5	58.0	59.0	63.0	--	--	--
63	77.0	71.5	78.5	65.7	57.6	64.4
125	93.0	92.5	96.5	83.0	82.5	81.0
250	76.5	82.0	81.5	73.0	73.5	73.0
500	66.5	62.5	71.5	78.5	79.0	79.5
1,000	57.5	58.0	60.5	75.0	74.0	73.5
2,000	54.5	54.0	52.0	72.0	71.0	20.5
4,000	39.0	40.0	41.0	68.0	67.5	67.5
8,000	33.0	33.0	33.5	64.0	66.5	61.5
16,000	36.5	26.0	28.0	55.5	61.5	53.0

Note: Hyphens signify that these data were not taken.

Table LXIX. Results of Acoustical Noise, Simulated Application Test, Model MC11HAL6-115
(COOL; Evaporator Side, Condenser Side)

Measurement	Corrected Sound Pressure Level (db Re 0.0002 microbar)						
	Evaporator Fan Low Microphone Position			Condenser Fan Low Microphone Position			Condenser Side (Average SPL, db)
	A	B	C	D	E	F	
Weighted Scales							
A	76.5	76.5	79.0	69.5	68.0	66.5	68.0
B	90.0	89.0	92.0	81.0	76.5	77.0	78.0
C	93.5	93.5	96.0	85.0	84.0	81.0	83.0
LIN	93.5	93.5	96.0	85.5	84.0	81.0	84.0
Octave Band Center Frequencies (cps)							
31.5	51.2	52.0	61.0	--	--	--	--
63	72.0	72.0	74.0	62.8	62.7	60.0	62.0
125	93.0	93.5	96.0	85.5	84.0	81.5	84.0
250	70.5	72.0	77.5	62.5	62.5	61.5	62.0
500	58.5	63.5	69.0	63.5	63.0	61.5	63.0
1,000	52.5	53.5	57.0	60.0	58.0	58.0	59.0
2,000	54.5	53.0	51.5	56.0	56.0	55.5	56.0
4,000	37.5	40.0	38.5	54.0	52.5	53.0	55.0
8,000	32.0	35.5	30.0	51.0	48.5	47.0	49.0
16,000	27.0	30.0	25.0	52.5	47.0	43.0	48.0

Note: Hyphens signify that these data were not taken.

Table LXX. Results of Acoustical Noise, Simulated Application Test, Model MC11HAL4-208 (VENT: Evaporator Side)

Measurement	Corrected Sound Pressure Level (db Re 0.0002 microbar)					
	Evaporator Fan High Microphone Position			Evaporator Fan Low Microphone Position		
	A	B	C	A	B	C
Weighted Scales						
A	67.0	66.0	67.0	59.0	56.7	59.6
B	72.0	69.5	72.0	62.3	--	58.2
C	76.5	--	76.5	73.9	--	75.6
LIN	77.0	75.3	77.0	76.5	--	77.5
Octave Band Center Frequencies (cps)						
31.5	49.7	--	49.5	76.5	--	77.5
63	77.0	--	75.0	--	--	--
125	--	--	67.0	--	--	67.7
250	67.1	69.0	68.5	52.5	65.5	54.5
500	64.5	62.0	64.0	49.5	46.0	49.0
1,000	62.0	61.0	63.0	52.0	50.0	53.5
2,000	58.0	57.5	59.0	56.5	53.0	57.0
4,000	54.0	54.5	54.0	41.5	43.0	42.0
8,000	51.0	52.0	50.5	36.5	37.0	36.0
16,000	43.0	45.5	44.0	--	24.8	--

Note: Hyphens signify that these data were not taken.

Table LXXI. Results of Acoustical Noise, Simulated Application Test, Model MC11HA L4-208 (COOL: Evaporator Side, Condenser Side)

Measurement	Corrected Sound Pressure Level (db Re 0.0002 microbar)						
	Evaporator Fan High Microphone Position			Condenser Fan High Microphone Position			Condenser Side (Average SPL, db)
	A	B	C	D	E	F	
Weighted Scales							
A	73.0	75.5	78.5	83.0	83.0	81.5	82.5
B	84.0	86.5	91.0	84.5	85.5	84.0	84.7
C	91.0	91.5	95.5	86.0	87.5	87.0	86.8
LIN	91.5	92.0	95.5	86.0	87.5	87.0	86.8
Octave Band Center Frequencies (cps)							
31.5	64.5	65.5	67.5	--	--	--	--
63	92.0	89.0	92.0	80.5	68.0	82.0	76.8
125	74.4	88.5	94.0	75.0	83.0	82.0	80.0
250	75.0	77.0	82.5	75.5	78.5	74.5	76.1
500	69.0	68.0	68.5	81.0	81.5	80.0	80.8
1,000	64.5	64.5	64.5	78.5	79.0	78.0	78.5
2,000	59.0	58.0	58.0	75.0	73.0	73.0	73.6
4,000	54.5	54.5	54.0	71.0	68.0	70.5	69.8
8,000	50.5	52.0	50.0	67.0	68.0	64.5	66.5
16,000	43.5	45.5	44.0	57.5	64.0	57.0	60.1

Note: Hyphens signify that these data were not taken.

Table LXXII. Results of Acoustical Noise, Simulated Application Test, Model MC1'HA L4-208 (COOL; Evaporator Side, Condenser Side)

Measurement	Corrected Sound Pressure Level (db Re 0.0002 microbar)					
	Evaporator Fan High Microphone Position			Condenser Fan Low Microphone Position		
	A	B	C	D	E	F
Weighted Scales						
A	68.0	75.0	78.5	65.0	67.5	69.0
B	74.0	86.5	90.5	71.0	78.0	79.5
C	78.0	90.0	94.0	74.5	82.0	82.5
LIN	79.5	90.5	94.0	75.0	82.5	82.5
Octave Band Center Frequencies (cps)						
31.5	74.0	74.0	71.5	79.0	60.7	--
63	76.0	73.0	71.5	71.0	73.5	68.0
125	72.0	89.0	94.0	71.5	82.0	82.5
250	69.0	71.5	73.0	60.5	62.0	62.0
500	65.5	62.5	65.0	64.0	61.5	62.5
1,000	62.0	61.5	62.5	59.5	58.5	57.5
2,000	58.5	59.0	58.0	57.5	56.5	55.5
4,000	[illegible]	54.0	53.5	53.5	53.0	51.5
8,000	[illegible]	52.0	50.00	50.00	50.0	47.0
16,000	43.5	43.5	43.5	46.0	48.5	44.0

Note: Hyphen signifies that these data were not taken.

Table LXXIII. Results of Acoustical Noise, Simulated Application Test, Model MC11HAL4-208 (COOL; Evaporator Side, Condenser Side)

Measurement	Corrected Sound Pressure Level (db Re 0.0002 microbar)					
	Evaporator Fan Low Microphone Position			Condenser Fan High Microphone Position		
	A	B	C	D	E	F
Weighted Scales						
A	71.0	75.5	80.0	83.0	82.0	82.5
B	83.0	87.5	92.0	84.5	85.5	85.0
C	90.5	92.0	96.0	86.5	87.0	87.0
LIN	91.0	92.5	96.0	86.5	87.5	87.5
Octave Band Center Frequencies (cps)						
31.5	75.5	73.0	73.5	--	59.7	57.8
63	90.5	89.0	90.5	80.0	75.5	82.5
125	79.0	90.0	95.0	74.5	82.5	82.0
250	74.0	78.0	80.0	79.5	80.5	76.5
500	67.0	68.0	71.0	81.0	79.5	80.0
1,000	62.0	62.0	63.0	79.5	81.5	79.0
2,000	56.5	54.0	54.5	74.5	72.0	72.5
4,000	45.5	44.5	44.5	70.5	69.0	70.5
8,000	38.0	38.0	37.0	67.0	68.0	64.5
16,000	28.4	26.3	26.0	59.5	63.5	58.0

Note: Hyphen signifies that these data were not taken.

Table LXXIV. Results of Acoustical Noise, Simulated Application Test, Model MC11HAL4-208 (COOL; Evaporator Side, Condenser Side)

Measurement	Corrected Sound Pressure Level (db Re 0.0002 microbar)						
	Evaporator Fan Low Microphone Position			Condenser Fan Low Microphone Position			Condenser Side (Average SPL, db)
	A	B	C	D	E	F	
Weighted Scales							
A	62.0	72.0	78.0	66.0	69.5	68.5	68.0
B	72.0	84.0	91.0	69.0	80.0	80.0	76.3
C	78.0	87.5	94.5	70.8	83.5	83.0	79.3
LIN	79.0	87.5	94.5	70.4	84.0	83.5	79.3
Octave Band Center Frequencies (cps)							
31.5						57.8	
63					60.0		
125	75.5	88.0	94.5	69.0	84.0	83.0	78.6
250	62.0	67.0	73.5	60.0	64.0	62.0	62.0
500	55.5	57.0	66.0	65.0	64.5	64.0	64.5
1,000	54.0	54.0	57.5	61.5	60.5	59.0	60.3
2,000	54.0	51.0	54.0	58.0	57.5	56.5	57.3
4,000	42.5	43.5	41.0	54.0	53.0	53.0	53.3
8,000	37.5	37.0	35.0	51.0	51.0	47.5	49.8
16,000	24.8	25.5	25.2	48.0	49.5	44.5	47.3

Note: Blank spaces indicate data were not available.

v. <u>Heater High-Limit Cutout</u>. The heater high-limit cutout test was conducted on Model MC11HAL6-208 to determine if the heater high-limit device functioned properly.

The evaporator fan motor was disconnected to simulate fan motor failure. The heaters were turned on and remained on until the high-temperature cutout device deenergized the heaters when a predetermined maximum temperature was obtained. The temperatures from start to cutout and from cutout to cut-in of the protective device were measured on calibrated instruments.

The heater high-limit cutout device on the unit actuated after 2 minutes, by which time the temperature had reached 324° F. The cut-in time, after cutout, was 28 minutes with the temperature having dropped to 108° F.

Results of heater hi-limit test, Model MC11HAL6-208 follow:

(1) Fan Running: High-Speed HI-HEAT Mode
Air Temperature at Protector - 85° F

(2) Fan Running: Low-Speed HI-HEAT Mode
Air Temperature at Protector - 100° F

(3) Blocked Evaporator Inlet - Fan Running, High-Speed HI-HEAT Mode
Air Temperature at Protector - 185° F at Cutout
108° F at Cut-in

(4) Blocked Evaporator Inlet - Fan Running, Low-Speed, HI-HEAT Mode
Air Temperature at Protector - 163° F at Cutout
108° F at Cut-in

(5) Fan OFF - HI HEAT
Air Temperature at Protector - 305° F at Cutout
108° F at Cut-in
(cycle repeated six times)

(6) Fan OFF - LO HEAT
Air Temperature at Protector - 324° F at Cutout
108° F at Cut-in
(cycle repeated six times)

(7) The conditions just referenced in (5) were again produced, and the unit was allowed to cycle at those conditions for 75 hours. Afterwards, the unit was examined and operated without damage or change in performance. Figure 17 indicates the cut-in and cutout cycle.

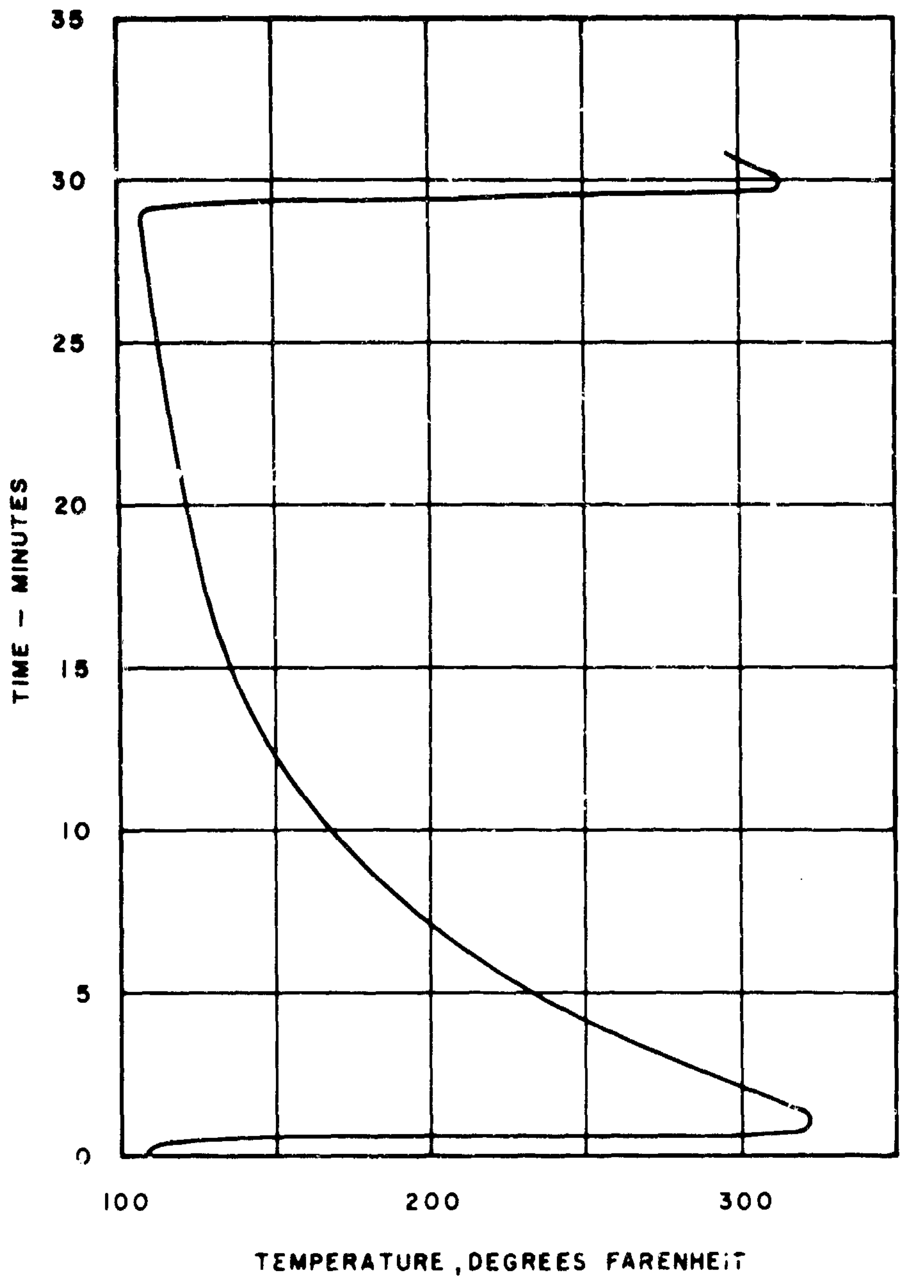


Fig. 17. Results of high-temperature cutout test, Model MC11HAL6-208.

w. Voltage and Frequency Variation. The voltage and frequency variation tests were conducted to determine the ability of the air conditioners to operate under temperature conditions of 120° F ambient and 90° F return air. Deviations from nameplate voltage and frequency are given in Table LXXV.

Table LXXV. Deviations in Rated Voltage and Rated Frequency

Deviation	Rated Voltage (%)	Rated Frequency (%)
(a)	95	100
(b)	110	100
(c)	100	95
(d)	90	95
(e)	105	95
(f)	100	105
(g)	90	105
(h)	105	105

Each unit was installed in a balanced-ambient room-type calorimeter as described in ASHRAE Standard 16-61. The tests were conducted in accordance with USAERDL Environmental Test Procedure No. 300, "Voltage and Frequency-Variation Cycling." Operational tests with the 60-cycle units at 50 cycles were omitted because these were conducted during the cooling capacity tests. The stopping and restarting requirement was also waived.

The results of the MC11HAL4-208 unit tests indicated a problem with the condenser fan motor protector which would not allow the unit to complete all of the tests properly. Further investigation has shown that the circuit opened prematurely, and the proper setting has been redesigned into the motor protector.

Results of the voltage and frequency variation tests are shown in Table LXXVI.

x. Physical Characteristics and Safety. Initial inspections of the air conditioner included those for size, weight, freedom from sharp edges, ease of handling, and protective devices for thermal, pressure, and current overload. In addition, inspections for safety and simplicity of

Table LXXVI. Results of Voltage-Frequency Variation Tests

Variation*	Model MC11HAL6-230			Model MC11HAL6-208			Model MC11HAL4-208		
	Voltage	Frequency	Operation	Voltage	Frequency	Operation	Voltage	Frequency	Operation
none	230	60	yes	230	60	yes	208	400	yes
(a)	218	60	yes	218	60	yes	197	400	yes
(b)	253	60	yes	253	60	yes	229	400	no
(c)	230	50	-	230	50	-	208	380	no
(d)	218	50	-	218	50	-	197	380	yes
(e)	242	50	-	242	50	-	219	380	no
(f)	230	63	yes	230	63	yes	208	420	yes
(g)	218	63	yes	218	63	yes	197	420	yes
(h)	242	63	yes	242	63	yes	219	420	yes

Note: Hyphens indicate 60-cycle units have operated satisfactorily at 50 cycles during cooling capacity tests.

* Refer to Table LXXV.

operation were made during the functional, operational, and environmental tests. Observations and results are presented in Table LXXVII.

Table LXXVII. Results of Physical Characteristics and Safety Tests

Electrical Type	Model	Weight (lb)	Dimensions (in.)
115/1/60	MC11HAL6-115	194	16-1/16 H x 23-3/4 W x 26-3/8 D
230/1/60	MC11HAL6-130	183	"
208/3/60	MC11HAL6-208	190	"
208/3/400	MC11HAL4-208	184	"

The units have been examined and determined to meet the following requirements in addition to those outlined in Section II of this report:

(1) Access limited to front, top, and back to permit side-by-side multiple installation.

(2) Carrying handles, tiedown fittings, and mounting provisions.

(3) Use of standard refrigerant and standard lubricants.

(4) High-pressure cutout safety device operates at:

(a) 436 psig for the 60-cycle unit.

(b) 443 psig for the 400-cycle unit.

(5) Heater high limit cuts off at 324° F at the most severe condition.

(6) In addition to tests for complete units, certain component testing was accomplished during development. An example is the high-pressure relief valve. Results of tests of five random samples (Table LXXVIII) follow:

Table LXXVIII. Results of High-Pressure Relief Valve Test

Sample	Initial Test Pressure (psig)			Final Test Pressure (psig)		
	Leak	Crack	Reset	Leak	Crack	Reset
1	560	505	505	530	540	505
2	565	580	520	540	540	520
3	560	580	525	540	540	520
4	520	530	470	500	200	480
5	605	605	510	530	550	520

If the high-pressure cutout (4) in the previous list of requirements, fails, then the high-pressure relief valve will relieve at approximately 60-psi additional pressure.

(7) The following observations on the safety aspect of the test items were made by USATECOM personnel in Report No. DPS-2173:

(a) No sharp edges or corners were found.

(b) The compressor was protected against over-currents by a circuit breaker which also disconnects the unit control circuit.

(c) The units were provided with four handles for lifting and carrying; these were adequate.

(d) The compressor, condenser fan, and evaporator fan motors were all protected with thermal cutouts.

(e) The refrigerant circuit was equipped with a low- and a high-pressure cutout which would stop the compressor.

(f) The heaters were protected by a thermal cutout.

No evidence of features which would constitute a hazard to personnel were found. In addition, the unit was suitably provided with protective devices to prevent undue damage.

y. <u>Blocked Air Inlet.</u> These tests were conducted on the Model MC11HAL4-208 to determine the effect of restricted airflow on air-conditioner operation.

(1) <u>Blocked Condenser Air Inlet</u>. The requirements here are that the unit operate without damage or failures, and that the compressor high-pressure cutout stop the compressor at a pressure not exceeding 510 psig.

The unit was installed and operated in the performance test chamber. Compressor discharge pressure was increased by operating the unit with the condenser fan at slow speed and with the air entering the condenser at 120° F. Refrigerant pressures were observed and recorded. The compressor high-pressure cutout switch was activated by an overpressure condition four times. After each time the circuit opened prematurely, the compressor was started manually by depressing the high-pressure reset switch.

The cutout pressure was between 438 psig and 445 psig. No unit malfunctions were observed during this test. The unit functioned normally at the conclusion of the test. Results are shown in Table LXXIX.

Table LXXIX. Results of Blocked Condenser Air Inlet Test, Model MC11HAL4-208

Pass	Suction Pressure (psig)		Discharge Pressure (psig)	
Number	At Start	At Cutout	At Start	At Cutout
1	188	92	190	436
2	188	93	192	435
3	190	95	194	435
4	197	98	203	434

(2) <u>Blocked Evaporator Air Inlet</u>. The requirements here are that the unit shall operate with a blocked evaporator air inlet without damage or failure, and return to normal operation upon removal of the restriction.

The unit was installed in the performance test room and stabilized on the test conditions listed in the first (open) column of Table LXXX. With the unit in the COOL mode, the evaporator air grille was gradually closed to provide the greatest restriction possible, although sufficient airflow was present to determine air temperatures. Operation continued for 1 hour, after which the grille was opened to provide for normal airflow.

During the test, no damage or failures occurred. Data were recorded, and the results are shown in Table LXXX.

z. Shock. The mechanical shock test was conducted on Model MC11HAL6-115 to determine the ability of the air conditioner to withstand extremely rough handling in military service.

Shock tests were conducted in accordance with MIL-STD 810A, Procedure I, "Basic Design Test" (7). This procedure included a preoperational test, the shock tests, an inspection for any component or structural failure, and a postoperational test. During the shock tests, the air conditioner was required to withstand without damage a shock of 20 g's with a duration of 10 milliseconds. The AVCO Model SM-030-1 machine was adjusted to provide these conditions.

The air conditioner was adapted to the shock machine by means of a rigid adapter base to which the unit was secured by straps. The output of the accelerometer used for sensing the shock was displayed on a scope and then recorded with a Polaroid camera. This instrumentation showed shock pulses with impacts up to 22 g's and durations up to 16 milliseconds during the test. Results are shown in Table LXXXI.

Inspection and postoperational testing showed no structural, electrical, mechanical, or component defects. Comparative test results are shown in Tables LXXXII through LXXXIV.

aa. Rain. The rain test was conducted to determine if the unit would be undamaged and function properly after exposure to rain environment. This test was conducted on the 18,000-Btu/hr Model MC20HAL6-208. As has been stated previously, the test findings for both the 18,000-Btu/hr and the 9,000-Btu/hr units were valid, because they are similar in mechanical construction and identical in materials and finishes.

The unit was installed in an S-141 Shelter. An operational check showed normal performance. The unit was tested under three different modes (storage or OFF, VENT, and COOL) under conditions of varying rainfall rate and wind velocity.

Table LXXX. Results of Blocked Evaporator Air Inlet Test, Model MC11HAL4-208

Measurement	Grille Position: Open	Closed	Closed	Closed	Open
		Interval after Full Inlet Closure (min)			
		0	20	60	
Air Temperatures (^oF)					
Entering Evaporator, Dry Bulb	90.0	90.0	90.0	90.0	90.0
Entering Evaporator, Wet Bulb	62.0	62.0	63.0	63.0	62.0
Leaving Evaporator, Dry Bulb	69.0	52.0	52.0	50.0	69.0
Entering Condenser, Dry Bulb	120.0	120.0	121.0	119.0	120.0
Leaving Condenser, Dry Bulb	142.0	131.0	132.0	130.0	142.0
Refrigerant Temperatures (^oF)					
Discharge Line	230.0	195.0	200.0	203.0	223.0
Condenser Out	148.0	131.0	133.0	129.0	147.0
Subcooler Out	139.0	128.0	130.0	125.0	138.0
TEV In	136.0	121.0	124.0	120.0	135.0
Suction at TEV Bulb	68.0	37.0	38.0	37.0	68.0
Suction at Compressor	74.0	36.0	37/30	37/25	74.0
Suction Pressure Regulating Valve Out	138.0	140.0	144.0	148.0	133.0
Quench Out	134.0	129.0	131.0	132.0	132.0
Equalization Solenoid Valve Out	143.0	138.0	139.0	138.0	146.0
Precooler In	233.0	204.0	207.0	208.0	229.0
Precooler Out	220.0	190.0	193.0	192.0	216.0
Subcooling at Subcooler	8.3				9.3
Subcooling at TEV	11.3				12.3
Superheat at TEV Bulb	16.0				16.0
Superheat at Compressor	22.0				22.0
Compressor Skin Temperature (^oF)	213.0	180.0	185.0	188.0	208.0
Discharge Pressure (psig)	366/372	312	313	308	366/372
Suction Pressure (psig)	86/89	63	63	62	86/89
Electrical Characteristics					
Voltage, Average	208.0				208.0
Amperage, Average	16.49				16.65
Wattage, Total	3,075				3,095
Power Factor (%)	51.8				51.5

Note: All blank spaces denote values were not applicable.

Table LXXXI. Shock Test Results, Model MC11HA L6-115

Measurement	Shock	Acceleration Level (g)	Duration (msec)
Mounting Base	1	19.0	16
	2	20.0	16
	3	20.0	16
Condenser	4	21.0	13
	5	19.0	13
	6	19.6	13
Right Side	7	19.0	13
	8	18.5	13
	9	19.5	13
Evaporator	10	19.2	13
	11	20.0	13
	12	19.8	13
Left Side	13	22.0	13
	14	22.0	13
	15	22.0	13
Top	16	22.0	13
	17	22.0	13
	18	22.0	13

Table LXXXII. Cooling Operation Test Results, Preshock and Postshock, Model MC11HAL6-115

Measurement	Mode			
	COOL - Cooler		COOL - Warmer	
	Preshock	Postshock	Preshock	Postshock
Air Temperatures (^{o}F)				
Entering Evaporator, Dry Bulb	90.0	90.0	87.0	87.0
Entering Evaporator, Wet Bulb	62.0	65.0	61.0	64.0
Leaving Evaporator, Dry Bulb	66.0	68.0	90.0	93.0
Entering Condenser, Dry Bulb	120.0	120.0	120.0	119.0
Leaving Condenser, Dry Bulb	144.0	143.0	127.0	125.0
Refrigerant Temperatures (^{o}F)				
Discharge Line	237.0	-	227.0	-
Condenser Out	149.0	149.0	123.0	122.0
Subcooler Out	139.0	140.0	121.0	120.0
TEV In	138.0	138.0	108.0	168.0
Suction at TEV Bulb	53.0	52.0	85.0	93.0
Suction at Compressor	73.0	73.0	94.0	101.0
Suction Pressure Regulating Valve Out	86.0	83.0	121.0	134.0
Quench Out	59.0	58.0	35.0	34.0
Equalization Solenoid Valve Out	122.0	122.0	132.0	132.0
Precooler In	233.0	234.0	238.0	242.0
Precooler Out	205.0	204.0	191.0	192.0
Subcooling at Subcooler	9.8	10.2	2.9	2.9
Subcooling at TEV	10.8	11.7	-	-
Superheat at TEV Bulb	1.2	0.5	-	-
Superheat at Compressor	21.2	20.5	70.1	77.5
Compressor Skin Temperature (^{o}F)	225.0	225.0	213.0	214.0
Discharge Pressure (psig)	376.0	380.0	274.0	272.0
Suction Pressure (psig)	87.0	86.5	47.5	47.0
Electrical Characteristics				
Voltage, Average	115.0	116.0	116.0	116.0
Amperage, Average	23.40	23.50	18.65	18.70
Wattage, Total	2,570	2,610	2,025	2,030
Power Factor (%)	95.5	95.7	93.6	93.6
Evaporator Fan Speed (rpm)	-	3,520	-	3,510
Condenser Fan Speed (rpm)	-	3,480	-	3,480

Note: Hyphens signify that these data were not taken.

Table LXXXIII. Heating Operation Test Results, Preshock and Postshock, Model MC11HAL6-115

Measurement	Mode			
	LO HEAT Warmer		HI HEAT Warmer	
	Preshock	Postshock	Preshock	Postshock
Air Temperatures (^{o}F), Dry Bulb				
Entering Evaporator	88.0	86.0	88.0	86.0
Leaving Evaporator	96.0	99.0	101.0	99.0
Electrical Characteristics				
Voltage, Average	115.0	115.0	115.0	115.0
Amperage, Average	10.7	10.7	18.5	10.7
Wattage, Total	1,210	1,220	2,105	1,220
Power Factor (%)	98.3	99.1	98.9	99.1
Evaporator Fan Speed (rpm)	-	3,510	-	3,510

Note: Hyphens signify that these data were not taken.

Table LXXXIV. Ventilation Test Results, Preshock and Postshock, Model MC11HAL6-115

Measurement	VENT Mode	
	Preshock	Postshock
Air Temperatures (^{o}F), Dry Bulb		
Entering Evaporator	90.0	90.0
Leaving Evaporator	91.0	92.0
Electrical Characteristics		
Voltage, Average	115.0	115.0
Amperage, Average	2.64	2.60
Wattage, Total	282.0	278.0
Power Factor (%)	92.8	92.9
Evaporator Fan Speed (rpm)	-	3,520

Note: Hyphen signifies that these data were not taken.

(1) Storage or OFF. This portion of the rain test was run with the switch in the OFF position, the condenser weather cover installed, all drains open, and the fresh-air damper closed (Table LXXXV). Rain was applied in the following sequence:

Table LXXXV. Application of Precipitation and Wind Velocity in Storage Test

Condition	Duration (hr)	Duration (min)	Rain Rate (in./hr)	Wind Speed (knots)
1	5	0	2	5-35
2	2	0	4	5-35
3	0	10	12	5-35
4	0	1	21	5-35
5	4	49	2	5-35

After the condenser weather cover was removed, the unit was opened and examined. The condenser section components were wet, but no water accumulated in the base. The junction box, the control module, and the evaporator air plenum were dry; but water accumulated to a depth of 1/4 inch in the blower air inlet section.

A postoperational test in all modes and fan speeds showed normal performance.

(2) Ventilation. This portion of the rain test was run with the unit in the VENT mode, the condenser weather cover raised, all drains open, and the fresh-air damper open.

Results of this portion of the rain test are shown in Table LXXXVI. Under conditions prevailing at the end of the vent phase of the rain test, the unit performed normally in all modes and fan speeds.

(3) Cooling. During this portion of the rain test the unit was set in the COOL mode, the evaporator fan at high speed, the condenser fan on automatic, and the fresh-air damper closed. At the start of the cooling phase, water 5 inches deep was in the return-air inlet base. Results of this portion of the rain test are shown in Table LXXXVII.

Table LXXXVI. Results of Ventilation Phase of Rain Test, Model MC20HA L6-208

Test	Duration (hr)	Duration (min)	Rain Rate (in./hr)	Wind Speed (knots)	Return-Air Inlet
1	2	30	2	5-35	Water in base 1/2 in. deep.
2	1	0	4	5-35	Water in base 5/8 in. deep.
3	0	5	12	5-35	Water in base 5/8 in. deep.
4	0	0.5	21	5-35	Water above height of base flange and dripping on shelter floor.
5	2	30	2	5-35	Dripping stopped water at height of base flange.

Note: The following conditions were revealed after the ventilation phase of 5 rain tests: Condenser compartment - no water accumulation.
Evaporator compartment - dry.
Junction box - dry.
Control module - dry.

Table LXXXVII. Results of Cooling Phase of Rain Test, Model MC20HA L6-208

Test	Duration (hr)	Duration (min)	Rain Rate (in./hr)	Wind Speed (knots)	Return-Air Inlet
1	2	30	2	5-35	Water depth decreased.
2	1	0	4	5-35	Water depth decreased.
3	0	5	12	5-35	Water depth decreased.
4	0	0.5	21	5-35	Water depth decreased.
5	2	30	2	5-35	Water in base 1/4 in. deep.

Note: The following conditions were revealed after the cooling phase of 5 rain tests: Condenser compartment - some damp surfaces; components dry.
Evaporator compartment - dry.
Junction box - dry.
Control module - dry.

At the close of the rain tests, the unit operated normally in all modes and at all fan speeds.

IV. DISCUSSION

6. Analyses of Test Methods. As many tests as practical were conducted in accordance with established standard test methods and criteria and, where necessary, these were modified to incorporate military development requirement conditions. Cooling capacity tests were conducted with ASHRAE Standard 16-61 being used as a guide. The heating capacity was computed from the input power to the heating elements. The evaporator and condenser airflow rates were also measured and calculated in accordance with ASHRAE Standard 37-60. Environmental tests were conducted to include the minimum test requirements established by MIL-STD-810A (7). Several of the electrical and safety tests were conducted according to or similar to tests delineated in ARI Standard 210-62 (8). Some deviations from this standard were necessary in order to accommodate development requirements (paragraph 3a) and MIL-STD-810A criteria. Radio frequency tests were conducted in accordance with MIL-E-55301(EL) (9) with the test units classified as Tactical Equipment.

The remaining tests were conducted in accordance with criteria established by the Environmental Control Division, USAERDL, from experience and knowledge in the field of military air conditioning. This group of tests was generally not used to rate the air conditioners but was intended for use in performance estimates for applications of the units.

Throughout the test program, measurements were recorded from recently calibrated instruments with scales and ranges commensurate with the requirements of tolerance and accuracy. (The individual tests in paragraph 5 of this report show any differences between the actual test procedure and the standard procedures previously mentioned.)

Other tests planned but not formally conducted or not completed are listed by the following Environmental Control Laboratory test numbers: 103c, Condenser fan motor locked rotor and single phasing; 103d, evaporator fan motor locked rotor and single phasing; 201, refrigerant charge; 306, insulation efficiency and condensate disposal; 516b, drop; and 700, endurance.

Three units are now undergoing endurance testing. A 4,000-hour continuous operation is required for each unit. One unit has completed

3,984 hours, another 3,594 hours, and the remaining unit, 204 hours. These units have suitable instrumentation and equipment for determining pressure, temperature, and power conditions; and these operational characteristics are checked regularly.

In addition to these, further voltage variation and frequency variation tests may be desired on Model CE11HAL4-208, the 400-cycle unit.

Some of the features in the numbered tests just mentioned were partly covered in other tests. Nevertheless, the findings of any further development testing are to be covered in a future report.

7. Analyses of Test Results. The results of each test were analyzed and compared with the requirements delineated in Section II, paragraph 3.

a. The required cooling capacity of the 9,000-Btu/hr air conditioner (with dehumidification) was exceeded by all four test units. The excess ranged between 6 and 12 percent, with the 400-cycle unit showing the lowest, i.e., 9,5[illegible]0-Btu/hr capacity. A new method of securing insulation to the evaporator fan outlet was later used to improve airflow, and a better cooling performance than that resulting from the test capacity is anticipated. The 60-cycle units passed the 50-cycle tests. Capacity at 50 cycles ranged from 22 to 25 percent below the 60-cycle capacity. The losses at this condition were well below the 30 percent maximum allowed.

b. Under high-temperature operating conditions the units proved their ability: (1) to operate under conditions of constant high temperature where sufficient heat is added in order to maintain a return-air temperature of 1[illegible]0° F, and (2) to reduce the temperature within the enclosure from 150° F to 90° F with the outside ambient at 120° F.

c. The units met the low-temperature cooling operation requirement. They were able to perform cooling at 0° F.

d. The required heating capacity (6,000 Btu/hr) was exceeded by all four test units. The excess was between 10 and 42 percent.

e. The units met the test requirement of low-temperature heating operation. Tests conducted at USAERDL proved that these units were able to heat at a temperature as low as -55° F.

f. The evaporator airflow tests conducted at USAERDL and ETL showed that the required minimum of 270 cfm (against zero external resistance) was exceeded by 21 to 48 percent.

g. The condenser airflow tests conducted at USAERDL and ETL showed airflow which ranged from 550 to 700 cfm. This airflow meets the requirement for high outdoor ambient temperatures, and the fan motors operate at half speed at low outdoor ambients.

h. The minimum fresh-air (ventilation) requirement of 35 cfm was exceeded by at least 15 percent.

i. Air recirculation tests conducted at ETL show that refrigerant pressure and temperature changes did not vary beyond the tolerance limits.

j. The units passed the operational controls test. The thermostats function within $\pm 4^{\circ}$ F of any preset temperature between 60° and 90° F, and the selector switch works properly. Numerous data from USAERDL and ETL prove operational adequacy, and all safety controls to protect the unit against overpressure, overheating, and electrical overcurrent, are sufficient.

k. The units passed the coil frost test. A reduction to 95 percent of rated return airflow is permissible, and the tests conducted at ETL showed that the air delivery loss, if any, is negligible.

l. The units were able to withstand the duress of high-temperature storage. USAERDL tests showed that pretest and posttest operations were practically identical.

m. The units also passed the low-temperature storage tests conducted at USAERDL.

n. The initial humidity tests conducted by USATECOM showed some shortcomings, and USAERDL provided the necessary corrections and modifications. Later tests showed requirements have been met. The functional data in the pretest and posttest operations are practically identical.

o. The salt fog test was performed on a Model MC20HA L6-230 air conditioner and its performance under such conditions was found to be sufficient.

p. The sand and dust test findings for Model MC20HAL6-230 air conditioner are satisfactory and are substituted for all the MC11HAL units in this report.

q. No rigorous test was made for the chemical-biological requirement At inspection of the unit, examination revealed no adverse conditions, and no normal operating condition could cause unwanted contaminated air leakage.

r. The starting current tests were conducted at ETL. Oscilloscope photographs were taken on gridded film, and the root mean square current requirements were computed. The critical demand is made by switching from OFF to COOL. The unit must go through the VENT mode first. Therefore, the evaporator fan motor starts first. The contact is made to the condenser fan motor almost instantly. There is a 25-second time delay before the compressor motor starts. Rather than one great initial surge, there are at least two surges of smaller magnitude. The requirement is that these units have minimum starting current surge. The test results (Table LII and Figs. 11, 12, and 13) should be reviewed to determine generator power requirements.

s. The radio interference tests performed by USATECOM show that the measured energy from each of the units was below the radiated and conducted energy limits outlined in Specification MIL-E-55301, with Amendment No. 1. All test models satisfied the engineering test plan for tactical noncommunication equipment.

t. During the vibration tests, some failures occurred, and modifications were made. After each modification, sufficient tests were made to prove structural adequacy.

u. The noise level test results for the conditioned area show the requirements are met in the speech frequency range (1,000 to 10,000 cps); but exceed the level in the lower frequencies (60 to 500 cps). The requirements were met for the condenser side noise level limits. These are specified in USAHEL (United States Army Human Engineering Laboratories), Standard S-1-63B (10).

v. The heater high-limit cutout tests were conducted at USAERDL. The heater high-limit cutout deenergized the heaters under conditions simulating fan motor failure Under the high heat-fan off condition, the unit passed a 75-hour test period. Because neither damage nor loss was sustained in performance, the units have passed this test.

w. The 60-cycle units passed the voltage and frequency variation tests. The 400-cycle unit failed under the test conditions of voltages higher, and frequencies lower, than nameplate values. The results of the MC11HAL4-208 unit tests indicated a problem with the condenser fan motor protector which would not allow the unit to complete all of the tests properly. Further investigation has shown that the circuit opened prematurely, and the proper setting has been established for the motor protector.

x. The physical characteristics and safety test results show that the requirements of size limit, weight limit, adaptability, safety, and reliability have been met.

y. The results of the blocked air inlet tests show that the units can be operated in spite of the difficulties imposed by a blocked air passage.

z. The shock test results show that the units are sufficient to withstand the impacts normally expected in severe military use, handling, and transport.

aa. The results of the rain test suggest the following shortcomings:

(1) Leakage through or under the center wall partition.

(2) Water entering the unit through the fresh-air damper when it is open. In contrast, the ability of the unit to perform under the duress of this test is of considerable merit.

When the unit was inspected by test personnel, they believed that improvements in the fresh-air closure and application of the gaskets and seals would present no serious problem.

AR 705-15 requires only 12 hours of total test time for the rain test. Therefore, if the operational phase is of 12-hour duration and the storage phase is also of 12-hour duration to test for all possibilities, then the unit should have been completely dried before the next test phase (12 hours) was conducted after the storage test. Discussion with USATECOM personnel shows that they agree to this procedure. If the unit had been dried out after the storage phase (before the operational phase), the unit would not have dripped any water onto the shelter floor as shown in Table LXXII, and the unit would have passed the test. Better bulkhead and panel seals have been designed into the unit to decrease the water seepage into the evaporator compartment.

8. Evaluation of Units. The 60-cycle and 400-cycle compact. horizontal air conditioners, Models MC11HAL6-115, MC11HAL6-230, MC11HAL6-208, and MC11HAL4-208, are approximately the same volume as their respective compact, vertical models, and fit into approximately 14 percent less space than do the 9,000-Btu/hr standard military models. Cooling capacity and power draw compare favorably with the compact, vertical units. Power draw is approximately 28 percent greater and cooling capacity 25 percent greater than those of the conventional military units.

Because of the high sensible cooling capacities and capability of cooling with or without external ducting, these units are highly desirable for use in military vans or shelters where cooling for electronic equipment is of paramount importance. The evaporator fan wheels are a centrifugal type with forward-inclined blades which do not become overloaded with increased static resistance.

The condenser fan wheel is a propellor type which normally becomes overloaded with increased static resistance; however, being shrouded by a volute casing precludes this problem.

The refrigerant cycle is equipped with a pressure-regulating valve (hot-gas bypass) system which eliminates on and off cycling of the air conditioner. By automatically energizing and deenergizing the appropriate solenoid operated valves, the air conditioner goes from cooling to bypass which, in turn, prevents severe current surges or radio interference.

These units are part of a family development program which provides for maximum interchangeability of components and minimum supply costs. Also, personnel trained to perform maintenance operations on one of the units in the family can perform the same functions on other units in the family with a minimum of training required.

As explained in the Analyses of Test Results, some portions of the prototype air conditioners were improved during these tests. In addition, the following modifications were made to the test units during the engineering design test phase in order to complete the tests successfully.

a. Redesign of condenser discharge louver mechanism.

b. Revision of insulation adhesion method.

c. Required structural modifications which occurred during vibration testing.

d. Provision for more adequate sealing around the center partition.

e. Addition of a 0.01-microfarad capacitor between B+ of the control circuit and ground. This corrective action was required on the 18,000-Btu/hr units and was added to the 9,000-Btu/hr units for control circuit standardization. Radio frequency interference will be no greater than respective data found in Tables LIII through LVIII.

V. CONCLUSIONS

9. Conclusions. It is concluded that:

a. The nominal 9,000-Btu/hr compact, horizontal air conditioners meet the design objectives of lightweight construction.

b. All test models meet the environmental, physical, operational, and electrical requirements of the tests covered in this report.

c. The units have high cooling capacities and highly advantageous airflow characteristics.

d. The dual-speed fan motors provide the advantage of noise control.

e. The units are safe and provide simple operation.

f. The units are suitable for applications which require great cooling capacities in a small, compact space envelope.

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UNCLASSIFIED
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NOMINAL 9,000-BTU/HR, COMPACT, HORIZONTAL AIR-CONDITIONING UNITS

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Final Engineering Report

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	U. S. Army Engineer Research and Development Laboratories, Fort Belvoir, Virginia

13. ABSTRACT

Tests were conducted to evaluate and improve the prototype development of compact, horizontal 9,000-Btu/hr air-conditioning units. Functional tests included cooling capacity, heating capacity, cooling operation at return-air temperatures as high as 150° F, cooling operation at outdoor ambient air temperatures as low as 0° F, and heating operation with inside ambient temperature as low as -55° F. Tests were made to determine electrical characteristics under normal as well as conditions of voltage and frequency different from nameplate values. Environmental testing included the duress of shock, vibration, and adverse weather conditions as well as noise and radio frequency interference. Improvements were made and the resulting unit has simple operation, adequate capacity, and is sufficiently durable to operate in world-wide climates.

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14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Air conditioner, lightweight compact, horizontal environmental control unit; family of air conditioners; heating and cooling for prefab structures, vans, shelters, and missile systems in world wide applications						

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