NATIONAL BUREAU OF STANDARDS REPORT

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PERFORMANCE OF A DEVELOPMENT MODEL WINDOW AIR-CONDITIONER GENERAL ELECTRIC COMPANY MODEL 21FF9B

by

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U. S. DEPARTMENT OF COMMERCE
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PERFORMANCE OF A DEVELOPMENT MODEL WINDOW AIR-CONDITIONER GENERAL ELECTRIC COMPANY MODEL 21FF9B

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to

Engineer Research and Development Laboratories
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Performance of a Development Model Window Air-Conditioner General Electric Company Model 21FF9B

ABSTRACT

Performance tests were made of a development model 3/4 horsepower window air conditioning unit manufactured by General Electric Company for high ambient temperatures. Capacity ratings were determined for three sets of ambient conditions and three different psychrometric conditions in the space to be cooled. Measurements of the air circulation rates of the evaporator and condenser fans were also made. The total net cooling capacity of the specimen was 8760 Btu/hr when tested in accordance with the standard conditions of the American Society of Refrigerating Engineers for such units. The dehumidifying capacity of the unit varied widely for a change of relative humidity in the conditioned space. There was relatively little leakage of outdoor air through the fresh-air damper in its closed position, but there was some short-circuiting of the chilled air from discharge to return grilles in the evaporator section.

I. INTRODUCTION

In accordance with requests from the Engineer Research and Development Laboratories, Fort Belvoir, Virginia, contained in letters dated September 28, 1951 and November 6, 1952, tests of three development model window-type air conditioning units were made to determine their performance as a basis for developing air conditioning equipment for vans and prefabricated buildings for Theater of Operation use. The three units were designed for capacities in the range from 8000 to 9000 Btu/hr. This report presents the results obtained on a specimen manufactured by General Electric Company, Bloomfield, New Jersey. Tests were made to determine net cooling capacity, the quantity of ventilating and conditioned air circulated, and the quantity of air circulated through the condenser.

Capacity tests were requested at standard rating conditions of the American Society of Refrigerating Engineers with outdoor temperatures of 95°F dry bulb, 75°F wet bulb and indoor temperatures of 80°F dry bulb, 67°F wet bulb; and at high ambient temperature conditions of 125°F dry bulb, 85°F wet bulb and indoor temperatures of 90°F dry bulb, 80°F wet bulb. In addition a capacity test was made under high humidity conditions with outdoor temperatures of 95°F dry bulb, 90°F wet bulb and indoor temperatures of 80°F dry bulb, 75°F wet bulb.

II. DESCRIPTION OF TEST SPECIMEN

The air conditioning unit was identified as follows:

(NBS Test Specimen 98-52)
General Electric Company, Bloomfield, New Jersey
Model 21FF9B
Serial Number WJ 500-036

The air conditioning unit was suitable for operation on alternating current, 115 volts, single phase, 60 cycle. It was designed for installation in a window or similar wall opening, with the condenser side on the outside of such opening and the evaporator side on the inside in the space to be cooled. The unit was enclosed in a housing made of aluminum sheet reinforced with aluminum angle. The top of this housing could be removed for servicing the machine compartment of the unit by loosening a number of screws.

The electrical controls for operation of the air conditioning unit were mounted in a recess of the housing located above the room air intake opening. A four-position control switch was used which could be placed in "Off", "Ventilate", "Manual Cool", or "Automatic Cool" positions. If placed in the "Ventilate" position, only the motor driving the evaporator and condenser fans would operate. If placed in the "Manual Cool" position, compressor and fans would operate. In the "Automatic Cool" position, a thermostat was included in the electrical circuit which permitted automatic control of temperatures in the conditioned space within a certain range by means of intermittent operation of the unit. The adjustment for this thermostat was located next to the electrical control switch. A recessed two-pole electric receptacle with threaded coupling was provided to receive a detachable power cord.

A fresh-air control, located next to the electrical controls, consisted of a horizontally mounted disc which could be rotated to simultaneously adjust the position of the fresh-air damper, located in the partition which separated the condenser and evaporator sections and a face damper at the return grille from the room. All controls can be seen in Figure 1, which is a view of the evaporator side of the unit. The receptacle for the power cord can be seen on the right hand side.

The specimen was equipped with a single motor driving both evaporator and condenser fans. The evaporator fan was of the centrifugal type, whereas the condenser fan was of the propeller type. In addition, the condenser fan was equipped with a slinger to throw the condensate which drains from the evaporator coil against the condenser for evaporation into the condenser air.

A thermostatic expansion valve of the adjustable maximum operating pressure type was used as the refrigerant flow control. The unit was equipped with a filter made of expanded aluminum mesh, located in the evaporator air circuit between the fan and the coil.

Figure 2 is an exterior view of the unit, showing the condenser section. A top view with the top housing panels removed is shown in Figure 3, revealing the location of major components.

The physical dimensions and weight of the air conditioning unit were as follows:

Length, inch	27
Width, inch	27
Height, inch	15-5/8
Weight, lbs.	129-1/2

The unit was equipped with a Tecumseh hermetic motor-compressor unit, Model B-7616, nominal 3/4 horsepower. The name plate showed that the refrigerant employed was Freon-12.

III. TEST PROCEDURE

Circular No. 16-R, published by the American Society of Refrigerating Engineers, entitled "Methods of Rating and Testing Air Conditioners", was used as a general guide in selecting the procedure to be used in determining the capacity of the air conditioning unit. The ASRE Standard states that the capacity rating of self-contained air conditioning units shall be the net total room cooling effect in British Thermal Units per hour. The following apparatus was used to determine this net room cooling capacity:

A portable, 150 cu. ft. warehouse normally used for the refrigerated storage of various materials was used as a calorimeter. The air conditioning unit was mounted in an opening in one wall of the warehouse in such a manner that the evaporator section of the unit was on the inside of this warehouse, and the condenser section of the unit was on the outside of the warehouse. The warehouse, with the unit in place, was calibrated to determine the heat transmission per degree temperature difference between the inside and outside, as a basis for computing this part of the sensible heat load. Electric heaters were placed on the inside of this warehouse to provide the remainder of the sensible heat load for the air conditioning unit. A humidifier consisting of an electric heating element immersed in water was also placed inside the calorimeter to provide the necessary humidity. The calorimeter was made as airtight as was considered necessary, and provisions were made to measure the amount of air which was

introduced into or exhausted from the warehouse calorimeter by the air conditioning unit during operation. This was done by removing air from or introducing air into the calorimeter by means of a blower through a pipe, and measuring the air quantities with calibrated gas meters or a pitot tube placed inside of the pipe. The amount of air flowing through the pipe was regulated by a throttling valve so the pressure difference between the inside and the outside of the calorimeter was zero ± 0.002 in. W. G. Calibrated watthour meters were used to measure all electric energy consumption. Temperatures were measured by means of calibrated thermocouples using an electronic constant-balance type potentiometer. Humidity measurements were made utilizing calibrated lithium-chloride-coated elements in conjunction with a micro-ammeter. Humidity measurements observed with this electric hygrometer were checked regularly with a 24" mechanical psychrometer.

Measurements of the quantities of air circulated by the air conditioner were made by means of a pitot tube located inside a smooth, round duct. This duct was connected to the outlet of the evaporator or condenser section by means of a plenum chamber and an exhaust blower was attached to the other end of the duct. The air flow through the duct was regulated by a throttling device so that the static pressure at the outlet of the evaporator or condenser section was zero ± 0.002 in. W.G with respect to the pressure in the test room to determine the free-air delivery of the fans.

IV. TEST RESULTS

A. Cooling Capacity.

Determinations of the total net cooling capacity of the unit were made for three different sets of indoor and outdoor temperature conditions. The capacity tests were made with the ventilation damper closed, but not sealed. Thus the enthalpy difference between outdoor and indoor temperature conditions for any air that leaked by the damper in its closed position or through the construction of the air conditioner was not credited to the total net cooling capacity of the unit. The desired test conditions, the average conditions maintained during the tests, and the results obtained are summarized in Table 1.

The capacity of 8760 Btu/hr observed in Test 1 is a standard ASRE capacity rating for this unit since the psychrometric conditions maintained in the conditioned space and outside the calorimeter were those prescribed for this type unit in Circular 16-R of the American Society of Refrigerating Engineers.

Table 1

PERFORMANCE OF GENERAL ELECTRIC WINDOW AIR-CONDITIONER MODEL 21FF9B, NBS SPECIMEN 98-52

Test No.	1	2	3
Desired Test Conditions			
Ambient Air Conditions			
Dry Bulb Temp., °F	95	95	125
Wet Bulb Temp., °F	75	90	85
Relative Humidity, %	40	83	20
Air Conditions at Evaporator Inlet			
Dry Bulb Temperature, °F	80	80	90
Wet Bulb Temperature, °F	67	75	80
Relative Humidity, %	51	80	65
Observed Test Conditions			
Ambient Air Conditions			
Dry Bulb Temp., °F	95.3	95.3	125.0
Wet Bulb Temperature, °F	75.2	90.5	84.4
Relative Humidity, %	39.7	83.0	19.6
Dry Bulb Temperature at Condenser Outlet, °F	114.1	107.4	141.9
Air Conditions at Evaporator Inlet			
Dry Bulb Temp., °F	80.1	80.3	90.2
Wet Bulb Temp., °F	67.2	76.1	79.7
Relative Humidity, %	51.3	83.6	63.6
Air Conditions at Evaporator Outlet			
Dry Bulb Temp., °F	60.3	70.0	76.3
Wet Bulb Temp., °F	57.8	--	72.2
Compressor Power Consumption, watts	1019	986	1272
Fan Motor Power Consumption, watts	312	312	307
Total Power Consumption, watts	1331	1301	1579
Compressor Current, amps	11.4	11.2	13.6
Fan Motor Current, amps	4.3	4.3	4.3
Terminal Voltage	115	114.5	114
Sensible Cooling Capacity, Btu/hr	8110	4170	5140
Latent Cooling Capacity, Btu/hr	650	5090	2860
Total Net Cooling Capacity, Btu/hr	8760	9260	8000
Sensible Heat Ratio, %	93	45	64
Performance Factor, Btu/hr per watt	6.6	7.1	5.1
Air leakage through conditioner, cfm	12	12	12

The results in Tests 1 and 2 provide a comparison of the performance of the air conditioning unit at two humidity levels but with the same dry bulb temperatures indoors and outdoors. Raising the indoor relative humidity from 51 to 84 percent increased the latent cooling capacity of the unit about eight times, and reduced the sensible cooling capacity by approximately 50 percent, with an overall increase in net cooling capacity of nearly 6 percent. During the test at higher humidity, Test 2, water dripped off the condenser onto the test room floor, indicating that the condenser did not successfully evaporate the large amount of moisture removed from the conditioned space under these conditions.

Table 1 shows that the sensible heat ratio was 93 percent for the test at ASRE standard rating conditions with 51 percent relative humidity in the conditioned space. This result indicates that the test specimen could remove only a very limited amount of moisture from a space at a humidity level of 51 percent. The Federal Specification for self-contained air conditioning units requires that the sensible heat ratio be in the range from 70 to 80 percent for these room conditions.

By contrast, the sensible heat ratio was reduced to 45 percent for the test conditions that were used for Test 2 (80°F dry bulb and 84 percent relative humidity in the conditioned space). For this test the dehumidification load seriously reduced the sensible cooling capacity of the unit. It is probable that if such ambient conditions did prevail in an actual installation together with a high latent load (5 lb. of water per hour) in the conditioned space that the unit would have inadequate sensible cooling capacity.

It will be noted from the data in Table 1 that the sensible heat removal of the evaporator as computed from the air circulation rate of the evaporator fan and the reduction in dry-bulb temperature by the evaporator does not agree with the values reported in the table for the calorimeter measurements using watt-hour meters. This computed sensible heat removal was from 16 to 28 percent higher than that reported in Table 1. This discrepancy is accounted for by the fact that in testing most window air conditioners it is nearly impossible to obtain an accurate weighted average of the discharge air temperature because of the confined conditions in the chilled air circuit. An examination of Figure 3 will show that a uniform velocity distribution at the evaporator outlet is improbable and consequently uniformly distributed temperature measurements would not provide a true average outlet temperature. For this reason, the calorimetric values for sensible cooling capacity shown in Table 1 are considered to be the more accurate values.

Federal Specification 00-A-372, covering self-contained air conditioning units, requires a minimum performance factor of 5.5 Btu/hr per watt for window air conditioning units under standard ASRE rating conditions. As shown in Table 1, the performance factor of this unit under standard ASRE rating conditions was 6.6 Btu/hr per watt, a value considerably higher than the minimum required in the Federal Specification.

B. Air Circulating Capacity.

Determinations of air circulating capacity were made for both evaporator and condenser fans. In addition, the maximum amount of ventilating air introduced into the cooled space by the unit through the fresh-air damper was measured. The results of these measurements are summarized in Table 2.

Table 2

AIR CIRCULATING CAPACITY OF GENERAL ELECTRIC UNIT

	Air Capacity cfm	Temp. of Air, °F DB	WB
Evaporator Fan	440	77	53
Condenser Fan	710	79	54
Ventilating Air	235	73	54

The ventilating air that was exhausted by the air conditioner with the damper closed but not sealed was measured during the three capacity tests. As shown in Table 1, it amounted to 12 cfm during each test, or about 3 percent of the air circulated by the evaporator fan. While it is considered desirable to have as little leakage as possible the observed value of 12 cfm is not considered excessive.

There was some short-circuiting of the chilled air discharged from the evaporator section back into the return grille. The two openings were adjacent in the same side of the cabinet as shown in Figure 1. This condition was revealed by the difference in relative humidity readings obtained at the right and left sides of the return air grille. A separate test showed that the disparity between the two readings could be reduced by installing a baffle between the supply and return openings. However, such a baffle was not used during the capacity tests.

No operating difficulties were experienced with the unit during the course of the tests.

V. CONCLUSIONS

The results of these tests reveal that the total net cooling capacity of the air conditioning unit increased about 6 percent when the indoor humidity was raised from 51 to 84 percent with identical dry bulb temperatures inside and outside the conditioned space. Operation of the specimen in an ambient temperature of 125°F in Test 3 did not decrease the capacity of the unit very much when the dry-bulb temperature in the conditioned space was maintained at 90°F.

The unit was not able to evaporate all of the condensate from the evaporator on the condenser surfaces when operated at the high humidity conditions in Test 2.

The construction of the unit generally appeared to be adequate, except that there was some short-circuiting of the chilled air between the discharge and return openings in the evaporator section of the cabinet because of their relative locations.


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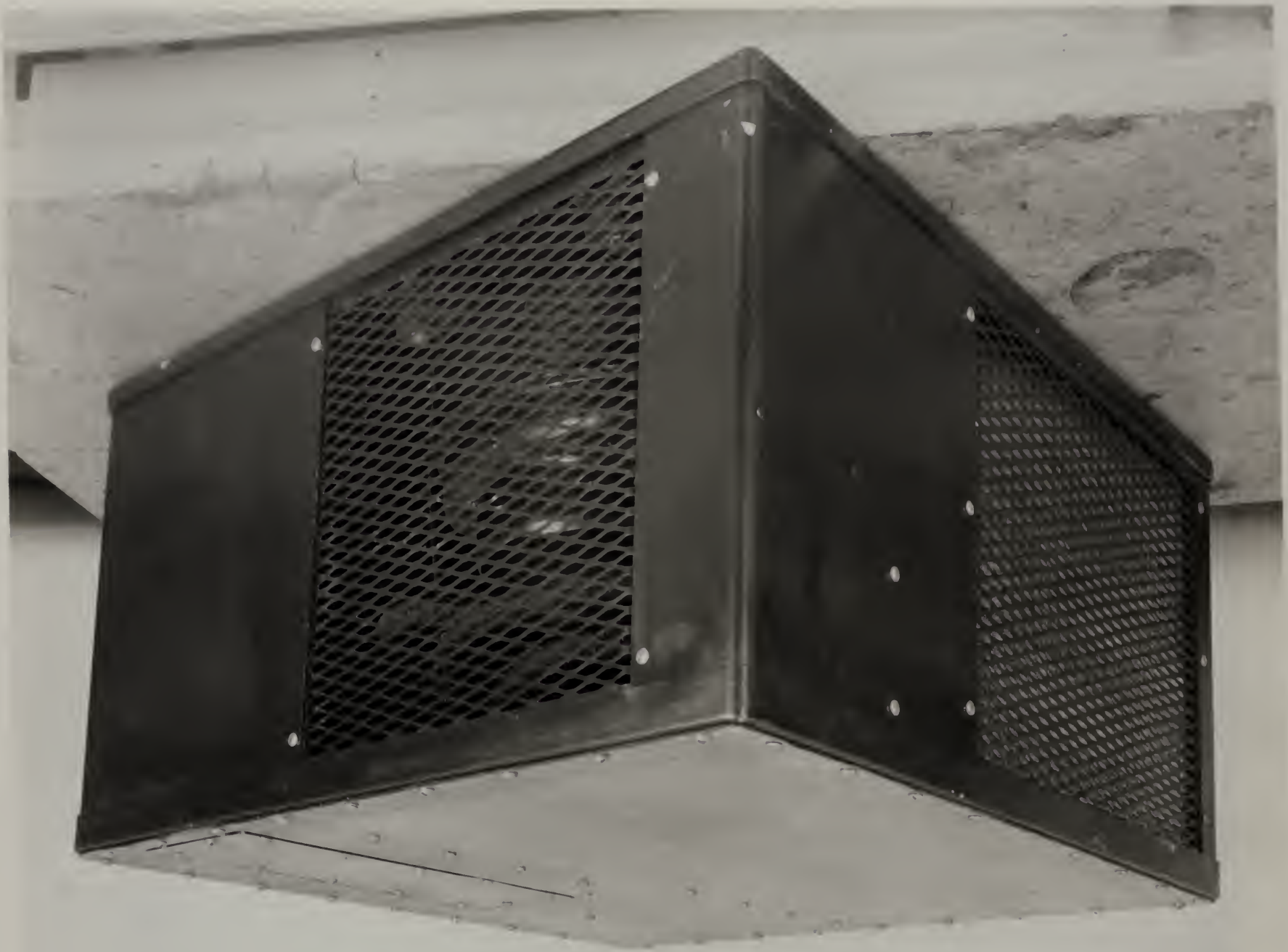

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