NBSIR 75-683

The Effect of Attic Ventilation on the Energy Required to Air Condition a One-Story Building

C. I. Siu, C. M. Hunt, and T. Kusuda

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U.S. DEPARTMENT OF COMMERCE, Rogers C.B. Morton, *Secretary*
James A. Baker, III, *Under Secretary*
Dr. Betsy Ancker-Johnson, *Assistant Secretary for Science and Technology*

NATIONAL BUREAU OF STANDARDS, Ernest Ambler, *Acting Director*

The Effect of Attic Ventilation on the Energy Required to Air Condition a One-Story Building

C. I. Siu, C. M. Hunt, and T. Kusuda
Thermal Engineering Section
Building Environment Division
Center for Building Technology
Institute for Applied Technology

ABSTRACT

Measurements were made on a masonry building at Fort Myer, Arlington, Virginia to determine the effects of attic ventilation on energy requirements for air conditioning. Also, the National Bureau of Standards Load Determination computer program, NBSLD, was used to calculate the hourly room and attic air temperatures of this building for different values of attic air changes and the results were compared with measured values.

Except for one day of testing, weather conditions during the testing period were similar. Experimental results for test periods of similar weather conditions indicated that the energy for air conditioning was greater, by as much as 7 percent, with attic fan in operation than without. In addition, in one case the total energy consumption (air conditioner plus attic fan) with attic fan in operation was found to be greater by as much as 17.5 percent, than that in which the attic fan was inoperative.

The values of the hourly room air temperature calculated using NBSLD were within 6 F (-14 °C) of the measured values. The calculated values of the attic air temperatures for attic ventilation rates of 0.7 and 5 air changes per hour were within 10 F (-12 °C) and 5 F (-15 °C), respectively, of the measured values.

Some general guidelines regarding the application of attic ventilation to other buildings are derived from this study.

Key Words: Attic air temperature; attic ventilation; energy conservation

TABLE OF CONTENTS

1. Introduction

Air conditioning techniques which lead to a reduction of energy requirements in buildings without impairing the health or aggravating illnesses of the occupants or without causing too much discomfort to the occupants are most desirable. It has often been speculated that attic ventilation leads to a reduction in the energy requirements for air conditioning. Experimental data relating to this conjecture are lacking. However, computer programs such as the National Bureau of Standards Load Determination, NBSLD, exist which are able to determine the validity of this conjecture.

The objectives of this work were to gather experimental data in order to determine the effect of attic ventilation on energy consumption and to compare NBSLD temperature predictions with experimental data. For this purpose, measurements were made on the Facilities Engineering Building (Building 219) at Fort Myer, Arlington, Virginia. Room temperature as a function of attic ventilation was of particular interest.

2. Building 219, Fort Myer

The Facilities Engineering Building, Building 219 (Figure 1), at Fort Myer, Arlington, Virginia was selected for this study. The building was built in 1895* to serve as a granary. After World War II, it was remodeled into an office building*. Presently, about two thirds of Building 219 is used for offices; the remaining one third consists of a plumbing shop (Figure 1).

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* Information furnished by the Office of Facilities Engineering.

Building 219 is made of red brick and has a gable roof. The gables face the north-south direction. Building 219 (offices) used in this study was 23 ft. (7 m) high. The basic construction data of Building 219 are given in Table 1. Figure 2 is a schematic diagram of the floor plan of that portion of Building 219 which was used in this study.

Table 1 Basic Construction of Building 219

Construction	Material
roof	green slate, 1/2 in. (1.3 cm) wood sheathing, 7/8 in. (2.2 cm)
attic wall	red brick, 13 in. (33.0 cm)
attic floor	fibrous glass wool insulation, 6 in. (15.2 cm) gypsum board, 1/4 in. (0.6 cm)
room wall	red brick, 13 in. (33.0 cm) air space, 3/4 in. (1.9 cm) gypsum board, 3/8 in. (0.9 cm)
room floor	asphalt tile, 1/8 in. (0.3 cm) wood floor, 3/4 in. (1.9 cm) wood subfloor, 2 in. (5.1 cm)
window	single pane glass

Other information about Building 219 pertinent to this study is given in Table 2.

Table 2 Additional Information About Building 219

Lighting		9,800 watts
Occupancy		20 persons
Central Air Conditioner		5 ton* (1.5 x 10^9 Joules)
Total Floor Area		3,255 sq. ft. (325 m^2)
Window Area:	east wall	120 sq. ft. (11 m^2)
	south wall	4.5 sq. ft. (0.4 m^2)
	west wall	155 sq. ft. (14 m^2)
Door Area:	west wall	50 sq. ft. (4.6 m^2)

* For purposes of NBSLD calculations, the sensible heat output is assumed to be 45,000 Btu/hr (16 kw) based upon the sensible heat ratio of 0.75 and the total capacity of the air conditioner of 5 ton (1.5 x 10^9 Joules).

3. Instrumentation

Figure 1 is a photograph of Building 219 prior to instrumentation. The louver in the south gable was the only ventilation port in the building (see Figure 1). It was necessary to construct a ventilation port at the north end of the attic. This was done by using a 12 in. (30 cm) flexible canvas duct. The duct was made to pass through the window and ceiling. The assembled duct is shown in Figures 3A and 3B. A 1/2 hp (373 watt) centrifugal fan was used to provide attic ventilation. A box-attachment assembly was built to permit attachment of the blower to cover the existing ventilation louver. The attic louver was about 11 ft. (3.3 m) above ground so that it was necessary to use scaffolding to set the blower as close as possible to the louver, Figure 4.

Attic air change rates were determined by a tracer-gas technique and by use of a calibrated hot wire anemometer. In the tracer method, a small amount of sulfur hexafluoride gas, SF_6, was introduced into the attic inlet port with the attic fan on. The concentration of SF_6 was monitored at the attic outlet. When a concentration of the order of 12-15 parts per billion was reached, and the rate of increase slowed, the tracer was turned off. Monitoring of the gas at the attic exhaust was continued. Ventilation rate was estimated from the rate of decay of tracer concentration. The tracer gas was also used to measure the fan exhaust rate by determining the degree of dilution when tracer was introduced into the fan at a known rate.

In the anemometer method measurements were made at the fan exhaust by scanning at a total of twelve points, six in the vertical and six in the horizontal positions with each point corresponding to an equivalent concentric flow area. The fan exhaust rate obtained from these measurements and the volume of the attic were used to estimate the ventilation rate. A similar estimate was made from tracer measurements.

Solar radiation was determined by use of a calibrated pyranometer positioned at the south end of Building 219. The pyranometer was at the same height as the top of the roof but placed at a distance 8 ft. (2.5 m) away from the gable at the south end of the building. A millivolt recorder with digital printout was used to record the output from the pyranometer.

Four thermocouples were fixed to the outside surface of the roof using adhesive tape. Two of these thermocouples were located at the centers of two equal halves of the east facing roof surface. Likewise, two thermocouples were located at similar positions on the west facing roof. These thermocouples were used to determine the temperature of the surface of the roof.

Four thermocouples were used to determine the attic air temperature. These were located plumb with the thermocouples at the roof surface and were placed at a distance mid-height between the roof and the attic floor. Four thermocouples were used to determine the temperature of the attic floor. These were located about an inch above the attic floor insulation material and were plumb with the thermocouples used to determine the attic air temperature.

Room and ceiling temperatures were determined only for the large office located in the northwest corner of Building 219. The ceiling temperature was determined from a thermocouple attached to the ceiling using adhesive tape. This thermocouple was located within a few feet of the central air conditioner shown in Figure 2. A thermocouple suspended below the ceiling thermocouple at mid-height distance was used to determine the room temperature. A thermocouple was suspended under the eaves, located just outside of this room, to determine the outdoor air temperature. This thermocouple was placed in the center of a 3 1/2 in. (25.4 cm) diameter aluminum foil cylinder to shield it from direct solar radiation.

A thermocouple was placed at the outlet of the central air conditioner to determine the outlet air temperature. Indoor and outdoor wet-bulb temperatures were determined using a sling psychrometer.

Power to the central air conditioner and blower were monitored using watt-hour meters. The window air conditioner unit was not in operation throughout the testing period.

The central air conditioner, shown as AC in Figure 2, was automatically controlled by fixing the setting of the thermostat in the room at 76 F (24 °C).

4. Experimental Procedure

The energy consumption of the central air conditioner of Building 219 was monitored when the attic fan was turned off and when the attic was subjected to various modes of ventilation. The experimental attic intake duct was left open throughout the testing period. Ventilation was accomplished by turning the blower on. Three separate modes of ventilation were used: continuous, cyclic and selective. In the continuous mode, the blower was allowed to operate continuously for a period of 48 hours. In the cyclic mode, the blower was left on for a period of 4 hours and turned off for a duration of 4 hours. This cycle was followed for a complete day. Two selective modes were followed. The blower was left on during the night and cut off during the day. In the other selective mode, the blower was turned on whenever the attic air temperature was 14 deg F (8 deg C) above the outdoor ambient air temperature.

All data, temperatures, solar radiation, watt-hour meter readings, etc., were recorded at the beginning of each hour for a period of one week (August 27 - September 3, 1973). Results of NBSLD calculations were compared with measured values.

5. Results

5.1 Experimental Results

Values of hourly records are given in Figures 5, 6, and 7. Actual solar radiation intensities are obtained by subtracting 11 Btu/ft^2-hr (1.25 x 10^5 Joules/m^2 hr), the background noise level of the pyranometer, from values shown in Figure 5. Figures 6 and 7 also include the operation modes of the blower (which shall be referred to as an attic fan for purposes of discussion). The measured values of attic air change rates when the attic fan was OFF and ON are given in Table 3. It can be seen that an attic air change of 0.7 air changes per hour occurred when the attic fan measurement of fan delivery rate was not in operation.

Table 3 Attic Ventilation Rates in Building 219

	Measurement Method	Air Changes Per Hour
ATTIC FAN OFF	Hot wire anemometer scan of fan exhaust	0.7
ATTIC FAN ON	Hot wire anemometer scan of fan exhaust	4.8
	Measurement of the fan exhaust rate by measuring dilution of tracer	5.1
	Measurement of decay rate of tracer concentration at attic exhaust	4.8

Maximum values of solar radiation were recorded at about noon of each day (Figure 5). Wet-bulb temperatures were maximum and minimum at about the 16th and 5th hour of each day, respectively (Figure 5).

The outdoor air temperature was at a maximum value at about the 16th hour of each day (Figures 6 and 7). This also corresponded to the time at which the temperature of the surface of the west-facing roof was at its maximum value. The maximum temperature of the surface of the east-facing roof occurred about four hours earlier (Figure 6). The temperatures of the room air, ceiling, attic floor and attic air closely followed that of the outdoor air temperature (Figures 6 and 7). Temperature ranges are summarized in Table 4. Weather conditions and the various modes of attic fan operation are also included in this table.

Solar radiation (Figure 5 and Table 4), outdoor air temperature (Figures 6 and 7 and Table 4) and weather conditions (Table 4) were similar from one test day to the next day during August 27, 1973 to September 3, 1973. Rain occurred at about the 16th hour of September 2, 1973 and lasted for three hours. Thus, except for the last day of testing, any significant changes should not be attributed to variations in daily weather.

The energy consumption of the central air conditioner and attic fan for the various modes of attic fan operation are given in Table 5.

Average values of outdoor, room, ceiling and attic floor temperatures for various modes of fan operations are presented in Table 6.

Figure 8 gives differences between attic air and outdoor air temperatures, T_d, for the various modes of attic fan operation. In general, T_d begins to decrease at about the 20th hour to a minimum value at about the same time at which the outdoor temperature reaches it maximum. Shortly after sunrise, T_d attains a local minimum, then it advances to its maximum value somewhere between the 19th and 20th hour.

Table 4 Measured Temperature Ranges for Various Conditions of Attic Ventilation of Building 219

Day	Attic Fan	Temperature Range (F)[++]							Solar Radiation (Btu/ft^2-hr)[+]	Weather Conditions
		Outdoor Air	Roof Surface		Attic Air	Attic Floor	Ceiling	Room Air		
			East	West						
8/27/73	OFF	73.6/93.3	73.4/150.5	73.5/141.8	79.0/108.8	78.7/106.5	71.5/80.8	72.7/80.2	208	Sunny, hazy
8/28/73	OFF	77.7/97.5	73.2/150.9	73.5/153.7	82.3/114.4	82.1/112.9	72.7/82.3	74.6/79.4	258	Sunny, hazy
8/29/73	ON	77.8/100.3	73.3/159.0	73.4/163.3	82.2/115.7	81.0/110.2	76.2/82.2	75.5/80.7	261	Sunny, hazy
8/30/73	ON	77.2/100.0	72.2/154.4	72.5/157.7	82.6/114.0	81.6/109.4	76.5/82.5	76.1/81.4	240	Sunny, hazy
8/31/73	OFF: 0800-2000 ON : 2000-0800	78.0/99.2	72.0/153.0	72.3/157.5	82.9/115.2	82.8/112.5	77.8/83.5	77.7/81.1	249	hazy
9/1/73	*ON/OFF	77.1/98.5	71.7/156.2	72.3/159.9	83.1/113.0	82.6/108.2	76.3/81.2	75.6/80.9	259	clear
9/2/73	**ON/OFF	73.5/96.1	68.9/142.7	69.8/152.1	77.9/108.1	77.7/106.8	74.4/79.3	73.7/78.1	238	Cloudy, rain

* ON when attic air temperature was greater than outdoor air temperature by more than 14 F

** Cycle: 4 hours ON, 4 hours OFF starting at 0800 with fan ON

\+ 1 Btu/hr ft^2 = 3.1543 w/m^2

++ $t_{\circ C} = 5\ (t_F - 32)/9$

Table 5 Energy Consumption of the Central Air Conditioner and Attic Fan in Building 219 for Various Modes of Attic Fan Operation+

Attic Fan Mode	Daily Energy Consumption (kw-hour)			
	Air Conditioner	Attic Fan	Total	Difference** (%)
0. Cyclic: 4-hour ON/OFF cycle ON at 0800	139.3	8.44	147.74	4.2
1. OFF: 0800-0800++	141.7	0	141.7	0
2. ON: whenever $T_{aa} > T_o + 14$* OFF: otherwise	146.3	3.66	150.0	5.8
3. OFF: 0800-2000 ON: 2000-0800	151.4	8.54	159.94	12.8
4. ON: 0800-0800++	150.4	16.71	166.57	17.5

+ Attic fan capacity: 5 air changes per hour.

++ Continuously for 48 hours.

* T_{aa} and T_o denote attic and outdoor air temperatures, respectively.

** $\% = \frac{\text{(Total consumption: fan mode)} - \text{(Total consumption: mode 1)}}{\text{(Total consumption: mode 1)}} \times 100.$

1 kilowatt-hour = 3.4130×10^3 Btu.

Table 6 Average Temperatures (F)** for Various Modes of Fan Operation

Mode	Outdoor	Room	T_{OR}*	Office Ceiling	Attic Floor	T_{CA}+
0	81.6	76.2	5.4	77.1	89.2	12.1
1	85.8	76.7	9.1	77.3	94.8	17.5
2	86.8	78.1	8.7	79.6	95.7	16.1
3	87.8	79.4	8.4	80.8	95.6	14.8
4	87.5	78.6	8.9	79.5	94.5	15.0

* T_{OR} denotes the difference between outdoor and room temperatures.

** $t_{°C} = 5\ (t_F - 32)/9$.

+ T_{CA} denotes the difference between attic floor and office ceiling temperatures.

The difference between attic and outdoor air temperatures, for all modes of attic ventilation, was greater than 14 deg F (7.8 deg C) for a duration of about 7 hours, from the 14-15th hour to the 21-22nd hour. During this period, the largest difference between attic and outdoor air temperature was obtained when the attic fan was ON during the night and early morning and OFF during the day. The smallest difference between attic and outdoor air temperature was obtained in the mode where the attic and outdoor air temperature was obtained in the mode where the attic fan was turned on only when this difference exceeded 14 deg F (7.8 deg C).

Figure 9 gives measured values of temperatures, ΔT, between the attic floor, $T_{attic\ floor}$, and the office ceiling, $T_{ceiling}$, for Modes 2, 4 and 5 relative to Mode 1 (fan completely off). Figure 9 indicates that operation of the attic fan led in general to a smaller value of ΔT.

5.2 NBSLD Results

Calculations using NBSLD give 1.07 x 10^6 Btu (313 kw-h) as the total daily cooling load of Building 219.

NBSLD computed and measured hourly values of room and attic air temperatures are shown in Figure 10, comparing continuous operation and fan-off conditions. The computer analysis correctly predicted the times of maximum and minimum attic temperatures, but predicted a greater temperature change due to increased ventilation than was observed. The agreement between the observed and calculated temperatures was much closer when averaged over a 24-hour period than it was at the maximum or minimum. In the fan-off condition a 24-hour average temperature of 98 F

(37 °C) was observed, while the computed value was the same. In the fan-on condition 96 F (35 °C) was observed and 92 F (33 °C) computed.

In the office space, comparison between computed and observed values was available only for the fan-off condition. However the computed curves for 0.7 and 5 air changes per hour did vary significantly. A maximum divergence of 4 deg F (2 deg C) was obtained. However at 0.7 air changes per hour the measured temperature averaged about 2 1/2 deg F (1.4 deg C) higher with the fan on than with the fan off.

6. Discussion

Figure 9 and Table 6 indicate that, on the average, the temperature difference between the attic floor and the ceiling below decreases when an attic fan was in operation. Thus, the usefulness of attic ventilation is suggested. However, it cannot be concluded from this alone that the energy consumption of the air conditioner will also be reduced. Other factors such as infiltration, building construction, weather conditions, and outdoor air temperature must also be considered.

Applying the expression $Q = U\Delta T$, where U is the coefficient of transmission to the ceiling construction of Building 219 and using the measured mean value of ΔT across this element, one arrives at $Q = 2.5 \times 10^3$ Btu/hr (0.73 kw) when the attic fan was not in operation (Mode 1). The average downward flow of heat through the attic floor, 2.5×10^3 Btu/hr (0.73 kw), represents about 5.6 percent of the total heat load of 4.5×10^4 Btu/hr (13.2 kw) as computed using NBSLD. With the attic fan operating continuously (Mode 4), Q correspondingly becomes 2.1×10^3 Btu/hr (0.61 kw). A reduction of 0.4×10^3 Btu/hr (0.12 kw), i.e., 16 percent, of the downward heat load through the attic floor is obtained. This reduction corresponds to less than one percent of the total cooling load as calculated by NBSLD. It is seen from Table 5 that energy consumption of the air conditioner was increased by 1.0 x 10^3 Btu/hr (0.36 kw). This value exceeds the beneficial decrease in cooling load of 0.4 x 10^3 Btu/hr (0.12 kw). Adding the energy required to operate the fan decreases further the beneficial effects derived from the operation of the attic fan. This conclusion is applicable to the other modes of fan operation; however, in the case of Mode 0 differences in weather conditions must be taken into account.

The above result is compatible with the conclusion drawn by Nelson et. al. [1], who made simulation calculations on a 900-square foot (274 m^2) 2-bedroom house having a maximum of 4 inches (10 cm) of fibrous glass insulation in the attic floor and concluded that it was not economically feasible to ventilate the attic using a fan.

Now if air leakage through the attic floor were of such a magnitude that the sensible heat associated with such infiltration exceeded the reduction in cooling load which arises from the decrease in temperature gradients across the attic floor and exterior walls, then, as generally shown in Table 5, the demand for the cooling would increase with increased usage of the attic fan. Increasing the air change rate in the office space of Building 219 by 0.5 air change per hour, for example, would lead to an 8 percent increase in the cooling load. This amount of air change is realized if ten percent of the air removed by the attic fan originated from the office spaces below.

In summary, using an attic fan to draw outdoor air through the space between ceiling and roof can affect the air conditioning load of the rooms below in the following two ways:

1. It can reduce the downward heat flow through the ceiling, if the attic temperature is lowered appreciably.
2. It can increase infiltration of outdoor air into the air-conditioned rooms if there are air passages through the ceiling construction, such as loose-fitting trap doors, pipe chases, leaks around ducts that penetrate the ceiling, etc.

These two processes would typically have opposite effects on the air conditioning load and would tend to cancel each other.

The beneficial effect from reduction of attic temperature by attic ventilation will be small in buildings such as Building 219 at Fort Myer having the following characteristics:

a. high thermal resistance in the ceiling
b. low thermal resistance in the roof
c. low thermal resistance in the walls of the air-conditioned spaces

The operation of a fan for attic ventilation will typically increase the infiltration in the spaces below the ceiling. To minimize this adverse effect, all cracks and openings between the attic and air-conditioned spaces should be sealed. These include loose-fitting trap doors, poor-fitting ducts that penetrate the ceiling, pipe chases through the ceiling, air leaks through studs spaces into the attic, and poor-fitting penetrations of the ceiling by light fixtures.

Thus, both the workmanship in the ceiling-wall construction and the thermal resistance of the ceiling in relation to roof and walls need to be considered in any proposed addition of an attic fan to an existing building.

7. Conclusions

Measurements of energy used to air condition Building 219 at Fort Myer indicated that operating an attic fan to reduce the attic temperature resulted in a small increase in the energy used by the air conditioner over a 24-hour period, whether the fan was operated intermittently or continuously. The increase amounted to about 7 percent when the fan was on from 2000 to 0800 and off from 0800 to 2000 and approximately 3 percent when the fan was operated only when the attic temperature exceeded the outside temperature by more than 14 deg F (7.8 deg C). The increase amounted to about 6 percent with the fan operated continuously. These estimates do not include the energy used to operate the fan.

Total cooling load of the building calculated by NBSLD was 1.07×10^6 Btu (1.13×10^9 Joules) over a 24-hour period. Calculations of heat transfer through the ceiling based on measured attic and room air temperatures indicated that the maximum reduction in total cooling load to be expected with the fan operating would be less than 1 percent.

The reason for the increase in energy used by the air conditioner has not been established experimentally, but a small increase in the ventilation rate of the occupied space with the fan operating could account for increases in cooling requirement comparable with those observed.

8. Acknowledgments

The authors wish to thank two members of the Military Construction Directorate, Mr. W. I. Jacob, Facilities Engineering Division, and Mr. W. Y. Sato, Engineering Division, for their kind assistance in making Building 219 available for this study. The authors also wish to thank Lt. Col. J. A. Sulik, Post Engineer, Fort Myer, and his staff for the efficient manner in which all of our requests were fulfilled and for their kind hospitality. The authors wish to thank Mr. P. R. Achenbach of the Center for Building Technology, NBS, for his critical review of the manuscript. The help provided by Messrs J. W. Bean, W. M. Ellis and D. R. Showalter of the NBS staff is acknowledged.

9. References

1. L. Nelson et. al., Honeywell Interoffice Correspondence, "Attic Ventilation - Effect on Air Conditioning Requirements", April 10, 1973.

10. SI Units

Familiar English units have been used in this report. To convert to SI units the following conversions are given.

$(t_F - 32)\ 5/9 = t_{°C}$

inches x 0.0254 = meters

feet x 0.3048 = meters

sq. feet x 0.09290 = sq. meters

cubic feet x 0.02832 = cubic meters

Tons of refrigeration x 3.039×10^8 = Joules

Horsepower (electric) x 746.0 = watts

British Thermal Units (mean) x 1055.9 = Joules

Btu/hr ft^2 x 3.1543 = watts/m^2

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Plumbing Shop

Figure 1 Building 219 Before Instrumentation

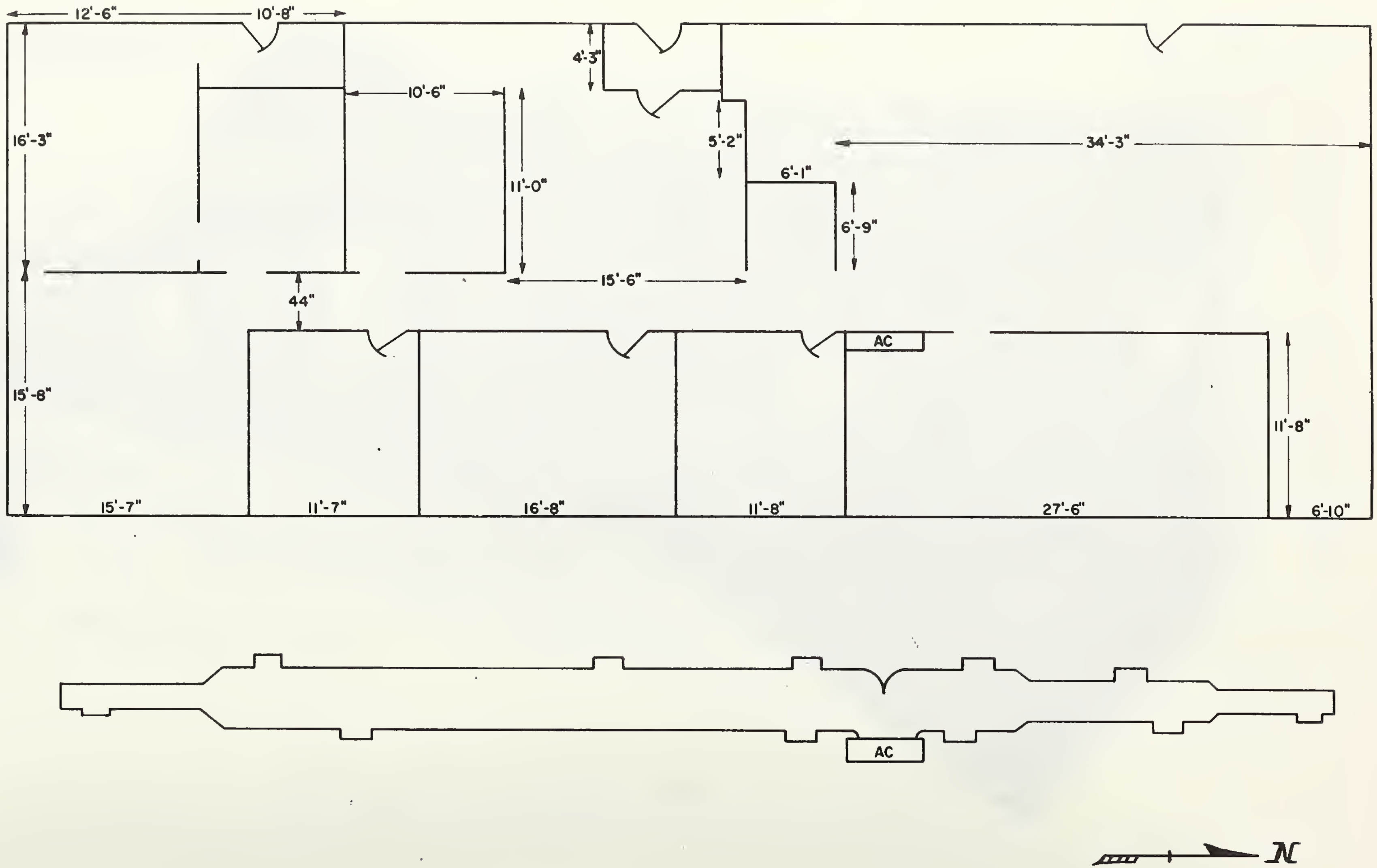

Figure 2 Floor Plan and Air Conditioning Duct Work of Building 219. Duct Work is Located Along the Ceiling of the Corridor. (See Section 10 for Conversion to SI Units.)

Figure 3A Flexible Duct Attic Ventilation System at the North End of Building 219

Figure 3B Flexible Duct Attic Ventilation Port

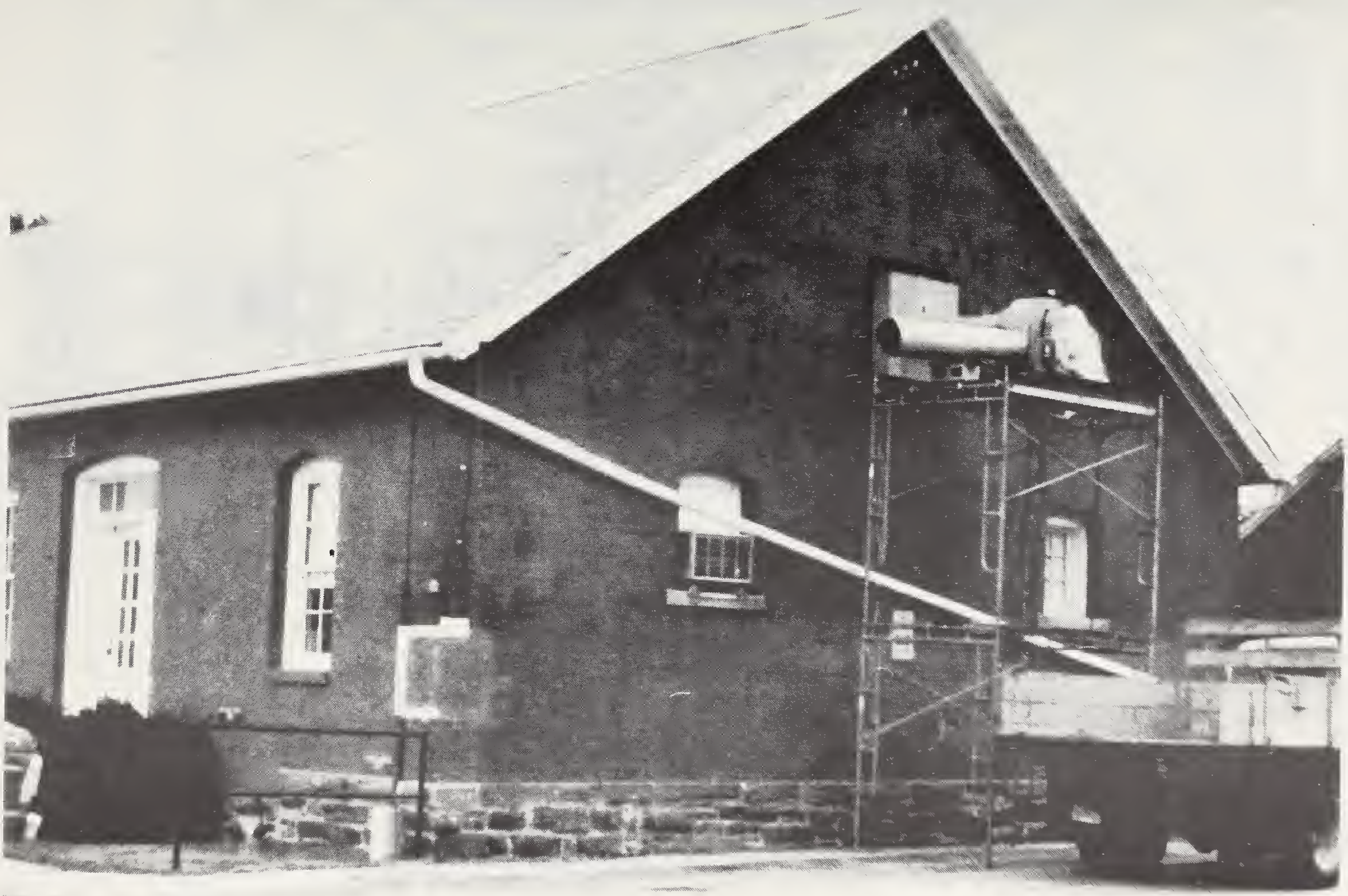

Figure 4 Blower for Attic Ventilation

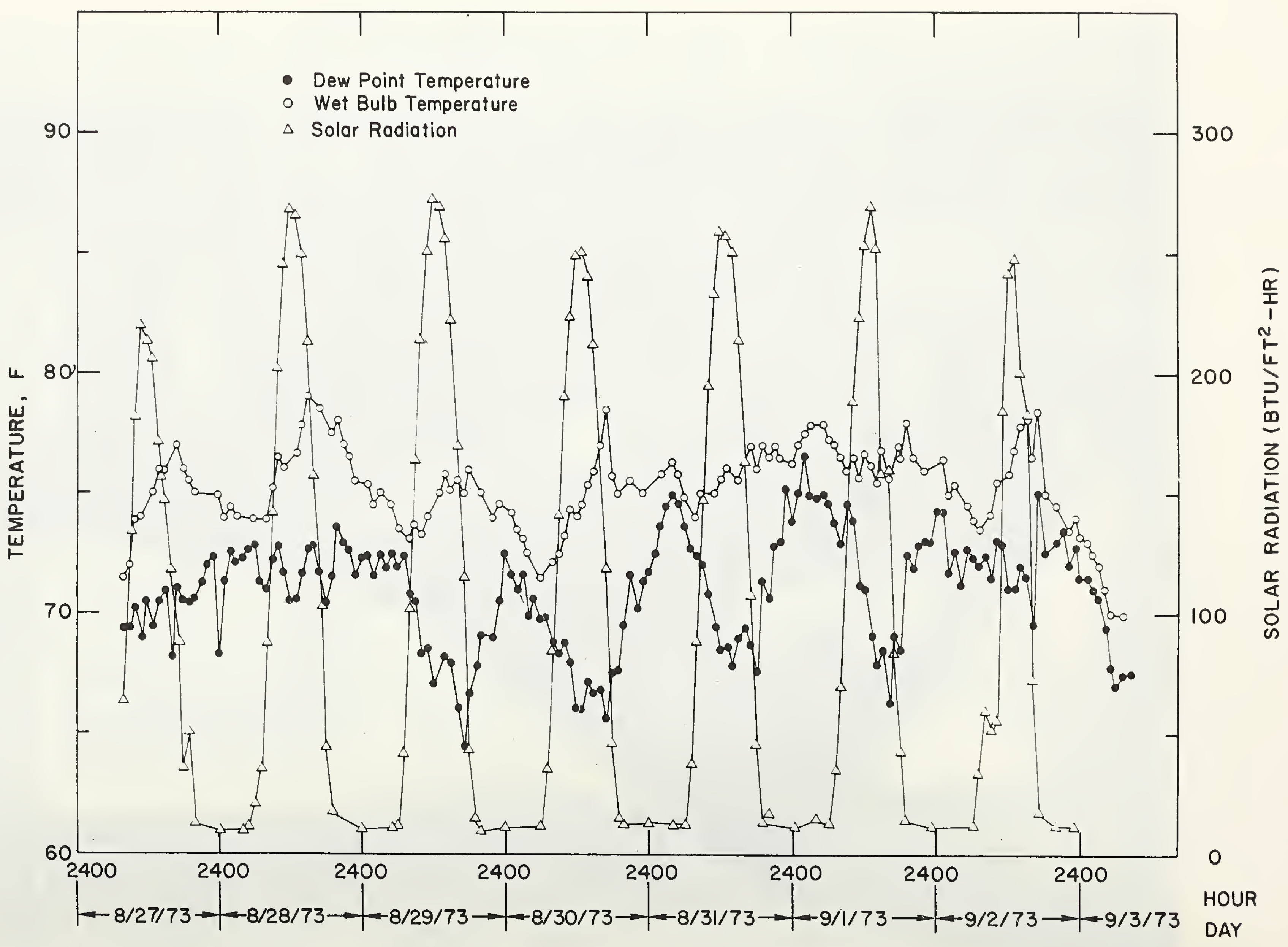

Figure 5 Solar Radiation, Wet-Bulb Temperature and Dew Point. (See Section 10 for Conversion to SI Units.)

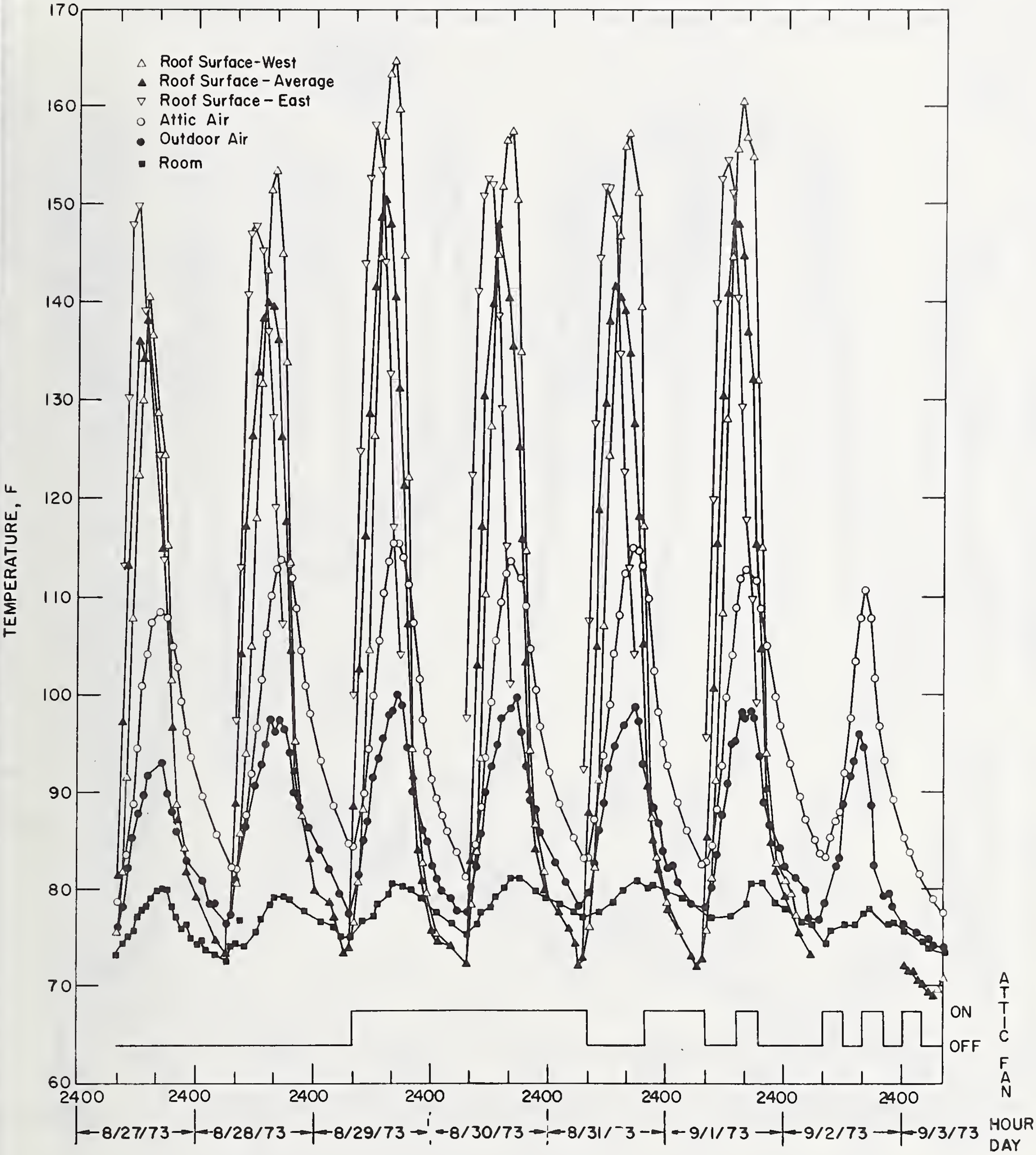

Figure 6 Outdoor Air, Roof Surface, Attic Air, and Room Temperature. (See Section 10 for Conversion to SI Units.)

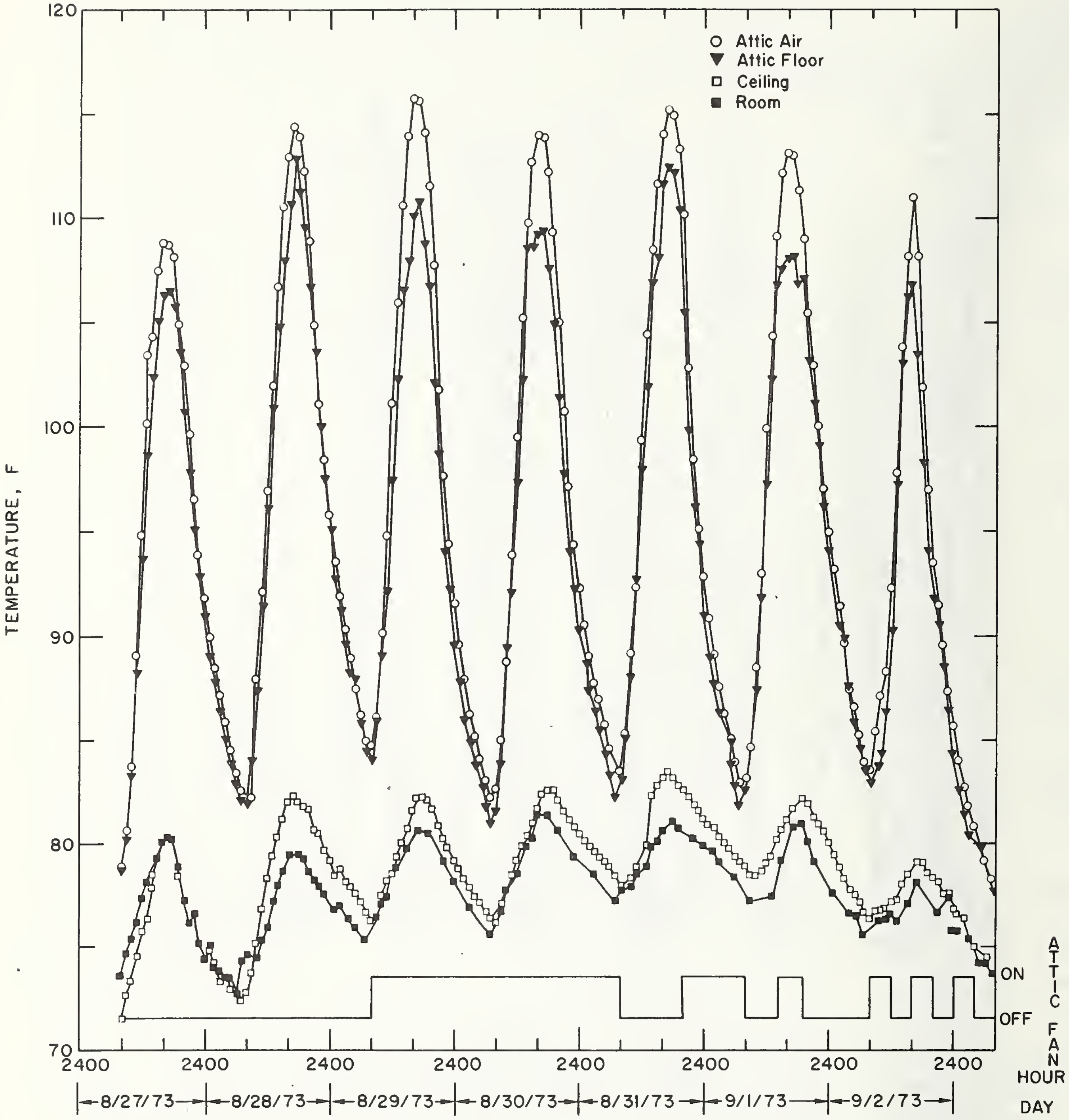

Figure 7 Attic Air, Attic Floor, Room, and Ceiling Temperatures. (See Section 10 for Conversion to SI Units.)

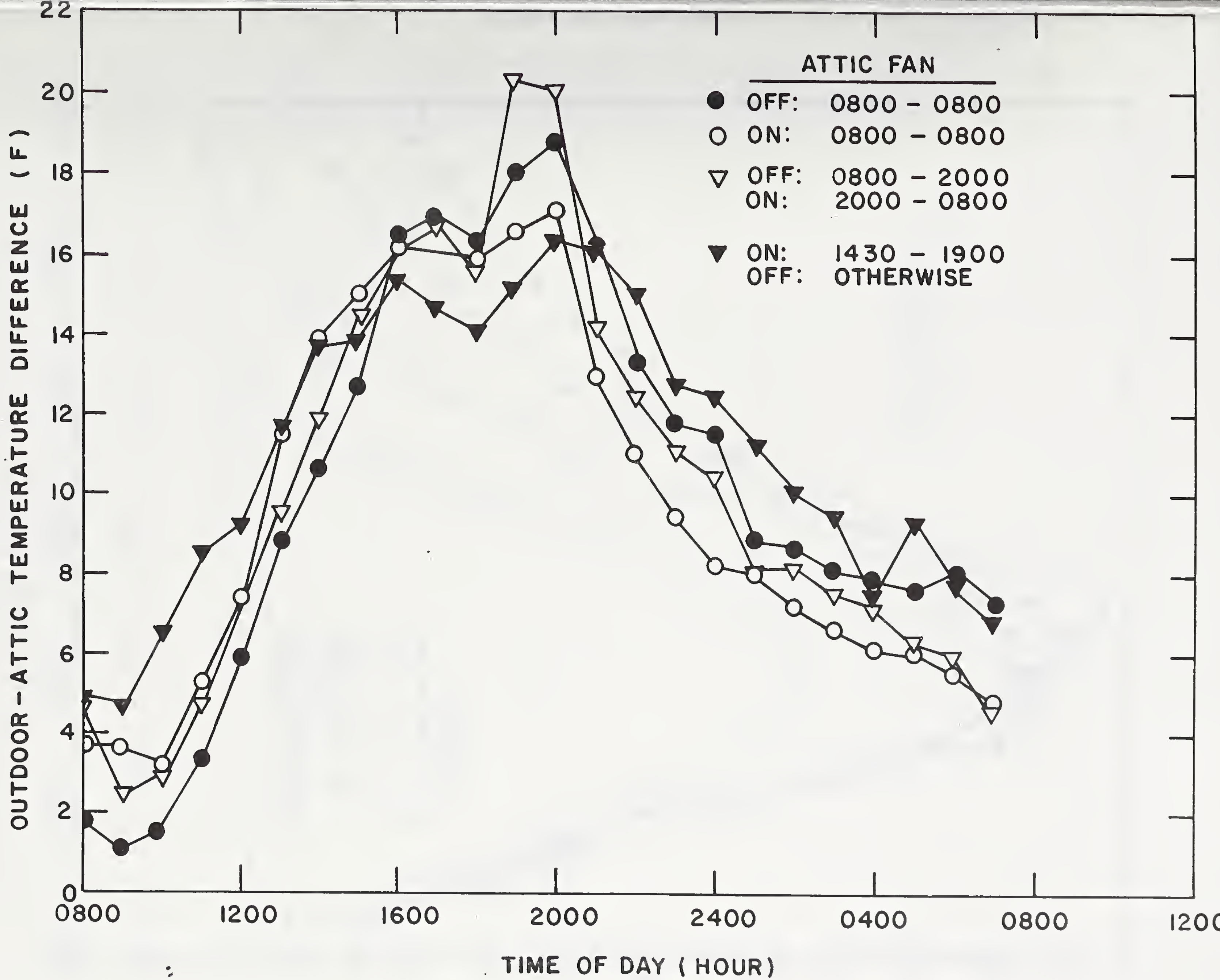

Figure 8 Difference Between Outdoor and Attic Air Temperatures for Various Modes of Attic Ventilation. (See Section 10 for Conversion to SI Units.)

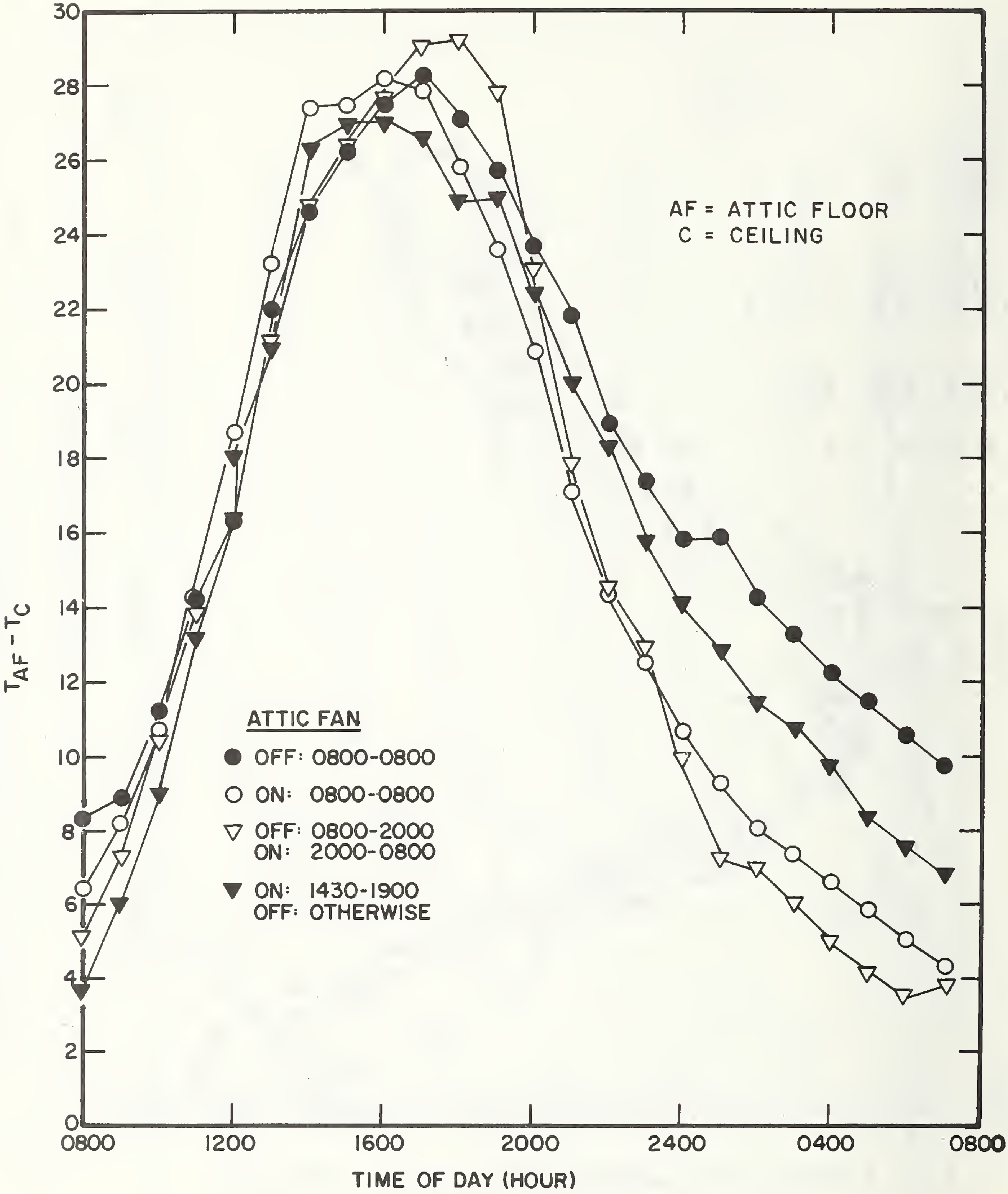

Figure 9 Difference Between Attic Floor and Office Ceiling Temperature for Several Modes of Attic Fan Operation. (See Section 10 for Conversion to SI Units.)

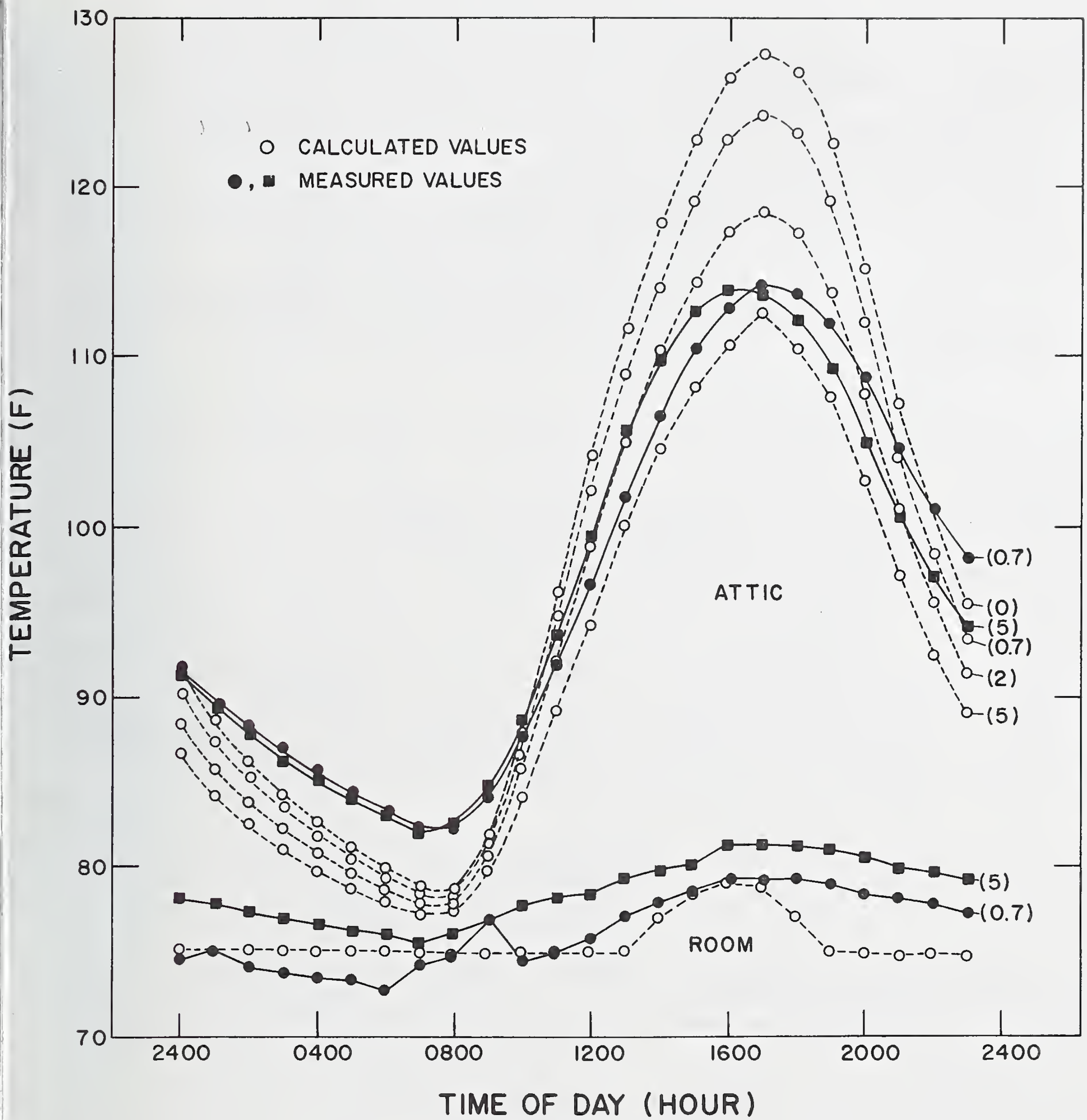

Figure 10 Comparison Between NBSLD and Measured Values for the Attic Air Temperature for Different Attic Air Changes Per Hour (Air Changes Per Hour Indicated in Parentheses). (See Section 10 for Conversion to SI Units.)

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15. SUPPLEMENTARY NOTES

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

Measurements were made on a masonry building at Fort Myer, Arlington, Virginia to determine the effects of attic ventilation on energy requirements for air conditioning. Also, the National Bureau of Standards Load Determination computer program, NBSLD, was used to calculate the hourly room and attic air temperatures of this building for different values of attic air changes and the results were compared with measured values.

Except for one day of testing, weather conditions during the testing period were similar. Experimental results for test periods of similar weather conditions indicated that the energy for air conditioning was greater, by as much as 7 percent, with attic fan in operation than without. In addition, in one case the total energy consumption (air conditioner plus attic fan) with attic fan in operation was found to be greater, by as much as 17.5 percent, than that in which the attic fan was inoperative.

The values of the hourly room air temperature calculated using NBSLD were within 6 F (-14 °C) of the measured values. The calculated values of the attic air temperatures for attic ventilation rates of 0.7 and 5 air changes per hour were within 10 F (-12 °C) and 5 F (-15 °C), respectively, of the measured values.

Some general guidelines regarding the application of attic ventilation to other buildings are derived from this study.

17. KEY WORDS *(six to twelve entries; alphabetical order; capitalize only the first letter of the first key word unless a proper name; separated by semicolons)*

Attic air temperature; attic ventilation; energy conservation

18. AVAILABILITY

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