NATIONAL BUREAU OF STANDARDS REPORT

7800

AIR DELIVERY PERFORMANCE OF A RITTLING UNIT VENTILATOR
UNDER ISOTHERMAL CONDITIONS

manufactured by
The Rittling Corporation
Hamburg, New York

by

Joseph C. Davis

Report to

Government of the District of Columbia
Washington, D.C.

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

Functions and Activities

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to government agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. Research projects are also performed for other government agencies when the work relates to and supplements the basic program of the Bureau or when the Bureau's unique competence is required. The scope of activities is suggested by the listing of divisions and sections on the inside of the back cover.

Publications

The results of the Bureau's research are published either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau publishes three periodicals available from the Government Printing Office: The Journal of Research, published in four separate sections, presents complete scientific and technical papers; the Technical News Bulletin presents summary and preliminary reports on work in progress; and the Central Radio Propagation Laboratory Ionospheric Predictions provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: Monographs, Applied Mathematics Series, Handbooks, Miscellaneous Publications, and Technical Notes.

A complete listing of the Bureau's publications can be found in National Bureau of Standards Circular 460, Publications of the National Bureau of Standards, 1901 to June 1947 ($1.25), and the Supplement to National Bureau of Standards Circular 460, July 1947 to June 1957 ($1.50), and Miscellaneous Publication 240, July 1957 to June 1960 (includes Titles of Papers Published in Outside Journals 1950 to 1959) ($2.25); available from the Superintendent of Documents, Government Printing Office, Washington 25, D.C.

NATIONAL BUREAU OF STANDARDS REPORT

NBS PROJECT | **NBS REPORT**

1003-30-10630 June 17, 1963 7800

AIR DELIVERY PERFORMANCE OF A RITTLING UNIT VENTILATOR UNDER ISOTHERMAL CONDITIONS

manufactured by
The Rittling Corporation
Hamburg, New York

by

Joseph C. Davis
Mechanical Systems Section
Building Research Division

Report to

Government of the District of Columbia
Washington, D.C.

IMPORTANT NOTICE

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

AIR DELIVERY PERFORMANCE OF A RITTLING UNIT VENTILATOR UNDER ISOTHERMAL CONDITIONS

by

Joseph C. Davis

1. INTRODUCTION

In accordance with a request from Mr. Richard C. Crutchfield, Chief, Office of Design and Engineering Department of Buildings and Grounds, Government of the District of Columbia, tests were made on a unit ventilator manufactured by the Rittling Corporation of Hamburg, New York. These tests were performed in compliance with specifications supplied by the Government of the District of Columbia. The other two unit ventilators made by different manufacturers previously tested by the National Bureau of Standards under similar arrangements and in accordance with the specifications noted above, each had a nominal air delivery rate of 1000 cfm. The nominal rating of the subject unit ventilator was 750 cfm. Because of this difference in unit size and structure, it was not feasible to compare sound pressure noise level test results of the 750 cfm units with the sound pressure test results of the two 1000 cfm units. The authorization letter of January 16, 1963 states that the noise level tests should not be performed.

The unit ventilator was selected by representatives of the District Government from a number of the same models which were being installed in one of the District schools. The test specimen was identified as Model No. SM 7532 and Serial No. 7046. Only tests pertaining to air delivery were performed; no evaluation was made of its heating performance. Figure 1 is a view of the front and right end of the unit. The discharge grille can also be seen in the figure.

The air delivery from the unit to the schoolroom can be 100 percent fresh air, 100 percent recirculated air or any proportion of fresh air to recirculated air between these amounts. During normal operation, the proportion is regulated by automatic control of dampers, but during testing, the dampers were set manually at selected positions to maintain fixed proportions of fresh air to recirculated air.

The name-plate voltage was 115 volts. The supply voltage to the permanent split-capacitor motor driving the four centrifugal blowers, was adjustable by the use of taps on a transformer. In order to attain maximum air delivery rate of 610 cfm when the impressed voltage on the transformer was 115 volts, it was necessary to use transformer tap No. 1 as specified by a representative of the Rittling Company. The impressed voltage on the transformer was maintained at the constant value of 115 volts by means of a variac for all tests.

2. METHODS OF TESTING

Air delivery from the supply grille of the unit was measured by means of a pitot tube. The pitot tube measurements were made at 50 equally-spaced positions in the cross-sectional area of a duct having the same cross-sectional area as the gross area of the supply grille and a length of about 4 feet. The duct was attached at an angle conforming to the angle of discharge of the air as determined during one of the tests. The length of 4 feet was necessary to produce reasonable mixing of the air and to minimize the number of very low pressure differences observed during pitot readings on a shorter duct.

The frictional resistance encountered by the moving air in the duct of 4 feet length at the discharge grille was not appreciable. Since the duct was fixed at an angle conforming to the angle of discharge, there was little effect due to air-impingement on the walls. Reference to the <u>Guide for 1961</u> of the American Society of Heating, Refrigerating and Air Conditioning Engineers, will show that at an air velocity of 350 fpm and for a duct of this length and of 6 inch diameter, the pressure drop due to resistance is only about 0.002 inches W.G. The duct at the discharge grille and at the fresh-air grille can be seen in Figure 2.

Figure 2 shows the pitot tube in position for measurement at the top of the duct at the discharge grille. Measurements were made with the impact opening and the static pressure holes of the pitot tube below the cross-sectional plane at the end of the duct.

Impact pressure readings obtained by the pitot tube were observed on a sensitive inclined manometer which had been calibrated against a Hook gage.

Once the proper transformer tap was selected to obtain a maximum air delivery rate with the fresh air damper 100 percent open, the rotational speed of the blowers was measured. This measurement was made with a stroboscope and also with a tachometer. The tachometer was applied to the blower shaft with as little pressure as possible, consistent with no slippage in order not to affect the motor speed. A negligible deviation in current from that occuring without the use of the 4 foot duct indicated little change in load during the speed measurement. Air delivery rates through the discharge grille were measured under the following positions of the sliding outdoor-air damper:

100 percent open
50 percent open
25 percent open
100 percent closed

For tests with all fresh-air damper positions, the voltage impressed on the transformer was maintained at 115 volts and rotational speed measured and checked in the same fashion.

With the fresh-air damper 100 percent open, the starting current of the unit was measured by means of an oscilloscope. This instrument was calibrated in terms of

current as a function of vertical displacement of the electron beam on the screen. During steady operation, temperatures of the motor casing were measured with a calibrated copper-constantan thermocouple and semi-precision potentiometer. Impressed transformer voltage, motor current, and energy usage readings were made every 30 minutes of the test. A watthour meter was used for determining the average power requirement. Wet- and dry-bulb determinations were made using a sling psychrometer having a new, clean wick for each test.

The air leakage through the recirculating-air damper system was measured when the fresh air damper was in the wide open position. To measure the small quantity of air leakage occurring in this unit under these conditions, the air that was leaking was forced to pass through a round 3-inch duct connected to a plenum fitted over the return air opening. The 3 inch tube was somewhat flattened to accomodate it to the plenum. The rate of air flow was measured with the pitot tube and manometer mentioned above. All openings at other points in the housing where air leakage into the blowers could occur, were sealed.

To test the unit for ability to prevent "blow-through" of winds from outdoors to the schoolroom, smoke-laden air was forced directly toward the outdoor-air intake grille at a velocity of 47 mph over about 33 percent of the grille area. The test was repeated for an adjacent one-thrid of the grille area, and then finally for the remaining third. The smoke-laden air was directed at the outdoor intake grille by a blower with a discharge duct measuring 8 by 8 inches. Sudden application of the air stream to each zone of 1/3 of the grille area was accomplished by suddenly raising a damper in the 8 by 8 inch duct, which caused a momentary rush of air similar to a gust of wind greater than 47 mph. This test was performed with the outdoor-air damper 100 percent open, 50 percent open, 25 percent open, and fully closed. Detection of amount of "blow-through" was made by looking for an issue of smoke at the recirculating-air grille.

All tests were performed with the outdoor grille and medium-mesh screen assembly attached to the unit. A 6-inch duct connected the grille to the screen assembly replacing the opening in the masonry in the wall of the school during normal use.

The angle of discharge of the air leaving the discharge grille was measured with a protractor which was sighted against 20 threads placed at representative positions in the grille.

The air delivery of the unit in every case was calculated using the observed temperature and moisture content of the air. Since a centrifugal blower is essentially a constant volume device at a given fan speed regardless of air density, the volume rate of air delivery would have been the same if the ambient air had been at standard conditions. The 50 pitot tube readings measured differences between total and static pressure in 50 areas of approximately equal size comprising the total grille area. Pressure difference was determined for each area and the velocity was calculated from the average pressure difference for all areas in accordance with the relation:

$$V = 4005 \sqrt{h} \sqrt{\frac{\text{Density of Standard Air}}{\text{Density of Ambient Air}}}$$

where h is the average difference between total pressure and static pressure, in. of water, as measured with the pitot tube.

3. TEST SPECIFICATIONS

The specifications supplied by the Government of the District of Columbia, modified to conform to the nominal rating of 750 cfm, are presented in the following paragraphs.

The tests are to determine that each unit tested delivers the specified amount of air in cubic feet per minute (cfm) corrected to standard air conditions. Tests of heating coil capacity are not required.

The units chosen for testing will be models with room or recirculated air admitted through louvered lower front panels. All units are to be tested at free delivery (no external resistance on unit discharge). Air deflection vanes, if provided, should be set for no lateral deflection. Units will be fitted with standard discharge grille normally furnished.

Units to be tested will be floor mounted models of a size designed to deliver 750 cfm standard air.

Units shall be tested with standard size outdoor air intake of standard construction (normally offered by the manufacturer) in the correct position set at normal distance from the outdoor air opening to the unit (approximately 6 inches from bird screen side of louver to unit).

Units will be fitted with a clean, permanent type filter. All units tested should be tested with filters which are identical in construction and resistance characteristics.

During tests, records should be kept of fan motor voltage, watts, amperes and temperature rise. Peak motor starting current should be recorded for each unit tested.

Preferably the tests should be conducted in a room of ambient temperature of approximately 70°F.

A. Determine fan rpm required to deliver 750 cfm standard air with outdoor air damper 100 percent open and room air damper closed. Also, determine amount of air leakage thru room air damper at this condition.

B. Set fan at the rpm obtained in Test A above and determine cfm at several damper positions with outdoor air damper 100 percent open to completely closed. Room air damper will vary inversely from completely closed to 100 percent open.

C. Test "blow-through" prevention performance, which should prevent gusts of outdoor air from blowing through the unit room air intake louver into the room, by setting the outdoor-air damper at various positions and blowing high velocity air through the outdoor air opening of the unit. Tests should be made with unit fans operating at the rpm determined in Test A above at free delivery into the room.

D. At 750 cfm standard air delivery, the units shall be tested for operating noise level by an approved method. Each unit test for noise level shall be identical as to method.

E. At free delivery into the room through a standard, normally furnished discharge grille, determine the angle of discharge leaving the unit and the average leaving velocity of the air. This test shall be performed with the unit delivering 750 cfm standard air. Deflector vanes, if provided, shall be set for no lateral deflection.

4. TEST RESULTS

The following test results are reported:

TEST A. (1) The test specimen did not circulate the required amount of air, 750 cfm, at the maximum blower speed attainable. The maximum speed attainable at an impressed voltage of 115 volts was 750 rpm, with outdoor air damper open and room air damper closed. The observed air delivery rate for this condition was 610 cfm.

(2) Amount of air leakage through room air damper at this condition was 30 cfm.

TEST B. The air delivery rate from the discharge duct, the fan speed, the motor current, and motor power were observed for several positions of the outdoor damper and at constant impressed voltage. The results are summarized in the following table:

Position of Outdoor-Air Damper (Trans. Displacement)	Rotational Speed of Fan (rpm)	Air Quantity* (cfm)	Motor Current (amp)	Impressed Voltage (volts)	Power Input (watts)
100 percent open	750	610	1.35	115	140
50 percent open	700	700	1.50	115	155
25 percent open	685	740	1.57	115	155
100 percent closed	720	570	1.45	115	150

*Due to the low values of air velocity encountered in this unit the uncertainty in the values of air delivery rate may be as much as 10 percent.

Position of Outdoor-Air Damper (Trans. Displacement)	Ambient Air Temperatures Dry Bulb (°F)	Wet-Bulb (°F)	Average Value for $\sqrt{h}$ (in. H_2O)
100 percent open	78.3	55.4	.0854
50 percent open	72.4	49.0	.0987
25 percent open	76.0	51.6	.1043
100 percent closed	79.3	54.8	.0799

Cross-sectional area of discharge duct ....1.79 sq.ft.

TEST C. There was no evidence of "blow-through" when smoke-laden air was forced directly into the outdoor-air intake grille at a velocity of 47 mph over about 33 percent of the grille area for outdoor damper positions of 100 percent open, 50 percent open, 25 percent open, and 100 percent closed (transverse displacement).

TEST D. The noise level test was not requested.

TEST E. The angle of discharge of the air through the discharge grille was 50 ±5 degrees referenced to the horizontal. The average leaving velocity with the outdoor damper 100 percent open was 350 fpm. Because of the low velocity at some positions of the grille, the threads used to measure the angle of discharge failed to respond the the air movement and lay flat on the grille.

While the unit was operating with the outdoor-air damper 100 percent open, peak starting current was 2.5 ±5 amperes. The maximum temperature rise of the motor casing was 37°F above the temperature of 55°F, the temperature of the motor casing at the beginning of the test. The maximum temperature was reached after 2.5 hours of operation

5. APPENDIX

The following information on components of the unit ventilator was supplied by the manufacturer, or taken from name plates.

Motor name plate: Split capacitor type motor, Century, rated, 1/12 HP, 775 rpm, 115 volt, single phase, 60 cycle, type CX, frame H 52Z, 2.0 amperes, EMI 657-F, Code 1, Spec. 28469, Serial No. B4EOAM cont. 55°C connection diagram C 41797, thermal protection NOT SF 10.

Unit name plate: Model No. SM 7532, Serial No. 7046, 115 volts, 2.2 amperes, Ph 1, and 60 cycle.

Fan 1/: Four centrifugal fans, manufactured by Revcor Blower Company, 8 in. in diameter, 4 1/2 in. wide, Model No. C-762-450 HD. Direct driven from motor.

Filters: Smith Lifetime Air Filter, manufactured by Smith Filter Corporation, Moline, Illinois. Size 6 3/4" x 1" x 43 1/2" (two) one for outside air and one for recirculated room air. (Permanent type.)

1/ Information furnished by Mr. Holliday, F. C. Clifford Company, Washington, D.C., supplier of Rittling Unit Ventilator.

Figure 1

Figure 2

U. S. DEPARTMENT OF COMMERCE
Luther H. Hodges, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its major laboratories in Washington, D.C., and Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant publications, appears on the inside of the front cover.

WASHINGTON, D. C.

Electricity. Resistance and Reactance. Electrochemistry. Electrical Instruments. Magnetic Measurements. Dielectrics. High Voltage. Absolute Electrical Measurements.

Metrology. Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Volume.

Heat. Temperature Physics. Heat Measurements. Cryogenic Physics. Equation of State. Statistical Physics.

Radiation Physics. X-ray. Radioactivity. Radiation Theory. High Energy Radiation. Radiological Equipment. Nucleonic Instrumentation. Neutron Physics.

Analytical and Inorganic Chemistry. Pure Substances. Spectrochemistry. Solution Chemistry. Standard Reference Materials. Applied Analytical Research. Crystal Chemistry.

Mechanics. Sound. Pressure and Vacuum. Fluid Mechanics. Engineering Mechanics. Rheology. Combustion Controls.

Polymers. Macromolecules: Synthesis and Structure. Polymer Chemistry. Polymer Physics. Polymer Characterization. Polymer Evaluation and Testing. Applied Polymer Standards and Research. Dental Research.

Metallurgy. Engineering Metallurgy. Metal Reactions. Metal Physics. Electrolysis and Metal Deposition.

Inorganic Solids. Engineering Ceramics. Glass. Solid State Chemistry. Crystal Growth. Physical Properties. Crystallography.

Building Research. Structural Engineering. Fire Research. Mechanical Systems. Organic Building Materials. Codes and Safety Standards. Heat Transfer. Inorganic Building Materials. Metallic Building Materials.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics. Operations Research.

Data Processing Systems. Components and Techniques. Computer Technology. Measurements Automation. Engineering Applications. Systems Analysis.

Atomic Physics. Spectroscopy. Infrared Spectroscopy. Far Ultraviolet Physics. Solid State Physics. Electron Physics. Atomic Physics. Plasma Spectroscopy.

Instrumentation. Engineering Electronics. Electron Devices. Electronic Instrumentation. Mechanical Instruments. Basic Instrumentation.

Physical Chemistry. Thermochemistry. Surface Chemistry. Organic Chemistry. Molecular Spectroscopy. Elementary Processes. Mass Spectrometry. Photochemistry and Radiation Chemistry.

Office of Weights and Measures.

BOULDER, COLO.

CRYOGENIC ENGINEERING LABORATORY

Cryogenic Processes. Cryogenic Properties of Solids. Cryogenic Technical Services. Properties of Cryogenic Fluids.

CENTRAL RADIO PROPAGATION LABORATORY

Ionosphere Research and Propagation. Low Frequency and Very Low Frequency Research. Ionosphere Research. Prediction Services. Sun-Earth Relationships. Field Engineering. Radio Warning Services. Vertical Soundings Research.

Troposphere and Space Telecommunications. Data Reduction Instrumentation. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Spectrum Utilization Research. Radio-Meteorology. Lower Atmosphere Physics.

Radio Systems. Applied Electromagnetic Theory. High Frequency and Very High Frequency Research. Frequency Utilization. Modulation Research. Antenna Research. Radiodetermination.

Upper Atmosphere and Space Physics. Upper Atmosphere and Plasma Physics. High Latitude Ionosphere Physics. Ionosphere and Exosphere Scatter. Airglow and Aurora. Ionospheric Radio Astronomy.

RADIO STANDARDS LABORATORY

Radio Standards Physics. Frequency and Time Disseminations. Radio and Microwave Materials. Atomic Frequency and Time-Interval Standards. Radio Plasma. Microwave Physics.

Radio Standards Engineering. High Frequency Electrical Standards. High Frequency Calibration Services. High Frequency Impedance Standards. Microwave Calibration Services. Microwave Circuit Standards. Low Frequency Calibration Services.

Joint Institute for Laboratory Astrophysics - NBS Group (Univ. of Colo.).

NBS