NATIONAL BUREAU OF STANDARDS REPORT

7714

AIR DELIVERY PERFORMANCE OF A HERMAN NELSON UNIT VENTILATOR UNDER ISOTHERMAL CONDITIONS

by

Joseph C. Davis

Mechanical Systems Section

Report to

Government
of
District of Columbia

NBS

U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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1. INTRODUCTION

In accordance with a request from Mr. Norman G. Smith, Engineer of Materials and Research, Bureau of Design Engineering and Research, Department of Highways and Traffic Government of the District of Columbia, tests were made on a Herman Nelson unit ventilator. These tests were performed in compliance with specifications supplied by the Government of the District of Columbia.

The unit ventilator under test 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. OWPGJXG 4341-26 and serial No. 373194. Only tests pertaining to air delivery were performed; no evaluation was made of its heating performance. Figure 1 is a front view of the unit ventilator tested.

The air delivery from the unit to the school room can be 100 per cent fresh air , 100 per cent 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 a minimum air delivery rate of 1000 cfm when the impressed voltage on the transformer was 115 volts, it was necessary to use the transformer tap delivering the maximum voltage to the motor. 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 70 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 2 feet. The duct was attached at an angle conforming to the angle of discharge of the air as determined during one of the tests. No other duct was employed during the specification test.

The frictional resistance encountered by the moving air in the duct of 2 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. Further, reference to the Guide for 1961 of the American Society of Heating, Refrigerating and Air Conditioning Engineers, will show that at an air velocity of 500 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. Comparative air flow measurements made using the unit ventilator, this duct, and a duct at the fresh air grille also showed that the pressure drop was not appreciable. The duct at the discharge grille and at the fresh-air grille can be seen in Figure 3.

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 of the pitot tube in the cross-sectional plane at the end of the duct. There were no significant differences in results when measurements were made with the impact opening and the static pressure holes of the tube well below this 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 minimum air delivery rate of 1000 cfm with the fresh air damper 100 per cent 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 deviation in current of 0.03 ampere from that occurring without the use of the tachometer indicated little change in load during the speed measurement. Air delivery rates through the discharge grille were measured under the following angular positions of the outdoor-air damper:

100 per cent open

50 per cent closed

75 per cent closed

100 per cent 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 per cent 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 Leeds and Northrup type K-3 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 4-inch duct connected to a plenum fitted over the return air opening. 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. Measurement was made using the arrangement shown in Figure 4.

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 52 mph over about 33 per cent of the grille area. The test was repeated for an adjacent one-third of the grille area, and then finally for the remaining third This test was performed with the outdoor-air damper 100 per cent open, 50 per cent open, 25 per cent 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 operation. Clean filters were used during all the tests.

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 centrigugal 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 70 pitot tube readings measured differences between total and static pressure in 70 areas of approximately equal size comprising the total grille area. Velocity for each area and an average for all areas was calculated in accordance with the following 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.

The operating noise level test was performed in the National Bureau of Standards reverberation room. The fresh air damper was closed and the unit was placed on a concrete floor with the fresh air grille next to the wall.

Sound pressure levels were measured at four microphone stations randomly selected in an area at least 17 feet from the unit and more than 6 feet from boundary surfaces of the room. Thus the microphone area was in a reverberant field, free of direct radiation from the source and interference from reflecting surfaces. The motor speed selector was in the "high" position and the recirculation damper was fully open when measurements were made. The unit was operated from the AC power line using a variac to maintain an applied voltage of 115 volts during operation.

Sound pressure levels were averaged over a 50-second interval for each octave frequency band, for a given microphone position. The values thus obtained for 4 microphone positions were averaged for each frequency band, giving suitable space-time averages. The values are rounded off to the nearest 0.5 decibel.

The accuracy of the sound pressure levels based on a single observation at each of four microphone positions is given in terms of the standard deviation in db, i.e. the deviations of the individual sound pressure levels from the arithmetic mean level. The repeatability of measurements at any given microphone position throughout the frequency range was within ±0.2db.

3. TEST SPECIFICATIONS

The specifications supplied by the Government of the District of Columbia 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 1,000 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 1,000 CFM standard air with outdoor air damper 100 per cent 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 per cent open to completely closed. Room air damper will vary inversely from completely closed to 100 per cent 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 RPM determined in Test A above at free delivery into the room.

D. At 1,000 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 1,000 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) Fan speed required to deliver 1000 cfm standard air with outdoor air damper 100 per cent open and room air damper closed .... 680 rpm

(2) Amount of air leakage through room air damper at this condition .... 40 cfm

The actual air delivery for a fan speed of 680 rpm was 1065 cfm. The fan speed for this test was adjusted, as nearly as possible to an air delivery of 1000 cfm, by the selection of one of several transformer taps in the electrical supply line to the fan motor. The transformer tap providing the highest available output voltage was required to attain this air delivery. The impressed voltage on the transformer was maintained at 115 volts.

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 (Angular Displacement)	Rotational Speed of fan (rpm)	Air Quantity (cfm)	Motor Current (amp)	Impressed Voltage (volts)	Power (watts)
100 per cent open	680	1065	1.93	115.3	180
50 per cent closed	670	1080	2.00	114.6	185
75 per cent closed	670	1040	1.95	115.0	180
100 per cent closed	710	970	1.80	115.0	170

Position of Outdoor-Air Damper (Angular Displacement)	Ambient Air Temperatures Dry Bulb (°F)	Wet Bulb (°F)	Average Value for $\sqrt{h}$ (in. H_2O)
100 per cent open	84.1	66.3	0.134
50 per cent closed	70.0	67.0	0.137
75 per cent closed	69.0	63.0	0.132
100 per cent closed	80.0	68.5	0.122

Cross sectional area of discharge duct .... 1.95 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 52 mph over about 33 per cent of the grille area. for outdoor damper positions of 100 per cent open, 50 per cent closed, 75 per cent closed, and 100 per cent closed (angular displacement).

TEST D.

Sound Pressure Levels in db, re 0.0002 dyne/cm2

Mid-frequency Octave Bands cycles/sec	Sound Pressure Levels db	Standard Deviation db
50	51.5	1.0
100	56.5	0.5
200	56.5	0.5
400	57.0	0.5
800	56.5	0.5
1600	53.0	0.5
3150	46.0	0.5
6300	39.5	1.0

Computed Overall Sound Pressure Level 63.5

The sound pressure levels given above were normalized to a reference room absorption of 10 square meters. The air temperature was 71°F ±2 and the relative humidity was 72 % ± 2 in the reverberation chamber.

TEST E. The angle of discharge of the air through the discharge grille was 70° ±5° referenced to the horizontal. The average leaving velocity with the outdoor damper 100 per cent open was 545 fpm.

While the unit was operating with the outdoor-air damper 100 per cent open, peak starting current was 4 ± .2 amperes. The maximum temperature rise of the motor casing was 40°F above an ambient temperature of 85°F. 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.

Motors: Permanent - split, capacitor type motor, rated 1/8 HP, 700 rpm, 115 volt, single phase, 60 cycle, sleeve bearing, 48 frame, with thermal protection.

We have three suppliers of these motors, Century rated 1.5 amps, General Electric rated 2.0 amps, Westinghouse rated 1.75 amps.

This motor has two windings, main winding and a starting or auxiliary winding, the capacitor being in series with the auxiliary winding. By means of an autotransformer with various voltage taps ranging from 115 to 45 volts, we vary the voltage to the main winding only, thus varying the motor speeds.

The autotransformer is supplied by either the Apex or Dormeyer Transformer Companies.

Fans: We manufacture the fan wheels used in our unit ventilators. Specifications of materials used are:

Fan wheel rims	- aluminum,	16 ga.	(.051")
Fan wheel blades	- aluminum,	20 ga.	(.032")
Fan wheel center disk	- steel,	16 ga.	(.060")
Fan wheel hub	- steel,	12 ga.	(.105")

Fabrication of this wheel is all by mechanical means except that the hub is spot welded to the center disk. A socket head type set screw is provided for attaching the wheel to the fan shaft.

Filter: We manufacture the filters used in our Unit Ventilators. The filter in question is our permanent type with overall dimensions of 12" x 43-13/16" x 1".

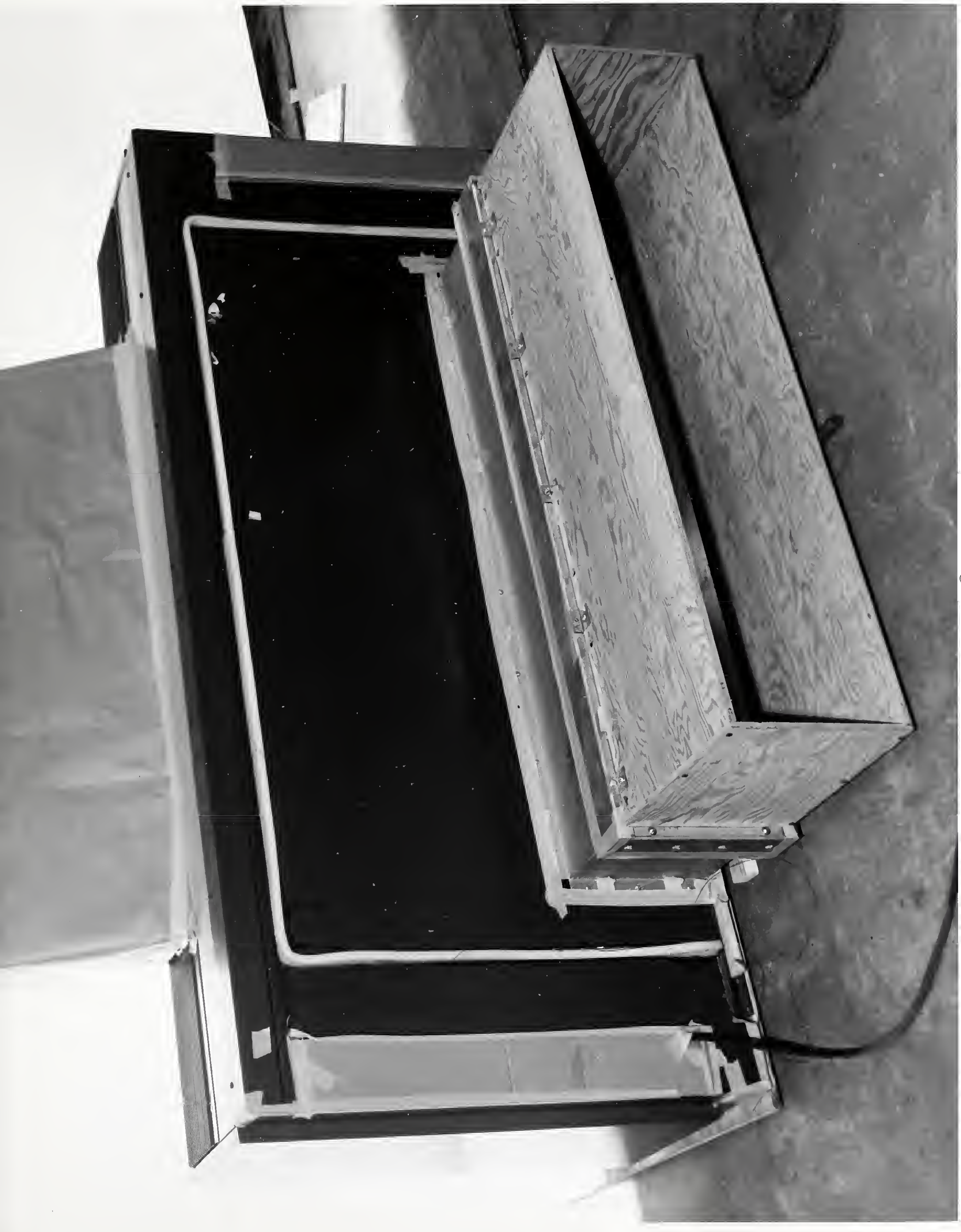
The frame is constructed of 22 ga. (.030"), zinc coated steel.

The media is constructed of three layers of #14 mesh galvanized wire screen. The cross-section of each layer has a specific configuration.

After fabrication the filter is sprayed with a light coat of "SH" or "TE" Viscosine.

This particular size filter offers a resistance of 0.030 inches of water at 1000 cfm.

Figure 1




Herman Nelson
AAF

U. S. DEPARTMENT OF COMMERCE
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THE NATIONAL BUREAU OF STANDARDS

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

Metrology. Photometry and Colorimetry. Refractometry. Photographic Research. Length. Engineering Metrology. Mass and Scale. Volumetry and Densimetry.

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.

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

Office of Weights and Measures.

BOULDER, COLO.

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CENTRAL RADIO PROPAGATION LABORATORY

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

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Radio Physics. Radio Broadcast Service. Radio and Microwave Materials. Atomic Frequency and Time-Interval Standards. Radio Plasma. Millimeter-Wave Research.

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

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