



STANDARD

ANSI/ASHRAE Standard 221-2020

Test Method to Field-Measure and Score the Cooling and Heating Performance of an Installed Unitary HVAC System

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CONTENTS

ANSI/ASHRAE Standard 221-2020 Test Method to Field-Measure and Score the Cooling and Heating Performance of an Installed Unitary HVAC System

SECTION	PAGE
Foreword	2
1 Purpose	3
2 Scope	3
3 Definitions and Acronyms.....	3
4 Classifications	7
5 Installed System Performance Basic Test and Calculation Procedures	7
6 Performance Metric Calculations	11
7 Data Collection Procedures.....	18
8 Test Instruments.....	32
9 References	33
Normative Appendix A: Generic Expanded Equipment Performance Tables	34
Informative Appendix B: Measurement Units and Conversion Table.....	36
Informative Appendix C: Calculations Background	37
Informative Appendix D: Data Collection Forms	39
Informative Appendix E: Informative References	52

NOTE

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FOREWORD

ASHRAE Standard 221 provides a method to field measure and estimate the capacity and efficiency and score the performance of an installed heating, ventilating, and air-conditioning (HVAC) system. An installed system's performance deteriorates because of less-than-perfect design and installation practices and poor maintenance. System airflow may be below the volume specified; system static pressures may be above the maximum allowable; duct systems may be undersized, poorly installed, or damaged; refrigeration circuits may be incorrectly charged; and combustion deficiencies may prohibit the delivery of equipment rated capacity.

This field test method is necessary because laboratory rated equipment capacity and efficiency are not intended to represent actual system performance once the equipment is installed in a building. Equipment capacity and efficiency ratings are tightly regulated and accurately represent equipment performance under a specific set of test conditions. This standard does not validate or invalidate a manufacturer's equipment energy rating or the laboratory testing performed on equipment at the time of manufacture; its purpose is to score the performance of a system, typically field fabricated by the installing contractor, that represents an end product different from its comprising parts, one that has traditionally not been scored.

This test method estimates the system capacity being delivered through the supply registers for both heating and cooling systems. The cooling and heating system performance ratios (CSP_r and HSP_r, respectively) represent the ratio of the installed system delivered capacity divided by the expected equipment capacity under test conditions for a specific installation on a specific day in a specific geographical location. The denominator of the ratio represents the near-ideal equipment capacity given the environmental conditions present during the test. This provides a consistent, objective reference against which the system delivered capacity is compared.

For cooling systems, the standard also includes an efficiency metric. The installed cooling system energy efficiency ratio (ICSeer) represents the installed system delivered capacity divided by the electrical power consumed by the system. This ratio is then multiplied by an adjustment factor to estimate the operating efficiency of the system under standard rating conditions. The resulting metric is comparable to the rated energy efficiency ratio (EER) of the equipment but also accounts for system inefficiencies and losses.

The fundamental approaches described in this standard have been in regular use since at least 2001. The principles used in this test method are supported by numerous industry standards, which have been adapted for field measurement and taught to contractors and technicians by National Comfort Institute (NCI). These approaches formed the basis of the standard and were subsequently improved upon and vetted by a balanced committee to define consistent and repeatable test, measurement, and calculation procedures.

This test and scoring method may be used by field practitioners to score a system before and after system repairs and upgrades. The score before upgrades documents the deterioration caused by defects in the installed system and helps identify what may be done to improve the performance and efficiency of the system. The system is again tested and scored after system repairs and upgrades are completed using the same methodology. The difference between the before and after score provides an estimate of the improvement in performance and efficiency of the installed system.

This standard is intended for field use to estimate the capacity and efficiency of installed systems. It is written in a language of and for field practitioners, enabling HVAC contractors, technicians, design engineers, balancing and energy measurement and verification (EM&V) professionals, manufacturers, facility personnel, and commissioning agents to measure and score the installed performance of HVAC systems. It is intended to augment but not replace, eliminate, or invalidate well-established product certification ratings or other industry standard.

1. PURPOSE

The purpose of this standard is to prescribe a field evaluation and test method to measure and score the performance, in terms of delivered cooling or heating capacity or cooling efficiency, of an installed unitary HVAC system.

2. SCOPE

This standard

- a. defines performance scoring methods for cooling and heating system delivered capacity and cooling system efficiency;
- b. establishes uniform methods of measurements and testing procedures for airflow, temperature, enthalpy, and power;
- c. specifies test instruments, specifications, and calibration requirements for performing such measurements and tests;
- d. specifies data required and calculations to be used; and
- e. applies to single-zone unitary split and packaged direct expansion (DX) cooling, air-source heat pump, and combustion furnace HVAC systems of any capacity and with forced-air distribution systems.

3. DEFINITIONS AND ACRONYMS

3.1 Definitions

accuracy:

- a. degree of freedom from error, that is, the degree of conformity to truth or to a rule.
- b. ability of an instrument to indicate or record the true value of a measured quantity.
- c. error of indication, which is the difference between the indicated value and the true value of the measured quantity, expresses the accuracy of an instrument.

air density: mass per unit volume of dry air.

air distribution: transportation of a specified airflow to or from the treated space by ducts or plenums. Air-treatment devices can be added to the distribution system for the purpose of treating the air (e.g., cleaning, heating, cooling, humidifying, or dehumidifying).

air inlet: device or opening through which air is withdrawn from a conditioned space or the outdoors (grilles, dampers, or other openings may be used as air inlets).

air velocity: rate of motion of air in a given direction, measured as distance per unit time. (See also *velocity*.)

ambient air: air surrounding a building, the source of outdoor air brought into a building, etc. (usually outdoor air or the air in an enclosure under study).

ambient temperature: temperature of the medium (such as air, water, or earth) into which the heat of equipment is dissipated.

balancing: the methodical proportioning of air and hydronic flows through the system mains, branches, and terminal devices, using acceptable procedures to achieve the specified airflow or hydronic flow within testing, design, and installation limitations.

branch:

- a. in ducts, piping, or conduit, another section of the same size or smaller, at an angle with the main.
- b. section of pipe or duct from a main to a terminal device.

building official: the officer or other designated representative authorized to act on behalf of the authority having jurisdiction (AHJ).

calibrate: the act of comparing an instrument of known or unknown accuracy with a standard of known accuracy to detect, correlate, report, or eliminate by adjustment any variation in the accuracy of the tested instrument.

calibration: comparison of the particular instrument with a primary standard, a secondary standard of higher accuracy than the instrument to be calibrated, or a known input source.