AHRI Standard 140-2023 (I-P)

2023 Standard for

Evaluation of Air-conditioning and Heating Equipment Test Stands

AIR-CONDITIONING, HEATING, & REFRIGERATION INSTITUTE

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ICS Codes: 17.060, 17.080, 17.100, and 17.120

Note:

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Intent

This standard is intended for the guidance of the industry, including manufacturers, engineers, installers, efficiency regulators, contractors, and users.

Review and Amendment

This standard is subject to review and amendment as technology advances.

2023 Edition

This edition of AHRI Standard 140-2023 (I-P), *Evaluation of Air-conditioning and Heating Equipment Test Stands*, was prepared by the Unitary Small Equipment Standards Technical Committee. The standard was published by the Unitary Standards Subcommittee on 12 June 2023.

Origin and Development of AHRI 140-2023 (I-P)

This is the initial publication of AHRI Standard 140-2023 (I-P), *Evaluation of Air-conditioning and Heating Equipment Test Stands*. AHRI Standard 140-2023 (I-P) was developed to:

Build on work done with Laboratory Evaluation and Adjustment Plan

Help improve certification programs that utilize witness testing

Support AHRI's certification services

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Equipment, Mini-Split (1:1) Air-conditioning and Heat Pump Equipment, and Demand Response through Variable Capacity HVAC Systems in Residential and Small Commercial Applications.

The following product types are out of scope for this STC: Packaged Terminal AC/HP, Commercial or Industrial AC/HP, Furnaces, Variable Refrigerant Systems (VRF), Geothermal and Water Source HP, Single Package Vertical Unit (SPVU), and Performance Rating of Zoning products.

For product definitions, refer to AHRI's website.

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EVALUATION OF AIR-CONDITIONING AND HEATING EQUIPMENT TEST STANDS

Section 1. Purpose

1.1 *Purpose*. The purpose of this standard is to establish for Test Stands: definitions; test requirements; rating requirements; minimum data requirements for Published Ratings; nomenclature; and conformance conditions.

Section 2. Scope

2.1 *Scope*. This standard applies to Test Stands used for performance testing for the following equipment types:

1) Unitary Air-conditioning and Air-source Heat Pump Equipment within the scope of AHRI Standard 210/240.
2) Commercial and Industrial Unitary Air-conditioning and Heat Pump Equipment within the scope of AHRI Standard 340/360.
3) Computer and Data Processing Room Air Conditioners within the scope of AHRI Standard 1360.
4) Variable Refrigerant Flow (VRF) Multi-split Air-conditioning and Heat Pump Equipment within the scope of AHRI Standard 1230.
5) Single Package Vertical Air-conditioners and Heat Pumps within the scope of AHRI Standard 390.
6) Packaged Terminal Air-conditioners and Heat Pumps within the scope of AHRI Standard 310/380.

2.2 *Exclusions.* Qualification procedures for water-cooled and evaporatively cooled equipment are not covered by this standard.

Section 3. Definitions

All terms in this document follow the standard industry definitions in the ASHRAE Terminology website unless otherwise defined in this section.

3.1 *Airflow Measurement Apparatus*. A device for determining the volume rate of air passing through the UUT. Commonly referred to as “code tester” within the industry.

3.2 *Air Side Capacity Measurement System*. The equipment used to determine UUT capacity including inlet psychrometric air properties, outlet psychrometric air properties, and the Air Flow Measurement Apparatus.

3.3 *Baseline Test*. A test conducted in accordance with a Reference Rating Standard on a Correlation Sample at a Reference Test Stand.

3.4 *Correlation Sample*. A sample with documented performance data from a Reference Test Stand

3.5 *Cyclic Test*. A test where all or part of the system is turned on and off in a cycle.

3.6 *Drain Trap*. A plumbing drain fixture designed to retain a small amount of the draining water to seal the pipe and prevent any gases from flowing through the pipe.

3.7 *Electric Heat Box*. Test apparatus used to supply a known quantity of heat to the air stream.

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3.8 *Error*. The difference between the true value of the quantity measured or calculated and the observed value. All errors in experimental data can be classified as one of two types: systematic (fixed) errors or random (precision) errors. The terms accuracy and precision are often used to distinguish between systematic and random errors.

3.8.1 *Fixed Error*. See Systemic Error

3.8.2 *Random Error*. An error that causes readings to take random values on either side of a mean value. The random error is quantified based on how well an instrument can reproduce subsequent readings for an unchanging input. Random errors cannot be corrected through calibration.

3.8.3 *Systematic Error*. An error that persists and cannot be deemed as due entirely to chance. Systematic error can be corrected through calibration

3.9 *External Static Pressure Drop Verification*. The percent difference between the exact coil only ASHRAE duct configuration baseline pressure and the corresponding test measured value from either conventional or alternative psychometric testing configuration divided by the corresponding test measured value from either conventional or alternative psychometric testing configuration.

3.10 *Heat Balance*

3.10.1 *Latent Heat Balance*. The percent difference between the latent heat calculated from the measured condensate flow rate and the measured psychrometric latent capacity, q_{lci}.

3.10.2 *Sensible Heat Balance*. The percent difference between the measured psychrometric sensible heat and measured electric heat added to the system.

3.11 *Indoor Blower*. The fan used to move air through the indoor side of the UUT.

3.12 *Laboratory*. The facility that houses the Test Stand(s).

3.13 *Leakage Rate*. The volume of air entering or leaving the Test Stand between the UUT outlet connection and the Nozzle Plate location.

3.14 *Measured Airflow Difference*. The deviation between two different Air Flow Measurement Apparatus nozzle size combination readings at the same airflow in CFM.

3.15 *Nozzle Chamber*. Apparatus containing the air flow measurement nozzles. Part of the Airflow Measurement Apparatus.

3.16 *Nozzle Plate*. A plate designed to seal the cross-sectional area of a duct with nozzles attached to allow air to pass through. Part of the Nozzle Chamber.

3.17 *Passive Pressure Drop Device*. A custom-built assembly, constructed without internal insulation, sealed to prevent any external or internal air leakage, and sized to provide a designated external static pressure over a range of airflow as shown in Appendix C.

3.18 *Qualified Facility*. A test laboratory that meets all of the requirements of the AHRI Standard 140.

3.19 *Reference Rating Standard*. The standard used to rate the UUT.

3.20 *Reference Test Stand*. A Test Stand that has been proven through data collection to provide baseline measurements.

3.21 *"Shall" or "shall not" and" should" or "should not"*

3.21.1 *"Shall" or "shall not"*. Indicate mandatory requirements to strictly conform to the standard and where deviation is not permitted.

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3.21.2 *"Should" or "should not"*. Express recommendations rather than requirements. In the negative form, a recommendation is the expression that a suggested possible choice or course of action is not preferred but not prohibited.

3.22 *Test Stand*. Facility constructed for the purpose of testing or developing ratings in accordance with a Reference Rating Standard.

3.22.1 *Indoor Room*. A portion of the facility used to maintain a controlled environment for the indoor test rating conditions in accordance with the Reference Rating Standard.

3.22.2 *Outdoor Room*. A portion of the facility used to maintain a controlled environment for the outdoor test rating conditions in accordance with the Reference Rating Standard.

3.23 *Test Type*. A specific test within this standard to verify a particular function of the Test Stand. Test Types are listed in Section 4.

3.24 *Uncertainty*. An estimated value for the error in a measurement or calculation, that can be the result of both Systematic and Random Error.

3.25 *Unit Under Test (UUT)*. The Correlation Sample used to validate the Test Stand. Each UUT is rated in accordance with a Reference Rating Standard.

3.26 *Validation*. The process of evaluating if a system accomplishes its purpose or intent.

3.27 *Verification*. The process of determining if a Test Stand is built according to specifications provided in a design, drawing, statement of work, or other document.

Section 4. Test Requirements

4.1 *Test Requirements*. All testing shall be conducted in accordance with the test methods and procedures as described in this standard and its appendices. Each Test Stand is tested in accordance with the Reference Rating Standard. Refer to Table 1 below for Test Types required per Reference Rating Standard. If the Test Stand is not able to meet these criteria, adjustments shall be made to resolve the issue.

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Table 1. Test Requirements per Rating Standard

AHRI 140 Test Procedure	AHRI Reference Rating Standard					
	210/240	340/360	1360	1230	390	310/380
Air Flow Measurement Apparatus Leakage	■	■	■	■	■	■
Zero Load	■	■		■	■	■
Air Flow Measurement Apparatus	■	■	■	■	■	■
Sensible Heat Measurement	■	■	■	■	■	■
Mixing Efficiency	■	■	■	■	■	■
Latent Heat Measurement	■	■	■	■	■	■
External Static Pressure Measurement	■	■	■	■	■	■
Thermal Energy Storage Effect for CD Testing	■	-	-	-	-	-
Full System Psychrometric Round Robin Testing[1]	■	■	■	■	■	■

Note:

1. If only one test facility exists, correlate between multiple indoor rooms. Run a complete set of tests with Room A and Room B. Then repeat the tests by swapping units between Room A and Room B. As an alternative, if only one room exists completely disassemble and reassemble the setup at a different date. This will show repeatability.

4.1.1 *Data Acquisition*. All test data shall be recorded in accordance with Appendix D.

4.1.2 *Instrumentation Calibration*. All measurement equipment should be calibrated in accordance with Appendix E.

4.1.3 *Uncertainty Analysis*. An Uncertainty analysis shall be completed. An example is shown in Appendix F.

Section 5. Evaluation Requirements

5.1 *Qualification Requirements*. Each Test Stand shall be qualified as defined in Section 5 within the tolerances shown in Table 2

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5.2 *Table 2.*

5.2.1 *Reference Rating Standard*. Each Test Stand shall be qualified in accordance with at least one Reference Rating Standard. Where more than one Reference Rating Standard applies, each Test Stand shall be qualified separately for each Reference Rating Standard.

5.2.2 *Validation Checks*. Each Test Stand shall be qualified using the validation checks defined in this Section.

Ratings related to airflow measurement are provided for a specific Airflow Measurement Apparatus.

5.2.2.1 *Air Flow Measurement Apparatus Leakage*. Test Stand air flow leakage shall be verified for a given Nozzle Chamber and ductwork configuration by measuring Leakage Rates at the following locations within the measurement apparatus system:

1) Nozzle Plate
2) Airflow Measurement Apparatus, including all permanent ductwork components from Nozzle Plate to UUT connection point.

Leakage Rates at each location are established at the target static pressure setpoints

5.2.2.2 *Zero Load*. Test Stand instrument induced error shall be verified for a given Nozzle Chamber across a range of airflow by the following:

1) Sensible Error
2) Latent Error
3) Pressure Transducer Zero Error

These deviations are established by comparing the total sensible and latent heat input of the UUT to the sensible and latent heat measured at a zero-load condition.

5.2.2.3 *Air Flow Measurement Apparatus Verification*. Test Stand air flow measurement shall be verified for a given Nozzle Chamber across a range of its nozzle configurations. Airflow measurements are verified by comparing two different Air Flow Measurement Apparatus nozzle size combinations at the same pressure drop using the Passive Pressure Drop Device.

5.2.2.4 *Sensible Heat Measurement*. Test Stand sensible heat measurements shall be verified for a given Capacity Measurement System by confirming Sensible Heat Balance.

Sensible Heat Balance is verified by comparing the total sensible heat input of the UUT to the sensible heat measured at Minimum Airflow, Mean of Minimum and Maximum Airflow, and Maximum Airflow.

5.2.2.5 *Mixing Efficiency*. Test Stand Mixing Efficiency shall be verified by comparing the difference between the maximum and minimum recorded temperatures on the outlet temperature grid with the difference between the average outlet and average inlet temperatures.

5.2.2.6 *Instrument Induced Humidity Ratio Verification*. Instrument induced humidity ratio verification is the measure of accuracy of the latent measurement equipment during sensible heat measurement tests where no latent change is expected.

5.2.2.7 *Latent Heat Measurement*. Test Stand latent heat measurement shall be verified for a given Capacity Measurement System by confirming the Latent Heat Balance.

Latent Heat Balance is verified by comparing the latent heat calculated from measured air properties against the latent heat calculated from measured condensate draining from the indoor coil of the system.

5.2.2.8 *External Static Pressure Measurement*. Test Stand external static pressure measurement shall be verified by comparing ANSI/ASHRAE Standard 37 duct configurations to ANSI/ASHRAE Standard 116 duct configurations.

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5.2.2.9 *Thermal Energy Storage Effect for CD Rating*. Test Stand thermal energy storage effect shall be determined for CD testing by cycling the heater in the Electric Heater Box. The result shall be used in accordance with Section 9.2 of ANSI/ASHRAE Standard 116.

5.2.2.10 *Full System Psychrometric Round Robin Testing*. Test Stand overall measurement accuracy shall be verified by correlation testing with one or more Reference Test Stands

5.2.2.11 *Large Unitary Sensible Heat Measurement*. Sensible heat measurement specific to Large Unitary devices.

5.2.3 *Test Stand Limits of Operation*. Test Stand minimum and maximum operational limits, as defined in Table 3, shall be established at the standard rating conditions specified by the Reference Rating Standard.

5.2.4 *Uncertainty of Measurement*. Uncertainty for all measurements (such as capacity, power, efficiency, pressure drop) shall be calculated.

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Table 2. Qualification Tolerance Limits per Reference Rating Standard

Symbol	Description	Tolerance	Reference Paragraph
Airflow Measurement Apparatus Leakage			
B4	Test 1: Nozzle Plate Leakage	Final before nozzle pressure ≥ -0.1 in H_2O	C3.1.5
Q_2	Test 2: Overall System Leakage Rate	< 1.0% of the minimum airflow rate or 5 CFM whichever is greater	C3.1.5
Q_3	Test 3: Overall System Leakage Rate	>Q_2	C3.1.5
Q_4	Test 4: Overall System Leakage Rate	< Q_2	C3.1.5
Airflow Measurement			
ΔQ_n	Measured Airflow Difference	1.0%	C3.3.5
Zero Load			
ΔT_{ave}	Inlet/Outlet Air Temperature Difference	Greater of ± 0.03ºF or Calibrated Accuracy of Measurement Device	C3.2
ΔP_{Nozzle}	Nozzle Delta Pressure	0 ± 0.01 in. wg	C3.2
P_0	Test 3: External Static Pressure	0.01 in. wg	C3.2
Sensible Heat Measurement Rating			
B_{SH_n}	Sensible Heat Balance	± 2.0%	C3.4.5.1
Mixing Efficiency			
η_{mixing}	Mixing Efficiency	0 – 0.1	C3.5.2
Instrument Induced Humidity Ratio			
ΔW	Instrument Induced Humidity Ratio	± 0.0002	C3.6.2.3
Latent Heat Measurement Rating			
B_{LH}	Latent Heat Balance	5.0%	C3.7.5
External Static Pressure Measurement Rating			
B_{ST}	External Static Pressure Drop Verification	5.0% or 0.01 in wg whichever is greater	C3.8.5.1
Thermal Energy Storage Effect for CD Rating			
$mc_{pm}(\mu)$	Cyclic Capacity of the Dry Coil	4.0 Btu/°F	C3.9.5.3
Full System Psychrometric Round Robin Rating			
Δq_{sci}	Sensible Capacity Difference	2.0%	C3.10.4.1
Δq_{lci}	Latent Capacity Difference	2.0%	C3.10.4.2
ΔE_i	Indoor Power Difference	1.0%	C3.10.4.3
ΔE_t	Total Power Difference	1.0%	C3.10.4.3
Uncertainty of Measurement			
-	Minimum Cooling Capacity	5%	-
-	Minimum Heating Capacity	5%	-

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Symbol	Description	Tolerance	Reference Paragraph
-	Minimum Power	3%	-
-	Maximum Cooling Capacity	3%	-
-	Maximum Heating Capacity	3%	-
-	Maximum Power	3%	-

Section 6. Minimum Data Requirements for Qualified Facilities

6.1 *Minimum Data Requirements for Qualified Facilities*. Table 3 provides minimum data requirements to publish Test Stand qualification.

All claims to qualification within the scope of this standard shall include the statement "Qualified in accordance with AHRI Standard 140 for performance testing in accordance with [Reference Rating Standard].", where "[Reference Rating Standard]" shall be replaced by the Reference Rating Standard used to rate the Test Stand in the following format of [Publisher] [Number]-[Publication Year] [(units)] (for example: AHRI 210/240-2017 (I-P).

All claims to qualifications outside the scope of the standard shall include the statement "Outside the scope of AHRI Standard ####."

Table 3. Facility Specifications

Specification	Unit of Measure	AHRI Reference Rating Standard	
		210/240	340/360, 1360, 1230, 390, 310/380
General			
Size – Maximum Available for UUT	-	-	-
Indoor Room (height, width, length)	ft	■	■
Outdoor Room (height, width, length)	ft	■	■
Outdoor Ambient Design Conditions	-	-	-
Dry Bulb Temperature	°F	■	■
Wet Bulb Temperature	°F	■	■
Fluids Available for Testing	-	■	■
Refrigerants Available for Testing	-	■	■
Electrical Connection(s) Available	-	-	-
Maximum Single-Phase Power	kW	■	■
Maximum Three Phase Power	kW	■	■
Volts	**V**	■	■
Phase	-	■	■
Frequency	Hz	■	■
Off Mode Power Capable	Y/N	■	■

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Specification	Unit of Measure	AHRI Reference Rating Standard	
		210/240	340/360, 1360, 1230, 390, 310/380
Indoor Room	-	-	-
Air Flow Range	cfm	■	■
UUT Static Pressure at Air Flow	in H2O	■	■
Dry Bulb Temperature Range	°F	■	■
Nominal Cooling Capacity Range	btu/h	■	■
Nominal Heating Capacity Range	btu/h	■	■
Max Humidification Rate	lbs/hr	■	■
Max Dehumidification Rate	lbs/hr	■	■
Outdoor Room	-	-	-
Air Flow Range[1]	cfm	■	■
UUT Static Pressure at Air Flow	in H2O	■	■
Dry Bulb Temperature Range	°F	■	■
Nominal Cooling Capacity Range	btu/h	■	■
Nominal Heating Capacity Range	btu/h	■	■
Max Humidification Rate	Lbs/hr	■	■
Max Dehumidification Rate	Lbs/hr	■	■
Heat Pump Capable	Y/N	■	■
Cyclic Testing			
Indoor Room	-	-	-
Air Flow	cfm	■	-
Fluid Flow	gpm	■	-
Nominal Cooling Capacity	btu/hr	■	-
Nominal Heating Capacity	btu/hr	■	-
UUT Pressure at Fluid Flow	Ft H2O	■	-
Outdoor Room	-	-	-
Air Flow	cfm	■	-
Fluid Flow	gpm	■	-
Nominal Cooling Capacity	btu/hr	■	-
Nominal Heating Capacity	btu/hr	■	-
UUT Pressure at Fluid Flow	Ft H2O	■	-
Uncertainty of Measurement (Confidence Interval of 95%)			
Net Cooling Capacity	btu/h	■	■
Net Heating Capacity	btu/h	■	■
Power	kW	■	■

Notes:
1. If available.

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Section 7. Conformance Conditions

7.1 *Conformance*. While conformance with this standard is voluntary, conformance shall not be claimed or implied for Test Stands within the standard's Purpose (Section 1) and Scope (Section 2) unless such claims meet all of the requirements of the standard and all of the testing and qualification requirements are measured and reported in complete compliance with the standard. Any Test Stand that has not met all the requirements of the standard cannot reference, state, or acknowledge the standard in any written, oral, or electronic communication.

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APPENDIX A. REFERENCES – NORMATIVE

A1. Listed here are all standards, handbooks, and other publications essential to the formation and implementation of the standards. All references in this appendix are considered as part of the standard.

A1.1. AHRI Standard 210/240-2017 (with Addendum 1), *Unitary Air-Conditioning and Air-Source Heat Pump Equipment*, 2019, Air Conditioning, Heating and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

A1.2. AHRI 310/380-2017, *Packaged Terminal Air-Conditioners and Heat Pumps*, 2017, Air Conditioning, Heating and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

A1.3. AHRI 340/360-2019, *Performance Rating of Commercial and Industrial Unitary Air-conditioning and Heat Pump Equipment*, 2019, Air Conditioning, Heating and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

A1.4. AHRI 390-2021 (I-P), *Single Package Vertical Air-Conditioners and Heat Pumps*, 2021, Air Conditioning, Heating and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

A1.5. AHRI 1230-2021 (I-P), *Variable Refrigerant Flow (VRF) Multi-split Air-conditioning and Heat Pump Equipment*, 2021, Air Conditioning, Heating and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

A1.6. AHRI 1360-2017, *Computer and Data Processing Room Air Conditioners*, 2017, Air Conditioning, Heating and Refrigeration Institute, 2311 Wilson Boulevard, Suite 400, Arlington, VA 22201, U.S.A.

A1.7. ANSI/ASHRAE Standard 37, 2009 *Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat Pump Equipment*, 2009, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. 1791 Tullie Circle NE, Atlanta, GA 30329, U.S.A.

A1.8. ANSI/ASHRAE Standard 116, 2010 *Methods of Testing for Rating Seasonal Efficiency of Unitary Air Conditioners and Heat Pumps*, 2010, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. 1791 Tullie Circle NE, Atlanta, GA 30329, U.S.A.

A1.9. ASHRAE Terminology. ASHRAE. Accessed November 18, 2021. https://www.ashrae.org/technical-resources/free-resources/ashrae-terminology.

Documents
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APPENDIX B. REFERENCES – INFORMATIVE

B1. Listed here are standards, handbooks and other publications which may provide useful information and background but are not considered essential. References in this appendix are not considered part of the standard.

B1.1. ASHRAE Handbook – Fundamentals: 2017, ASHRAE,. 180 Technology Parkway NW, Peachtree Corners, GA 30092, U.S.A.

B1.2. ASME PTC 19.1-2013, *Test Uncertainty*, The American Society of Mechanical Engineers, Two Park Avenue, New York, NY 10016, USA

APPENDIX C. METHOD OF TESTING AIR-CONDITIONING, HEATING, OR REFRIGERATION UNIT TEST STANDS – NORMATIVE

C1. *Purpose*. This appendix prescribes a method of testing for Test Stands.

C2. *Devices for Verification*.

C2.1. *Passive Pressure Drop Device*. Construct the assembly as detailed in Table 4 based on the Test Stand minimum and maximum airflow. A graphical representation of a Passive Pressure Drop Device is shown in Figure 1.

C2.2. *Design of Restriction Plate*. The restriction plate can be made with several different hole combinations. Holes can be covered during testing to achieve required pressure drop.

Table 4. Passive Pressure Drop Device – Informative

Item	**Specification per Airflow (CFM) Range**			
	≥ 200 and ≤ 2,500	**≥ 1,000 and ≤ 5,000**	**≥ 2,500 and ≤ 10,000**	**>8000 and <30,000**
Cross Sectional Area[1]	2.5 ft^2	5 ft^2	10 ft^2	30 ft^2
Length	≥ 4.74 ft	≥ 6.71 ft	≥ 9.49 ft	≥16.43 ft
Position of restriction plate[2,3]	Centered on length	Centered on length	Centered on length	Centered on length
Position of pressure measurement locations	8 total, evenly spaced along length and centered in cross sectional dimension	8 total, evenly spaced along length and centered in cross sectional dimension	8 total, evenly spaced along length and centered in cross sectional dimension	8 total, evenly spaced along length and centered in cross sectional dimension

Notes:
1. Sized to allow only air velocity ≤ 1000 feet per minute through the open assembly.
2. More than one passive restriction plate may be required to meet pressure drop requirements.
3. Restriction shall be kept consistent throughout the testing.

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