STANDARD

ANSI/ASHRAE Standard 116-2010
(Supersedes ANSI/ASHRAE Standard 116-1995 [RA 2005])

Methods of Testing for Rating Seasonal Efficiency of Unitary Air Conditioners and Heat Pumps

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NOTE

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FOREWORD

ASHRAE Standard 116 was developed to provide uniform methods of testing for rating the seasonal efficiency of unitary air conditioners and heat pumps used in residential applications. It was first published in 1983, revised in 1995, and reaffirmed in 2005. This revision of the standard improves the alignment with related ASHRAE and ARI standards, especially ASHRAE Standard 37; Sections 6.6 through 6.13 from Standard 116-1995 (RA 2005) have been deleted and replaced by sections that refer the user to corresponding sections in Standard 37-2005. In addition, the revised Standard 116 incorporates mandatory language throughout, adds the ASHRAE map of climate zones for US locations, updates references, and makes various editorial improvements.

1. PURPOSE

This standard provides test methods and calculational procedures for determining the capacities and cooling seasonal efficiency ratios for unitary air-conditioning and heat pump equipment and heating seasonal performance factors for heat pump equipment.

2. SCOPE

2.1 This standard covers electrically driven, air-cooled air conditioners and heat pumps used in residential applications with cooling capacity of 65,000 Btu/h and less or, in the case of heating-only heat pumps, heating capacity of 65,000 Btu/h and less.

2.2 The methods of test in this standard are broadly applicable, but this standard provides cooling and heating hours in temperature bins for only the contiguous states of the continental USA.

2.3 This standard includes test methods for steady-state, cyclic, and part-load performance and methods for establishing seasonal performance. Equipment with single-speed, multiple-speed, variable-speed, unloading, or multiple compressors for ducted and ductless systems is included.

2.4 This standard does not apply to room air conditioners. See ASHRAE Standards 16 and 58 in Appendix B, Bibliography.

3. DEFINITIONS AND NOMENCLATURE

air-conditioning systems:

cooling (heating) air-conditioning system: specific air-treating combination that may consist of means for ventilation, air circulation, humidity control, air cleaning, and heat transfer, with controlled means for cooling (heating).

single package air-conditioning system: air-conditioning system consisting of equipment provided entirely in one assembly or enclosure.

split air-conditioning system: air-conditioning system consisting of equipment provided in more than one assembly or enclosure, usually with supply air distribution equipment housed separately from refrigerant condensing equipment.

air, standard (I-P): dry air having a mass density of 0.075 lb_m/ft^3.

ARI: Air-Conditioning and Refrigeration Institute.

bin: in the bin method, a statistical class (sometimes, a class interval) for outdoor air temperature, with the class limits expressed in a temperature unit.

bin method: energy calculation method, usually used in prediction, in which the annual (or monthly) energy use of a building is calculated as the sum of the energy used for all of the outdoor temperature bins. The bin method allows heat pump (or other heater or cooler) performance, which is different for each bin, to be accounted for.

capacity, air conditioner, latent (dehumidifying): available steady-state refrigerating capacity of an air conditioner for removing latent heat from the space to be conditioned (Btu/h).

capacity, air conditioner, sensible: available steady-state refrigerating capacity of an air conditioner for removing sensible heat from the space to be conditioned (Btu/h).

capacity, air conditioner, total: available capacity of an air conditioner for removing sensible and latent heat from the space to be conditioned (Btu/h).

capacity, heating: the rate at which the equipment adds heat to the air passing through it under specified conditions of operation (Btu/h).

coefficient of performance, heating (COP): ratio of the rate of heat delivered to the conditioned space to the rate of energy input, in consistent units, for a complete operating heat pump system or some specific portion of that system under designated operating conditions. Derived by the equations in 9.2.3 and 9.2.4.

coil, indoor: the heat exchanger that removes heat from or adds heat to the conditioned space.

coil, outdoor: the heat exchanger that rejects heat to or absorbs heat from a source external to the conditioned space.

cooling load factor (CLF): ratio of the cooling building load to the steady-state cooling capacity (derived by the equation in 9.2.2).

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degradation coefficient (C_D): factor of efficiency loss due to the cycling of the unit. It is the effect of reduction in performance under cyclic operation as derived by the equations in 9.2.2 and 9.2.4.

energy:

(a) capability for doing work.

(b) capacity for producing an effect, having several forms, which may be either stored or transient and can be transformed from one form into another.

energy-efficiency ratio, cooling (EER): ratio of net cooling capacity in Btu/h to the total rate of electric input in watts, under designated operating conditions.

equilibrium: for the purposes of this standard, equilibrium is a steady-state condition during which the fluctuations of variables being measured remain within stated limits as given in Section 8.

heat, latent: change of enthalpy during a change of phase (Btu/h).

heat, sensible: heat that causes a change in temperature (Btu/h).

heat pump, cooling and heating: system designed to utilize alternately or simultaneously the heat extracted at a low temperature and the heat rejected at a higher temperature for cooling and heating functions, respectively.

heating load factor (HLF): ratio of the heating building load to the steady-state heating load (derived by the equation in 9.2.4).

heating seasonal performance factor (HSPF): ratio of the total heat delivered over the heating season (not to exceed 12 months) to the total energy input over the heating season, in consistent units. Derived by the equations in 10.2.

pressure, standard barometric: Approximately 14.696 psi or 29.921 in. Hg at 32°F.

seasonal energy-efficiency ratio, cooling (SEER): ratio of the total heat removed, in Btu, during the normal period of usage for cooling (not to exceed 12 months) to the total energy input, in watt-hours, during the same period. Derived by equations in 10.1.

shall ("it is required"): used in standards and regulations (as "shall" or "shall not") to indicate a provision that is mandatory.

should ("it is recommended"): used in standards and regulations to indicate a provision that is not mandatory but that is recommended as good practice.

4. CLASSIFICATIONS

Unitary equipment within the scope of this standard shall be classified as follows:

(a) Unit employing a compressor, indoor air coil, and outdoor coil in a single package assembly.

(b) Unit employing a compressor and indoor coil in one assembly with remote outdoor coil.

(c) Unit employing an indoor coil assembly, with outdoor coil and compressor in another assembly.

(d) Unit employing an indoor coil assembly, an outdoor coil assembly, and a compressor assembly.

See also Tables 1 and 2.

5. INSTRUMENTS AND DATA ACQUISITION SYSTEMS

5.1 Temperature-Measuring Instruments

5.1.1 Temperature measurements shall be made with one or more of the instruments discussed in ASHRAE Standard 41.1, Standard Method for Temperature Measurement.[1]

5.1.2 All temperature measurement shall be made in accordance with Tables 3a, 3b, and 3c, Test Tolerances.

5.1.3 All air temperature measurements shall be made as indicated in Figures 1, 2, 3, and 4 by use of thermocouple grids and sample temperature-measuring instruments.

5.1.4 It is highly recommended that the same instrumentation be used for making both steady-state and non-steady (cyclic) test measurements.

5.1.5 For non-steady-state test measurements, the instruments used shall have the following performance, or better:

(a) Have a total system accuracy of ±0.3°F of indicated value.

(b) Have a total system response time of 2.5 seconds or less. The response time for this standard is defined as the time

TABLE 1
Classification of Unitary Air Conditioners

Types of Unitary Air-Source Air Conditioners
Designation
Single Package
Refrigeration Chassis
Year-Round Single Package
Remote Condenser
Year-Round Remote Condenser
Condensing Unit Coil Alone
Condensing Unit Coil and Blower
Year-Round Condensing Unit and Blower

TABLE 2
Classification of Unitary Heat Pumps

Types of Unitary Air-Source Heat Pumps
Designation
Single Package
Remote Outdoor Coil
Remote Outdoor Coil with No Indoor Fan
Split System
Split System with No Indoor Fan

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TABLE 3a
Permissible Variations in Test Conditions for Steady-State Test

	Heating Mode		Cooling Mode	
	Test Operating Tolerance (1)	Test Condition Tolerance (2)	Test Operating Tolerance (1)	Test Condition Tolerance (2)
Indoor dry-bulb, °F				
Entering(3)	2.0	0.5	2.0	0.5
Leaving(3)	3.0	--	2.0	--
Indoor wet-bulb, °F				
Entering	1.0	--	1.0	0.3
Leaving	--	--	1.0	--
Outdoor dry-bulb, °F				
Entering	2.0	0.5	2.0	0.5
Leaving(4)	3.0	--	2.0	--
Outdoor wet-bulb, °F				
Entering(4)	1.0	0.3	1.0	0.3
Leaving(4)	1.0	--	1.0	--
External resistance to airflow, inches of water	0.05	0.02	0.05	0.02
Electrical voltage, ±%	2.0	2.0	2.0	2.0

(1) *Test Operating Tolerance* shall be defined as the maximum permissible range of any measurement When expressed as a percentage, the maximum allowable variation is the specified percentage of the average value,
(2) *Test Condition Tolerance* shall be defined as the maximum permissible variation of the average value of the measurement from the specified test condition.
(3) For the dry-coil steady state tests, the dry-bulb temperatures of the air entering and leaving the cooling coil or the difference between these two dry-bulb temperatures shall be recorded at time intervals no greater than 10 seconds (or continuously) with the instrumentation having a total system accuracy and precision of ±0.3°F.
(4) Dry Coil Test 8.2.1—Tolerances not applicable. Indoor wet-bulb shall at no time exceed that value of the wet-bulb temperature which results in the production of condensate by the indoor coil at the dry-bulb temperature existing for the air entering the indoor portion of the unit.

TABLE 3b
Test Tolerances for Cyclic Performance Tests

	Test Operating Tolerance (1)	Test Condition Tolerance (2) (3)
Indoor dry-bulb, °F		
Entering(4)	2.0	0.5
Leaving(4)	--	--
Indoor wet-bulb, °F		
Entering	1.0	--
Leaving	--	--
Outdoor dry-bulb, °F		
Entering	2.0	0.5
Leaving(5)	--	--
Outdoor wet-bulb, °F		
Entering(5)	2.0	1.0
Leaving(5)	--	--
External resistance to airflow, inches of water	0.05	0.02
Electrical voltage, ±%	2.0	2.0

(1) *Test Operating Tolerance* shall be defined as the maximum permissible range of any measurement. When expressed as a percentage, the maximum allowable variation is the specified percentage of the average value.
(2) *Test Condition Tolerance* shall be defined as the maximum permissible variation of the average value of the measurement from the specified test conditions.
(3) Cyclic Dry Coil Tests 8.2.4—Readings shall be within indicated tolerances 30 seconds after compressor start-up.
(4) For the dry-coil steady-state and cyclic tests, the dry-bulb temperatures of the air entering and leaving the cooling coil or the difference between these two dry-bulb temperatures shall be recorded at time intervals no greater than 10 seconds (or continuously) with instrumentation having a total system accuracy and precision of ±0.3°F.
(5) Cyclic Dry Coil Tests 8.2.4—Tolerances not applicable. Indoor wet-bulb shall at no time exceed that value of the wet-bulb temperature which results in the production of condensate by the indoor coil at the dry-bulb temperatures existing for the air entering the indoor portion of the unit.

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TABLE 3c
Test Tolerances for Frost Accumulation Tests

	Testing Operation Tolerance (1)		Test Condition Tolerance (2)
	During Heating	During Defrost	(Heating Portion Only)
Indoor dry-bulb, °F			
Entering	2.0	4.0 (3)	0.5
Leaving	--	--	--
Indoor wet-bulb, °F			
Entering	1.0	--	--
Leaving	--	--	--
Outdoor dry-bulb, °F			
Entering	2.0	10.0	1.0
Leaving	--	--	--
Outdoor wet-bulb, °F			
Entering	1.5	--	0.7
Leaving	--	--	--
External resistance to airflow, inches of water	0.05	--	0.02
Electrical voltage, +%	2.0		

(1) *Test Operating Tolerance* shall be defined as the maximum permissible range of any measurement. When expressed as a percentage, the maximum allowable variation is the specified percentage of the average value. *Test Operating Tolerance During Heating* applies when the heat pump is in the heating mode, except for the first 5 minutes after termination of a defrost cycle when the heat pump is operating in the heating mode.
(2) *Test Condition Tolerance* shall be defined as the maximum permissible variation of the average value of the measurement from the specified test conditions. *Test Condition Tolerance* applies only when the heat pump is operating in the heating mode.
(3) Not applicable during defrost if the indoor fan is off.

required for the instrumentation to obtain 63% of the final steady-state value when subjected to a step change in temperature of 15°F or more in air. The tests shall be made in air having the same velocity as observed at the location where the temperature was measured.

Cautionary Note: When using temperature transducers in series or parallel (such as thermocouple grids) to obtain the average temperature or average temperature difference in a duct with nonuniform velocities, the overall response time can be much larger than the response time measured at the average velocity.

5.2 Refrigerant Pressure-Measuring Instruments

5.2.1 Pressure measurements shall be made with one or more of the following instruments:

(a) Liquid column
(b) Bourdon tube gauge
(c) Electronic pressure transducers

5.2.2 The accuracy of' the pressure-measuring instruments shall permit measurements within ±2.5% of the indicated value.

5.2.3 The pressure-measuring instruments shall be calibrated with respect to a dead weight tester or by comparison to a liquid column.

5.3 Airflow and Static Pressure Measurements

5.3.1 Static pressure across nozzles or velocity pressure at nozzle throats shall be measured with manometers or pressure transducers having a least scale division that shall not exceed 2.0% of the reading. The pressure-measuring instruments shall be calibrated against a standard manometer or dead weight tester that shall have an accuracy of ±1.0% of the reading.

5.3.2 Duct static pressure shall be measured with rnanometers or pressure transducers having an accuracy of ±0.01 inch of water (2.5 Pa).

5.3.3 Areas of nozzles shall be determined by measuring their inside diameters to an accuracy of ±0.2% in four places approximately 45 degrees apart around the nozzle in each of two planes through the nozzle throat, one at the outlet and the other in the straight section near the radius.

5.4 Electrical Instruments

5.4.1 Instruments used for measuring electrical input to system components shall be accurate to ±2.0% of the indicated value. Instruments used for measuring the electrical input to heaters or other apparatus furnishing heat loads shall be accurate to ±1.0% of the quantity measured.

5.4.2 For rating purposes, a watt-hour measuring system with an accuracy of ±0.5% of the indicated value shall be used for total system measurement. This applies to both ON and OFF cycle measurements. For non-steady-state tests, the total electrical energy shall be integrated over the test period.

5.4.3 Voltages shall be measured at the equipment terminals.

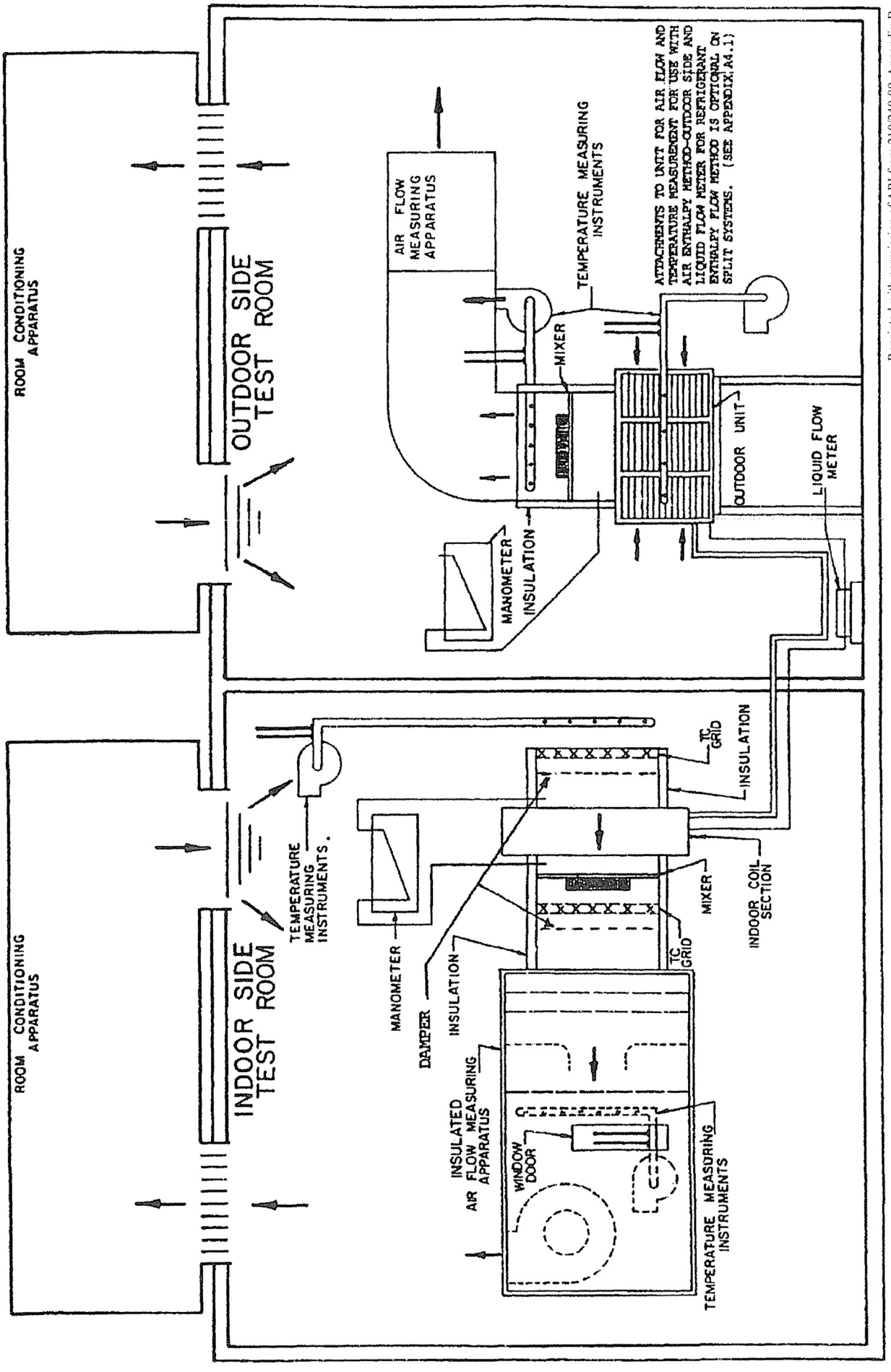
5.5 Volatile Refrigerant Flow Measurement

Volatile refrigerant flow shall be measured with an integrating type flowmeter having an accuracy of ±1.0% of the indicated value.

5.6 Speed-Measuring Instruments

Speed measurements shall be made with a revolution counter, tachometer, or stroboscope having an accuracy of ±1.0%.

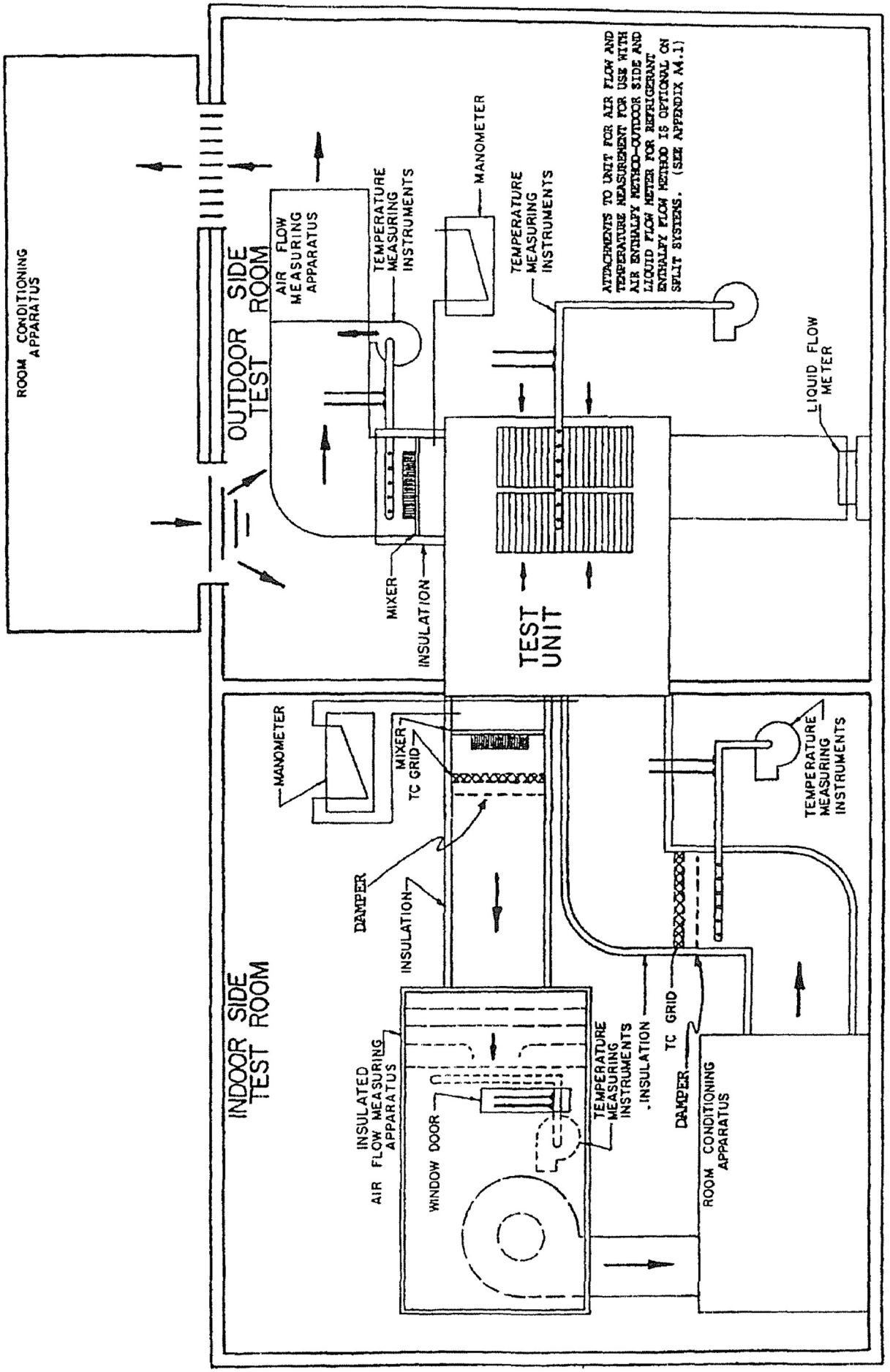
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Figure 1 ARI figure—tunnel air enthalpy test method arrangement.

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Figure 2 ARI figure—loop air enthalpy test method arrangement.