



SURFACE VEHICLE STANDARD

J2765™

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Superseding J2765 OCT2008

Procedure for Measuring System COP [Coefficient of Performance] of a
Mobile Air Conditioning System on a Test Bench

RATIONALE

This revision of this standard has been done to add additional test descriptions for two evaporator systems, systems with chillers, systems with electric compressors, systems with indirect condensers, and make other improvements.

1. SCOPE

- 1.1 The impact of mobile air conditioning systems on the environment is becoming more important. Fuel used to power the system impacts both fuel economy of the vehicle and tail pipe emissions of carbon dioxide.
- 1.2 This Standard applies to mobile air conditioning systems consisting of one or two in-car air coil (evaporator), a compressor, an expansion device, one under-hood air coil (condenser), and either with or without a liquid to refrigerant evaporator (chiller).
 - 1.2.1 This standard can also be used for measuring systems that use electrically driven compressor if measurement of input power to compressor is carefully considered.
 - 1.2.2 This standard can also be used for measuring systems that include the entire air handling system if air side pressure drop for the entire vehicle system is carefully considered.
 - 1.2.3 This standard can also be used for measuring systems that include the entire front end cooling module if air side pressure drop for the entire vehicle system is carefully considered.
 - 1.2.4 This standard can also be used for measuring systems that include a secondary cooling loop if the power to drive the pumps in this system is carefully considered.
 - 1.2.5 This standard can also be used for dual evaporator systems.
 - 1.2.6 This standard can also be used for mobile air conditioning systems with chillers used to condition the battery of an electric vehicle.
- 1.3 This Standard specifies procedures, apparatus, and instrumentation that will produce accurate steady state capacity and efficiency data for refrigerant components.
- 1.4 This Standard does not:
 - 1.4.1 Specify transient test methods,
 - 1.4.2 Make recommendations for safety

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1.4.3 Specify tests for production, specification compliance, or field testing of mobile air conditioning systems.

1.5 Purpose

1.5.1 This Standard provides a method of testing the capacity (performance) and efficiency (COP) of mobile air conditioning refrigerant systems under steady state conditions.

1.5.2 The procedure proposed is designed to give maximum repeatability and minimum error in determining cooling capacity (Q) and efficiency (COP – Coefficient of Performance) of the refrigeration system of the mobile air conditioner. For that reason a “breadboard” type facility is proposed in which components are assembled into a system and exposed to operating conditions in individual, separately controlled chambers. The facility should allow for three methods to determine system performance: refrigerant side, airside, and calorimetric chambers. Each side yields its own energy balance calculation to find the capacity of the system. With the three methods used, instead of two as typically required, redundancy will be maintained even when the evaporator refrigerant exit is two phase. In this case only the airside and chamber balances are available. However, the calorimetric chamber is not required provided the airside heat rejection is properly balanced with the refrigerant side heat rejection. The design should be made so that two independent methods could provide agreement of less than $\pm 4.0\%$ between two independent balances.

2. REFERENCES

2.1 Applicable Documents

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 ASHRAE Publications

Available from American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329-2305, Tel: 404-636-8400, www.ashrae.org.

¹ ANSI/ASHRAE Standard 41.1-1986 (RA 2001)	Standard Method for Temperature Measurement
² ANSI/ASHRAE Standard 41.6-1994 (RA 2001)	Standard Method for Measurement of Moist Air Properties
³ ASHRAE Standard 41.3-1989	Standard Method for Pressure Measurement
⁶ ASHRAE Standard 41.2-1987 (RA 92)	Standard Methods for Laboratory Airflow Measurement
⁷ ANSI/ASHRAE Standard 51-1999	Laboratory Methods of Testing Fans for Aerodynamic Performance Rating (AMCA Standard 210-99)
⁸ ANSI/ASHRAE Standard 37-2005	Methods of Testing for Rating Electrically Driven Unitary Air-Conditioning and Heat Pump Equipment
⁹ ANSI/ASHRAE Standard 41.4-1996	Standard Method for Measurement of Proportion of Lubricant in Liquid Refrigerant

2.1.2 ASME Publication

Available from ASME, P.O. Box 2900, 22 Law Drive, Fairfield, NJ 07007-2900, Tel: 800-843-2763 (U.S./Canada), 001-800-843-2763 (Mexico), 973-882-1170 (outside North America), www.asme.org.

⁴ Fluid Meters—Their Theory and Application, Sixth Edition, 1971

2.1.3 ARI Publication

Available from Air-Conditioning and Refrigeration Institute, 4100 North Fairfax Drive, Suite 200, Arlington, VA 22203, Tel: 703-524-8800, www.ari.org.

⁵ ARI Standard 700-2004 Specifications for Fluorocarbon Refrigerants

2.1.4 NIST Publication

Available from NIST, 100 Bureau Drive, Stop 1070, Gaithersburg, MD 20899-1070, Tel: 301-975-6478, www.nist.gov.

¹⁰ NIST Standard Reference Database 23 NIST Thermodynamic and Transport Properties of Refrigerants and Refrigerants and Refrigerant Mixtures—REFPROP 6

3. DEFINITIONS

3.1 AIR, STANDARD

Dry air having a mass density of 1.204 kg/m³ (0.075 lb/ft³) which represents the density at 20°C at standard barometric pressure defined in section 3.6.

3.2 APPARATUS

As used in this standard, this term refers exclusively to test room facilities and instrumentation.

3.3 CAPACITY, TOTAL COOLING

The rate, expressed in watts (Btu/hr), at which the equipment removes heat from the air passing through it under specified conditions of operation.

3.4 COP, COEFFICIENT OF PERFORMANCE

A measure of the efficiency of an air conditioning system is defined as the average heat removed through the evaporator divided by the average work input to the compressor. Averaging is done using the balances available and/or as described in 7.4.1. This COP is the highest possible because it does not account for air movement, heat transmission or other losses of similar nature.

3.4.1 Adjustments to this calculation may be necessary for electrically driven compressors, in case the air handling system is used, in the case of front end cooling module is used, and for secondary cooling loop systems.

3.5 EQUIPMENT

As used in this standard, this term refers exclusively to the mobile air conditioning equipment to be tested.

3.6 PRESSURE, STANDARD BAROMETRIC

101.325 kPa (14.696 psi).

3.7 REFRIGERANT

A refrigerant that changes from the liquid to the vapor state in the process of absorbing heat.

3.8 INDIRECT CONDENSER

A condenser that rejects heat from refrigerant to a liquid cooling medium. Also called a water-cooled, liquid-cooled, or secondary loop condenser.

3.9 INDIRECT CONDENSING

A method of condensing utilizing a secondary loop, whereby the refrigerant is condensed in the indirect condenser, and the associated heat is then rejected from the coolant to the ambient air via a low-temperature radiator (LTR).

3.10 SHALL OR SHALL NOT

Is used to indicate a provision that is mandatory if compliance with the standard is claimed.

3.11 SHOULD, RECOMMENDED OR IT IS RECOMMENDED

Is used to indicate provisions which are not mandatory but which are desirable as good practice.

4. INSTRUMENTATION

4.1 Temperature Measuring Instruments

4.1.1 All temperature measurements (with the exception of dew point temperature) shall be made in accordance with ANSI/ASHRAE Standard 41.1-1986 (RA 2001).¹

4.1.2 If used in determining the water vapor content of the air, dew point hygrometers shall be applied as specified in ANSI/ASHRAE Standard 41.6-1994 (RA 2001)² and shall be accurate to within ± 0.2 °C (0.4 °F).

4.1.3 Inlet air temperature measurements are to be taken upstream of static pressure taps on the inlet duct (if installed). Outlet air temperature measurements shall be taken downstream of the static pressure taps on the outlet. Very often the best practice is to take temperature immediately downstream of the nozzle throat.

4.2 Pressure Measuring Instruments

4.2.1 Pressure measurements shall be made with any device meeting the requirements of ASHRAE 41.3-1989.³

4.2.2 The accuracy of pressure measuring instruments shall permit measurement to within $\pm 1.0\%$ full scale.

4.3 Air Differential Pressure and Airflow Measurements⁴

4.3.1 The static pressure difference across nozzles and velocity pressures at nozzle throats shall be measured with manometers or electronic pressure transducers that have been calibrated against a pressure standard to within $\pm 1.0\%$ of the reading. The resolution of the device shall be equal to or less than 2.0% of the reading.

4.3.2 Areas of nozzles shall be determined by measuring their diameters to within $\pm 0.20\%$ in four places approximately equally spaced 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.

4.4 Electrical Instruments

4.4.1 Electrical measurements shall be made with indicating or integrating instruments.

4.4.2 Instruments used for measuring the electrical power input to fan motors or other equipment accessories shall be accurate to within $\pm 0.5\%$ of the reading for voltage, and $\pm 1.0\%$ of reading for current measured by shunt.

4.4.3 Voltages shall be measured at the equipment terminals. Instruments used for measuring voltage shall be accurate to within $\pm 0.5\%$ of the reading.

4.5 Refrigerant Flow Measurement

4.5.1 Refrigerant flow shall be measured with an integrating flow measuring system that is accurate to within $\pm 1.0\%$ of the reading

4.6 Latent Heat Transfer Measurement

Latent heat transfer can be measured via condensation collection or outlet humidity measurement vs. the inlet humidity condition.

4.6.1 Condensate collection rates shall be determined using a liquid quantity meter that is accurate to within $\pm 0.5\%$ of the reading or other method that provides the same accuracy.

4.6.2 Latent load can also be determined via dew-point measurement on the downstream side of the evaporator capable of $\pm 1\%$ Relative Humidity or the use of dry-bulb/wet-bulb temperature measurements accurate to within $\pm 0.2\text{K}$.

4.7 Coolant Flow Measurement Equipment

4.7.1 Coolant flow meters shall be measured using volumetric flow accurate to 0.2% of actual value.

4.8 Speed Measuring Instruments

4.8.1 Speed measurements shall be made with a revolution counter, tachometer, stroboscope, or oscilloscope that is accurate to within $\pm 1.0\%$ of the reading.

4.9 Time and Mass Measurements

4.9.1 Time interval measurements shall be made with an instrument that is accurate to within $\pm 0.2\%$ of reading.

4.9.2 Mass Measurement shall be made with an apparatus that is accurate to within $\pm 1.0\%$ of reading.

4.10 Torque Measurements

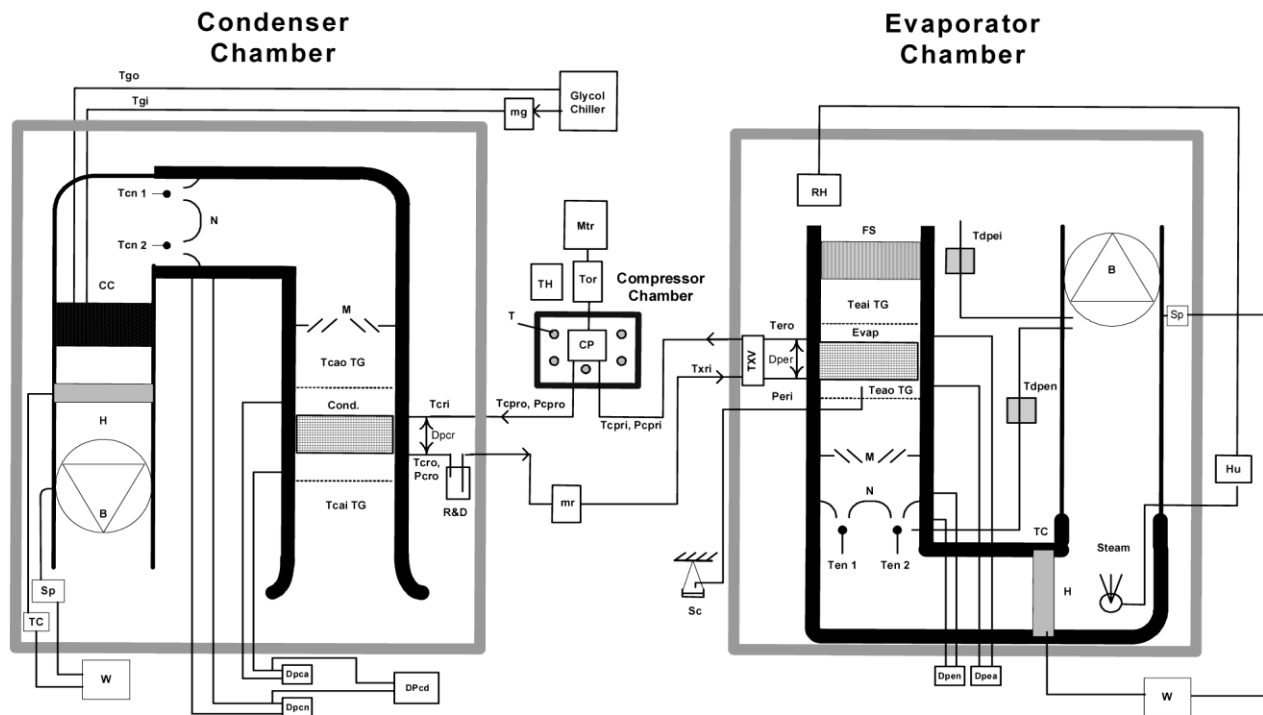
4.10.1 Torque measurements shall be made with an instrument that is accurate to within $\pm 2.0\%$ of reading.

4.11 Refrigerant mass composition measurements for refrigerant mixtures shall be made using an instrument that is in accordance with ARI Standard 700-2004.⁵

5. TEST FACILITY AND MEASURING APPARATUS

5.1 Test Facility (Figure 1)

Recommended configurations for the test facility are provided below. In all cases, suitable means for determining the dry-bulb temperature and water vapor content of the air entering and leaving the heat exchangers shall be provided.



B - Blower, **CP** - Compressor, **CC** - Cooling Coil, **CH** - Glycol Chiller, **Cond** - Condenser, **Dp** - Differential Pressure Transducer, **Evap** - Evaporator, **FS** Flow Straightener, **H** - Heater, **Hu** - Humidifier, **mg** - Glycol Mass Flow Meter, **mr** - Refrigerant mass Flow Meter, **Mtr** - Motor, **N** - Nozzle, **P** - Pressure Transducer, **RH** - Relative Humidity Probe, **Sc** - Condensate Scale, **Sp** - Speed Controller and Tachometer, **T** - Thermocouple, **TC** - Temperature Control Unit, **TG** - Thermocouple Grid, **Tor** - Torque Transducer, **W** - Watt Transducer, **TXV** - Thermal Expansion Valve
Indices : a - air, c - condenser, cp - compressor, e - evaporator, g - glycol, i - inlet, n - nozzle, o - outlet, r - refrigerant,

Figure 1A - Sample test facility closed bench

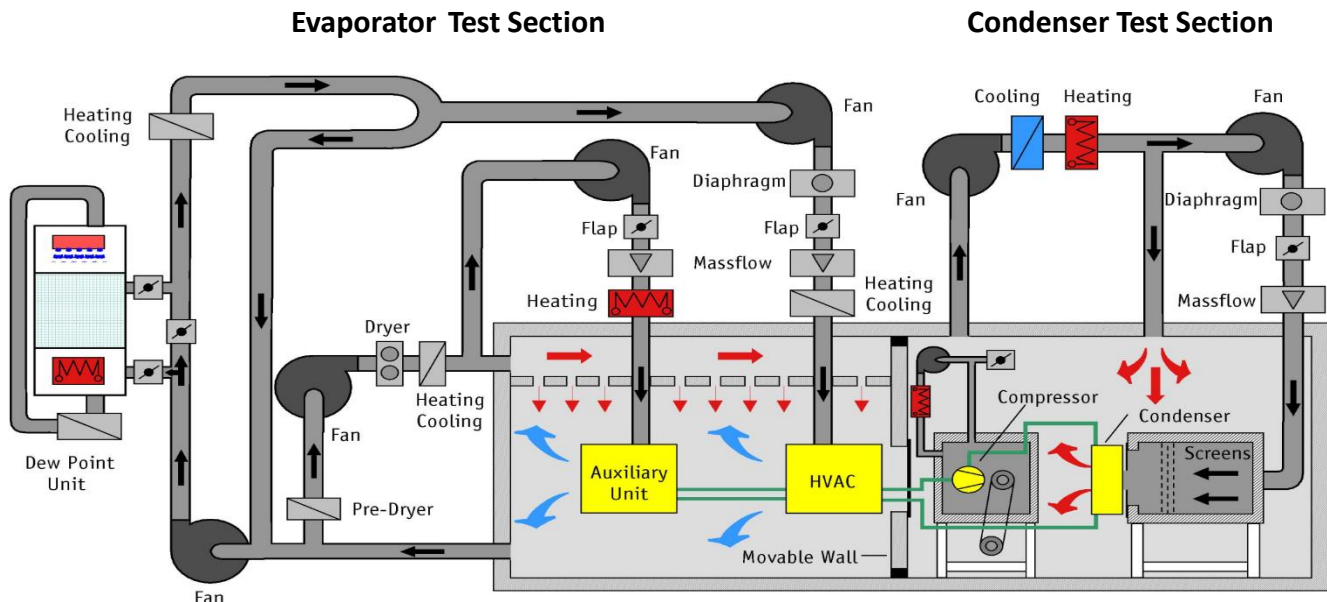


Figure 1B - Sample test facility open bench

Figure 1

5.2 Test Room Requirements

- 5.2.1 Typically, two test rooms are required; an in car room and an under-hood room. If desired, a third room may be used for the compressor to simulate under-hood conditions. That room can be located either outside or in the under-hood room.
- 5.2.2 An in car condition test room is required. This may be any room or space in which the desired test conditions can be maintained within the tolerances given in Table 1.
- 5.2.3 An under-hood test room is required. This may be any room or space in which the desired test conditions can be maintained within the tolerances given in Table 1. A condenser wind tunnel may be substituted for the under-hood test room provided it is capable of maintaining the conditions given in Table 1.

Table 1 - Permissible variations in test conditions

Controlled Test Parameter	Operating Tolerance ⁽¹⁾ ±	Condition Tolerance ⁽²⁾ ±
Evaporator inlet air dry-bulb temperature (°C)	0.5	0.3
Evaporator inlet air humidity (%)	3	1
Evaporator air flow rate (kg/min)	0.3	0.1
Targeted air temp. downstream of evaporator (°C)	0.5	0.3
Condenser inlet air dry-bulb temperature (°C)	0.5	0.3
Condenser face air velocity (m/s)	0.18	0.06
Compressor speed (rpm)	2	1

1. Operating Tolerance is the maximum permissible range of any measurement.

2. Condition Tolerance is the maximum permissible variation of the average value of the measurement from the specified test condition.

5.3 Wind Tunnels for Heat Exchangers

- 5.3.1 To produce repeatable and comparable results, it is recommended to control the inlet air temperature and velocity profile across the face of the test heat exchangers.
- 5.3.2 Below is an example of one setup that has been used to accomplish this end.
- 5.3.2.1 Each test heat exchanger shall be mounted in a wind tunnel inside their respective test room. The wind tunnel may be constructed from any suitable duct material. The illustration of a duct sections for the test heat exchanger in a wind tunnel are shown in Figure 2.
- 5.3.2.2 Air enters over the flow straightener (1) and inlet thermocouple grid (2) to the test heat exchanger (evaporator, condenser, or gas cooler). At the exit of the test heat exchanger is the outlet thermocouple grid (3) before the flow measuring devices – nozzles (4). After the nozzles, average air stream temperature is measured by a thermocouple or other appropriate thermometer (5). Reconditioning of the air (cooling or heating) is done in the conditioning test facility heat exchanger (6). For control purposes, an electrical heater is recommended. The test facility Blower (7) provides air circulation for the test heat exchanger.