SURFACE VEHICLE RECOMMENDED PRACTICE

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Rating Air-Conditioner Evaporator Air Delivery and Cooling Capacities

RATIONALE

This document has been revised to add in 1234yf information.

1. SCOPE

The purpose of this SAE Recommended Practice is to establish uniform test procedures for measuring and rating air delivery and cooling capacity of truck and off-road self-propelled work machines used in earth moving, agriculture, and forestry air-conditioner evaporator assemblies. It is the intent to measure only the actual cooling capacity of the evaporator. It is not the intent of this document to rate and compare the performance of the total vehicle air-conditioning system.

1.1 This procedure is designed to provide truck and off-road self-propelled work machines used in earth moving, agriculture, and forestry manufacturers and air-conditioning system suppliers with a cost-effective, standardized test method and calculations for measuring and rating air delivery and cooling capacity of truck cab air-conditioner evaporator assemblies. This procedure relates to HFC-134a (R-134a) and HFO-1234yf (R1234yf) refrigerant system.

2. REFERENCES

There are no referenced publications specified herein.

3. DEFINITIONS

3.1 EVAPORATOR ASSEMBLY

The evaporator assembly as defined consists of a coil (heat transfer surface), the means of forcing air over the heat transfer surface into the cab, and the complete enclosure (air-conditioning unit) to be furnished for the installation.

3.2 REFRIGERANT CONTROL

The device furnished with the evaporator assembly to regulate the flow of refrigerant into the coil. It is to be the control specified and included with the evaporator assembly being tested.

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3.3 EVAPORATOR ASSEMBLY CAPACITY

3.3.1 AIR DELIVERY RATE

The actual rate of airflow SCFM (standard air volume flow rate as specified in 8.1) for wet coil conditions. The air delivery is to be measured during the Capacity Rating Test in Section 7.

3.3.2 COOLING CAPACITY (AIR SIDE)

The amount of heat absorbed from the air flowing through the evaporator in W, kW (Btu/hour), as specified in 8.3 and 8.4.

3.3.3 COOLING CAPACITY (REFRIGERANT SIDE)

The amount of heat absorbed by refrigerant flowing through the evaporator tubes in W, kW (Btu/hour), as specified in Section 9.

3.4 DRY BULB TEMPERATURE

Air temperature in °C (°F) as read from a standard thermometer or other appropriate temperature measuring device.

3.5 WET BULB TEMPERATURE

Air temperature in °C (°F) essentially equal to that read from a wet bulb thermometer or one whose sensing bulb is covered by a water-wetted wick located in the moving airstream.

3.6 RELATIVE HUMIDITY

Ratio of the amount of moisture (in mol-fraction) in the air to the maximum amount the air can hold at the same temperature and pressure.

3.7 HUMIDITY RATIO

Ratio of the mass of water vapor to the mass of dry air kg_w/kg_a (lb_w/lb_a).

3.8 DEW POINT (SATURATION) TEMPERATURE

Air temperature in °C (°F) at which moisture begins to condense out as the air is cooled at constant pressure.

3.9 TOTAL HEAT (ENTHALPY)

The total heat content (sensible and latent) in the air j/kg_a (Btu/lb_a) equal to the sum of the individual partial enthalpies of the dry air and water vapor.

3.10 SENSIBLE HEAT

The amount of heat associated with a change in the dry bulb temperature of the air.

3.11 LATENT HEAT

The amount of heat required to change the state of a substance. Specifically, it is the heat released as water vapor condenses out of moist air and also the heat associated with the phase change of certain heat transfer fluids (volatile refrigerants, steam, etc.).

3.12 DISCHARGE LINE

High pressure (inlet line) that carries liquid Refrigerant to the expansion device.

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3.13 SUCTION LINE

Low pressure (outlet line) that carries evaporated (gaseous) Refrigerant to the compressor.

3.14 SUBCOOLING

The degrees of temperature below the saturation temperature (based on the inlet pressure of expansion device) of the liquid Refrigerant °C (°F).

3.15 SUPERHEAT

The degrees of temperature above the saturation temperature (based on the outlet pressure of the evaporator) of the vaporized Refrigerant °C (°F).

3.16 EXPANSION DEVICE

Valve or fixed orifice in the Refrigerant circuit whose purpose is to meter refrigerant into the evaporator, inducing a large pressure-drop that causes a change of state.

3.17 COMPRESSOR

Pumps low-pressure Refrigerant vapor out of the evaporator by suction, raises its pressure, and then pumps it, under high pressure, into the condenser.

3.18 CONDENSER

Removes heat from entering high-pressure, high-temperature de-superheated Refrigerant vapor, changing it to a high-pressure, high-temperature liquid.

3.19 EVAPORATOR

Removes unwanted heat from the air by the boiling of liquid Refrigerant in the evaporator coil.

3.20 PSYCHROMETRIC CHART

Graphical presentation of moist air properties.

3.21 RESISTANCE TEMPERATURE DEVICE (RTD)

Used for precision measurement of refrigerant temperature for the purpose of capacity calculations.

4. SYMBOLS AND UNITS

A = Area in square meters (square feet)

A_N = Area of nozzle in square meters (square feet)

BP = Barometric pressure (Absolute) in Pa (in Hg)

$C_{p.a}$ = Specific heat of the air in j/(kg*K) (Btu/lb/°F)

CFM = Air volume flow rate in m^3/min (cubic feet per minute [CFM]) at the air density calculated for the conditions existing at the air measurement nozzle

D = Diameter in meters (inches or feet)

DB = Dry bulb in °C (°F)

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DC = Direct current, amp

DN = Diameter of nozzle, square meters (square feet)

dn = Density of air at the nozzle in kg/m^3 (lb/ft^3)

G = Mass flow rate of the air (kg/s; sometimes kg/hour [lb/hour]) kg_a/s, kg_{mix}/s, kg_w/s; (lb_a/hour, lb_{mix}/hour, and lb_w/hour) = air mass flow of the dry air, moist air - air-water vapor mixture, and water vapor

G_r = Mass flow rate of the refrigerant in kg/hour (lb/min)

Hg = Mercury

h = Enthalpy (change in heat content), j/kg (Btu/lb)

in = Inches

N_T = Air temperature DB at nozzle in °C (°F)

PD = Pressure differential in Pa (psi)

Q_r = Total heat transferred (total cooling capacity), refrigerant side in kW (Btu/hour)

Q_s = Sensible heat transferred (sensible cooling capacity), air side in kW (Btu/hour)

Q_t = Total heat transferred (total cooling capacity), air side in kW (Btu/hour)

SCFM = Air volume flow rate in standard cubic feet per minute based on 1.20 kg/m^3 (0.075 lb/ft^3) for dry air at 21 °C (70 °F) and 101.04 kPa (29.92 in Hg) (see detailed explanation in 8.1.2); metric equivalent: SCFM * 1.699 = m^3/hr

SP = Static pressure, Pa (“WC)

T = Temperature in °C (°F)

V = Velocity in m/min (feet per minute [FPM])

W = Air humidity ratio in kg_w/kg_a (lb_w/lb_a)

WB = Wet bulb, °C (°F)

WG = Water gauge in millimeters (inches)

5. TEST EQUIPMENT

5.1 Test Room (Calorimeter Room)

A room in which specified ambient test conditions can be maintained to supply a controlled ambient for the evaporator assembly with constant inlet DB and WB as specified in 6.4.

5.2 A means of measuring airflow such as described in 5.2.1 through 5.2.3 or any other device of equivalent accuracy that does not interfere with the intent of the test.

5.2.1 Airflow Measurement Chamber (Air Booth)

See Figure 1.

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5.2.2 Nozzle

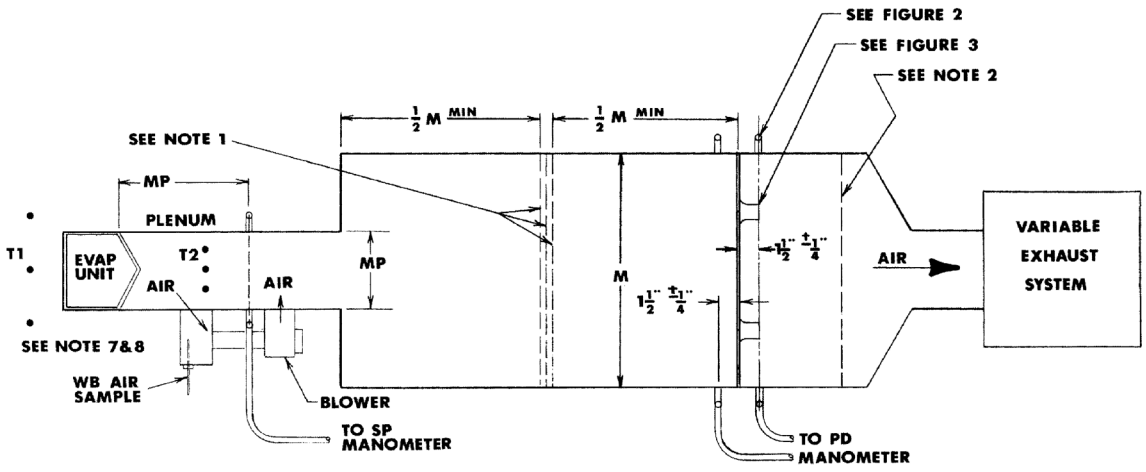
See Figure 3.

The nozzle throat shall be measured on four diameters at 45-degree intervals to an accuracy of 0.001 D and shall not deviate more than 0.002 D from the mean. Measurements shall also be made on the inlet of the parallel section, which may be +0.002 D greater than the exit but no less. The nozzle surface must be smooth with surface waves no greater than 0.001 D peak-to-peak. Recommended construction is spun aluminum, and the dimension D can be calculated from 8.3 based on anticipated airflow measurement requirements.

NOTE: Minimum acceptable nozzle PD shall be 99.5 Pa (0.4 in WG).

5.2.3 Inclined Manometers

Inclined manometers used in conjunction with 5.2 shall have a scale expansion factor of at least 10 (distance between 0 and 249 Pa [0 and 1 in WG] to be at least 25.4 cm [10 inches]) with scale divisions of 2.49 Pa (0.01 in WG) maximum for pressures below 498 Pa (2 in WG) and 12.4 Pa (0.05 in WG) maximum scale divisions for pressures above 498 Pa (2 in WG). Micromanometers may be used in place of the inclined manometers.



1. Chamber settling means shall be provided consisting of one perforated plate 30 to 40% open area followed by at least ten orifice diameters with two screens of 50% or less open area at least ten mesh lengths apart, or other means to provide substantially uniform velocity distribution ahead of nozzles. Maximum velocity at any point in a plane midway between the nozzle plate and the settling means, shall not exceed 122 m/min (400 FPM).
2. One perforated plate or screen of 50% maximum open area is to be placed downstream of nozzles as shown. There shall be a minimum clearance between the nozzle discharge and the perforated plate of 2–½ DN of the largest nozzle.
3. Chamber cross sectional area shall be such that V_M is less than 122 m/min (400 FPM) where $V_M = CFM/A_M$. Chamber cross sectional shape may be circular or rectangular. M is the diameter of a round chamber or the equivalent diameter of a rectangular chamber with sides a and b: $M = \sqrt{4ab/\pi}$.
4. If more than one nozzle, they shall be located as symmetrically as possible.
5. Minimum distance from center line of nozzle to wall of chamber shall be 1.5 DN.
6. Minimum distance between centers of any two nozzles in simultaneous use shall be 3 DN of the larger nozzle.
7. T_1 represents the air inlet DB and WB temperature averaging grid (see Fig. 4).
8. T_2 represents the air outlet WB temperature averaging grid (see 7.3.13).
9. SP and PD are to be measured with four connections 90 deg apart manifolded into a piezometer ring. Static taps shall be 0.318 cm ID (⅛ in) or less, and are to be straight and normal to the surface for a distance of two diameters. No surface irregularities shall be in the vicinity of the static holes (see Fig. 2).
10. The minimum acceptable reading for nozzle PD shall be 99.5 Pa WG (0.4 in) (see Fig. 3).

Figure 1 - Air measurement chamber

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