



SURFACE VEHICLE RECOMMENDED PRACTICE

J2646™

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Cab Air-Conditioning Test Procedure - Heavy Trucks with and without Sleepers

RATIONALE

This document has been revised to increase the air-conditioning performance by lowering the temperature goals for test phases 3 and 4, and by adding requirements for louver air temperatures. This recommended change is based on input from the truck user community through discussions at meetings of the Technology and Maintenance Council of the American Trucking Association. Performance criteria for the crew cab compartment have been added.

1. SCOPE

This SAE Recommended Practice establishes a uniform test procedures for on highway trucks equipped with an air-conditioning system used to condition the air in the cabin and sleeper compartment of the vehicle. This specification will apply to heavy trucks with and without sleeper compartments.

1.1 Purpose

The purpose is to provide a standard test procedure for comparison and evaluation of heavy truck air-conditioning performance.

2. REFERENCES

2.1 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Report.

2.1.1 SAE Publications

Available from SAE International, 400 Commonwealth Drive, Warrendale, PA 15096-0001, Tel: 877-606-7323 (inside USA and Canada) or +1 724-776-4970 (outside USA), www.sae.org.

SAE J1163 Determining Seat Index Point

SAE J1559 Measurement of Solar Heating Effect

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2.1.2 TMC Publications

Available from Technology & Maintenance Council – American Trucking Associations, 950 N. Glebe Road, Arlington, VA 22203, Tel: 703-838-1763, <http://tmc.truckline.com>

TMC RP 436B(T) Air Conditioning System Performance Requirements For Truck Cabs With And Without Sleepers

3. DEFINITIONS

3.1 AIR CONDITIONING SYSTEM

Any system that lowers air temperature and humidity by the means of a refrigerant.

3.2 AMBIENT TEMPERATURE

Air temperature measured external to the vehicle and internal to the Vehicle Environmental Chamber.

3.3 DAY CAB AND FRONT CAB COMPARTMENT

A truck cab with single row front occupant space for a driver and one or two passengers.

3.4 FRONT CAB COMPARTMENT

The front occupant space in a crew cab or sleeper cab for a driver and one or two passengers.

3.5 FRONT CAB COMPARTMENT OR DAY CAB AVERAGE TEMPERATURE

The average of the six cab occupant probe locations for driver and passenger as shown in Figure 1.

3.6 CREW CAB COMPARTMENT

The back seating portion of a four-door cab.

3.7 CREW CAB COMPARTMENT AVERAGE TEMPERATURE

The average of the head, lap and foot probe locations for each belted crew compartment occupant as shown in Figure 1.

3.8 COMPRESSOR

A device that pumps low pressure refrigerant vapor out of the evaporator by suction, raises the pressure, then pumps it under high pressure into the condenser.

3.9 CONDENSER

A device that removes heat from the entering high pressure, high temperature de-superheated vapor refrigerant, changing it to a high pressure, high temperature subcooled liquid refrigerant.

3.10 EXPANSION DEVICE

Valve, orifice tube, or other expansion device in the refrigerant circuit for the purpose of metering liquid from the condenser into the evaporator inducing a large pressure drop changing the refrigerant to a low temperature, low pressure liquid.

3.11 EVAPORATOR

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

3.12 REFRIGERANT

A substance used by the air conditioning system that has the needed characteristics to boil at a low temperature and is able to change its state readily from liquid to vapor, and vice versa.

3.13 SLEEPER COMPARTMENT

The living and sleeping space at the back portion of a cab normally divided by a curtain from the seated and belted driver and occupant area.

3.14 SLEEPER COMPARTMENT AVERAGE TEMPERATURE

The average of the six probe locations as shown in Figure 2, Table 1.

4. TEST EQUIPMENT

4.1 Vehicle Environmental Chamber (VEC)

Environmental chamber large enough to contain the vehicle and test equipment. The chamber must have provisions to maintain ambient temperature, relative humidity, and solar intensity. Chamber capability shall maintain the following levels of accuracy:

Temperature: $\pm 1.7^{\circ}\text{C}$ ($\pm 3^{\circ}\text{F}$)
Relative Humidity: 3% ($\pm 1.5\%$)
Solar Load: $\pm 50\text{ W/m}^2$

4.2 Engine Speed

Engine tachometer with an accuracy of 2% of observed values.

4.3 Pyranometer

A device used to measure radiant energy from the solar load placed horizontal above the vehicle roof surface.

4.4 Temperature Measurement Devices

Devices used to measure temperature inside the VEC as well as inside and outside the vehicle to be used for calculating and comparison of cooling performance, i.e., thermocouples, RTDs, etc. Must have an accuracy of $\pm 1.5^{\circ}\text{C}$ ($\pm 2.7^{\circ}\text{F}$).

4.5 Air Velocity/Wind Speed

Anemometer to measure air velocity (with a measuring accuracy of 2% of observed values).

4.6 Data Acquisition System

System that will monitor and record all required test parameters and necessary measured conditions consistent with this specification at the required time interval.

4.7 Pressure Transducer

Device used to measure refrigerant pressure within the refrigeration system that are required within this specification for the purpose of calculating cooling performance.

4.8 Mass Flow Meter

Device used to measure the mass flow of refrigerant in the refrigeration system.

4.9 Refrigerant Charging and Recovery Station

Equipment used to charge the refrigeration system and recover the refrigerant from the refrigeration system.

4.10 Voltage/Current Shunt

Device used to measure voltage or current from the HVAC system electrical components.

5. AIR-CONDITIONING TEST VEHICLE PREPARATION

5.1 Instrumentation/Test Setup

5.1.1 Louver Direction

All HVAC louvers are open and directed perpendicular to their mounting surface, however none of the louvers should be directed at any of the thermal probes unless location of the louver is located directly at a probe when adjusted perpendicular to their mounting surface.

5.1.2 Vehicle Exterior Ambient Temperature

The vehicle test chamber temperature shall be measured by four exterior thermocouples. Two thermocouples are to be placed along the centerline of the vehicle, $\frac{1}{2}$ way between the ground and the highest point of the vehicle (excluding bolt on items), 915 mm (3 feet) forward of the front of the vehicle and 915 mm (3 feet) away from the back of the vehicle. Left and right side vehicle ambient shall be measured at a point 150 mm (6 inches) away from left side and right side of the vehicle. If a vehicle does not have mirrors, take measurement 450 mm (18 inches) outward from left and right side window.

5.1.3 Fresh Air Inlet Temperature

A minimum of one temperature measurement device shall be installed in the fresh air inlet.

5.1.4 Recirc Air Inlet Temperature

A minimum of one temperature measurement device shall be installed in the recirc air inlet at the each air-conditioning unit.

5.1.5 Air Outlet Louver Temperature

A minimum of one temperature measurement device shall be installed in the center of all louvers. Install temperature measurement device 19 mm (0.75 inch) into the louver and secured not to block airflow exiting the louver. For larger louvers multiple temperature measurement devices may be used and averaged.

5.1.6 Air Temperature Probe Locations

Thermocouples for measuring interior temperatures will be used to determine air-conditioning system performance. Additional temperature measurements may be recorded at the discretion of the testing party to achieve further information related to the vehicle air-conditioning system.

Locate temperature probes at the driver and passenger positions relative to each Seat Index Point (SIP) per Figure 1.

Locate temperature probes at the sleeper positions per Figure 2, Table 1.

5.1.7 Voltage and Current Measurement

Voltage and current measurements shall be taken in all applicable locations related to power consumed by HVAC components including: Cab blower motor voltage and current, Sleeper blower motor and Auxiliary condenser fans (if applicable) voltage and current, Compressor clutch-voltage, Engine fan-voltage, thermostat-voltage, Primary batteries voltage. All measurements taken within 152 mm (6 inches) from the component being measured or as close as possible. Location shall be documented.

5.2 Refrigeration System Instrumentation

5.2.1 Mass Flow Meter (optional)

Install a mass flow meter in the liquid line of the refrigeration system between the condenser outlet and the expansion device or orifice tube.

5.2.2 Refrigerant Temperature

Install temperature measurement devices at the inlet and outlet of the compressor, condenser and evaporator coil. All measurements shall be taken within 152 mm (6 inches) of the location to be measured or documented if different.

5.2.3 Refrigerant Pressure

Install pressure transducer connections at the inlet and outlet of the compressor, condenser and evaporator coil. All measurements shall be taken within 152 mm (6 inches) of the location to be measured or documented if different.

5.3 Vehicle Soak

5.3.1 VEC Ambient

43.3 °C ± 1.7 °C (110 °F ± 3 °F).

5.3.2 Relative Humidity

40% ± 1.5%.

5.3.3 Engine Load

None.

5.3.4 Wind Speed: (Air Velocity)

Maximum wind velocity shall not exceed 8 km/h (5 mph).

5.3.5 Engine Speed

0 (engine off).

5.3.6 HVAC Controller

HVAC system off.

6. TEST PROCEDURE

6.1 Heat the VEC and test vehicle and maintain it at 43.3 °C ± 1.7 °C (110 °F ± 3 °F) for the duration of the test. Maintain wind speed within the VEC so that it does not exceed 8 km/h (5 mph). Maintain the relative humidity at 40% ± 3%. Record data at least once per minute when soaking is started

6.2 Open vehicle windows, cab doors, interior and exterior compartment doors, hood, sleeper curtains, and any other feature that can be opened that would preclude air circulation inside the vehicle.

6.3 Leave the vehicle to stand inoperative for a period of 10 hours or until such time as all thermocouples stabilized at 43.3 °C ± 1.7 °C (110 °F ± 3 °F). Minimum soak period of 3 hours. (Soak time shall be documented.) This chamber temperature shall be maintained during all phases of the test.

6.4 Close vehicle windows, cab doors, interior and exterior compartment doors, hood, sleeper curtains, and any other feature that would be closed during normal operation.

6.5 Start the vehicle, place the transmission in neutral, and set the engine speed to 1500 rpm $\pm$ 50 rpm or to the pre-set high idle engine rpm provided as standard by the vehicle OEM, whichever is higher. Maintain the engine speed with no load (normal engine parasitic loads only) throughout the test.

6.6 Set the vent system to recirculation mode, the air conditioning system to ON, and the blower fans to their highest speed.

Turn solar load on and adjust to 1000 W/m² $\pm$ 50 W/m². Measure the solar load at the roof's surface on the center of the truck cab

6.7 Begin Test

6.8 Monitor the voltage across the vehicle's primary battery. The test shall be considered invalid if the voltage level drops below 13.2 V.

6.9 Record data for all channels at least once every minute

6.10 Record data for a total test duration of 150 minutes in the following phases:

Once the test has begun the recirculation modes and engine speed should be changed using methods that do not require the cab to be opened to the chamber environment.

Phase	Duration (Min)	Vent Mode	Engine RPM
1	60	Recirculation	1500 or High Idle Pre-set
2	30	Recirculation	1500 or High Idle Pre-set
3	30	Fresh Air	1500 or High Idle Pre-set
4	30	Fresh Air	Low Idle

6.11 Data Reduction/Reporting

Graphs - A list of suggested graphs for use of comparison of performance and system evaluation:

Graph 1: Refrigerant pressures

Graph 2: Cab Average (all six thermocouples per Figure 1)

Graph 3: Upper sleeper Average (all Top and Middle four thermocouples per Figure 2, Table 1)

Graph 4: Lower sleeper Average (two floor thermocouples per Figure 2, Table 1)

Graph 5: Sleeper Average (all six thermocouples per Figure 2, Table 1)

Graph 6: Panel Louver Average

Graph 7: Clutch Cycle

Graph 8: Condenser/Engine fan cycle

7. PERFORMANCE CRITERIA

Day Cab or Front Cab Compartment Performance Goals	
Phase 1	Reduce average temperature from 43.3 °C (110 °F) to ≤ 23.9 °C (75 °F).
	All louver temperatures at the end of the phase do not exceed 14.5 °C (58 °F).
	Difference between the highest and lowest cab dash louver temperature does not exceed 5.6 °C (10 °F).
Phase 2	Maintain average temperature ≤ 23.9 °C (75 °F).
	All louver temperatures remain below 14.5 °C (58 °F).
	Difference between the highest and lowest louver temperature does not exceed 5.6 °C (10 °F).
Phase 3	Maintain average temperature ≤ 25.6 °C (78 °F).
Phase 4	Maintain average temperature ≤ 26.7 °C (80 °F).
All Phases	The occupant head temperature at the end of each phase should not exceed the respective foot temperature by more than 1.7 °C (3 °F).
	The difference between each cab occupant temperature and the average temperature at the end of each phase should not exceed 1.7 °C (3 °F). This requirement does not apply for any phase where the average temperature at the end of the phase is more than 3° below the nominal temperature criteria.

Crew Cab Compartment Performance Goals	
Phase 1	Reduce average temperature from 43.3 °C (110 °F) to ≤ 23.9 °C (75 °F).
Phase 2	Maintain average temperature ≤ 23.9 °C (75 °F).
Phase 3	Maintain average temperature ≤ 25.6 °C (78 °F).
Phase 4	Maintain average temperature ≤ 26.7 °C (80 °F).

Sleeper Compartment Performance Goals	
Phase 1	Reduce average temperature from 43.3 °C (110 °F) to ≤ 23.9 °C (75 °F).
	All louver temperatures at the end of the phase do not exceed 14.5 °C (58 °F).
	Difference between the highest and lowest louver temperature does not exceed 5.6 °C (10 °F).
Phase 2	Maintain average temperature ≤ 23.9 °C (75 °F).
	All louver temperatures remain below 14.5 °C (58 °F).
	Difference between the highest and lowest louver temperature does not exceed 5.6 °C (10 °F).
Phase 3	Maintain average temperature ≤ 25.6 °C (78 °F).
Phase 4	Maintain average temperature ≤ 26.7 °C (80 °F).