SAE International™ **SURFACE VEHICLE STANDARD**	SAE **J2763 AUG2008** Issued 2008-08

Test Procedure for Determining Refrigerant Emissions from Mobile Air Conditioning Systems

RATIONALE

This SAE Refrigerant Mini-Shed Emission Test is intended to ensure accurate and repeatable measurements of refrigerant emission and to provide a basis for correlation of laboratory measured emission rates to actual vehicle emissions. Correction factors must be applied to correlate the results of this testing to real-world test vehicle system emissions. This document can be considered a companion to SAE J2727.

INTRODUCTION

Vehicle makers and A/C system and component suppliers are continually improving the containment of system refrigerant. For development purposes, a common means of measuring refrigerant emissions was deemed desirable; this standard test method is intended to serve that purpose. For commonality with existing vehicle testing, the testing takes place in a chamber (mini-shed) under a static temperature profile and under the California Air Resources Board's Title 13 ambient profile (CARB Profile).

1. SCOPE

This SAE Standard covers the Mini-Shed testing methodology to measure the rate of refrigerant loss from an automotive air conditioning (A/C) system. This SAE procedure encompasses both front and rear air conditioning systems utilizing refrigerants operating under sub-critical conditions.

1.1 Purpose

The purpose of the SAE Mini-Shed Test Refrigerant Emission procedure is to provide a means of measuring refrigerant emissions from properly assembled vehicle air conditioning systems under specific A/C usage conditions (i.e., typical use conditions) and to convert the results to an estimated annual refrigerant emission rate (g/yr). Such conversion from laboratory test results to estimated vehicle emission applies to properly assembled systems and does not account for normal production assembly variations.

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: http://www.sae.org

2. REFERENCES

2.1 Applicable Publications

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

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 724-776-4970 (outside USA), www.sae.org.

SAE J2727 HFC-134a Mobile Air Conditioning System Refrigerant Emission Chart

2.1.2 Other Publications

European Emission Regulation Number 706/2007 of 21 June 2007

California Air Resources Board's Title 13 Ambient Profile

Armines, Dr. Denis Clodic, Ecole Des Mines (Paris): "Research Study on the Definition of the Implementation of a Method of Measurement of Annual Leak Flow Rates (LFRs) of MAC Systems"

3. TEST PROCEDURE

3.1 System Assembly

3.1.1 Starting with components that have never been exposed to refrigerant, assemble the A/C system on the test fixture per system schematic. Do not charge the system with refrigerant.

3.1.2 Tighten each fitting to its specified minimum torque.

3.1.3 Make all electrical connections and pressure connections.

3.1.4 Place test fixture in the Emission Test Chamber (Volume of ~1 cubic meter).

3.1.5 The Emission Test Chamber (Mini-Shed) should be equipped with an expansion bag to assure isobaric conditions throughout the test. Changes in temperature cause corresponding changes in pressure (which can cause leakage from the chamber), or in volume (which slightly affect ppm/vol readings). Slight variations in volume are preferred over mass loss from the chamber during testing. Readings taken at calibration temperature should not be affected.

3.1.6 Larger chambers may be required for large A/C systems and will require proportionately larger volumetric injections of refrigerant during the calibration procedure (below).

3.2 Chamber Calibration

3.2.1 Refrigerant vapor injected in this procedure is to be accomplished at known and recorded atmospheric pressure and temperature for subsequent conversion to mass injected.

3.2.1.1 Record atmospheric pressure.

3.2.2 Refrigerant concentration measurements (ppm by volume readings) should be taken every 2 minutes. If the equipment has a longer response time, measurements should be taken at the shortest measurement interval possible.

3.2.3 To verify chamber integrity, inject 100 cc of refrigerant per cubic meter chamber volume and record ppm measurement for 24 hr. Readings shall vary no more than 5% after initial stabilization.

3.2.4 The following procedure is intended to enable construction of a calibration curve covering the full range of expected refrigerant emission to be measured.

3.2.5 Purge the chamber with fans. Flush the gas analyzer lines with dry nitrogen to remove any residual water vapor and refrigerant from the line sets.

3.2.6 Close the chamber and record refrigerant ppm. If above 5 ppm of refrigerant, open chamber, start fans to purge chamber. Close chamber and re-measure ppm. Repeat as necessary until the level drops below 5 ppm.

3.2.7 Stabilize the system at 20 °C ± 2 °C chamber temperature for 1 hr, recording emissions. Record initial chamber concentration (ppm) for 10 minutes. ppm readings should vary less than 10%. If greater, check for refrigerant intrusion from outside the chamber or equipment malfunction.

3.2.8 Record initial chamber ppm and then, with a gas-tight syringe, inject 5.0 cc of pure refrigerant vapor into chamber and record refrigerant concentration for at least 10 minutes. Last 2 readings must be within 10% of each other. If greater, check for refrigerant intrusion from outside the chamber or equipment malfunction. Open chamber, start fans to purge chamber. Close chamber and re-measure ppm. Repeat as necessary until the level drops below 5 ppm.

3.2.9 Repeat 3.2.8, injecting 10.0 cc of pure refrigerant vapor.

3.2.10 Repeat 3.2.8, injecting 20.0 cc of pure refrigerant vapor.

3.2.11 Repeat 3.2.8, injecting 30.0 cc of pure refrigerant vapor.

3.2.12 Repeat 3.2.8, injecting 40.0 cc of pure refrigerant vapor.

3.2.13 Continue additions as necessary to construct calibration curves covering the expected range of test chamber concentrations.

3.3 Calibration Curves

3.3.1 Calculate the net change in refrigerant emission concentration (c) for each injection.

$$c = \text{final concentration} - \text{initial concentration} \quad \text{(Eq. 1)}$$

3.3.2 From the volumes of refrigerant added in 3.2.8 to 3.2.13 and their corresponding net changes in measured concentration (c), construct a calibration curve of ppm vs. V_{ref} as shown in Figure 1.

3.3.3 Multiply the refrigerant vapor density (at measured and recorded injection conditions of atmospheric pressure and temperature) by each volume of refrigerant added to construct a calibration curve of ppm vs. refrigerant mass emitted as shown in Figure 2. Record the atmospheric pressure to which this calibration curve corresponds for subsequent atmospheric pressure corrections of test data.

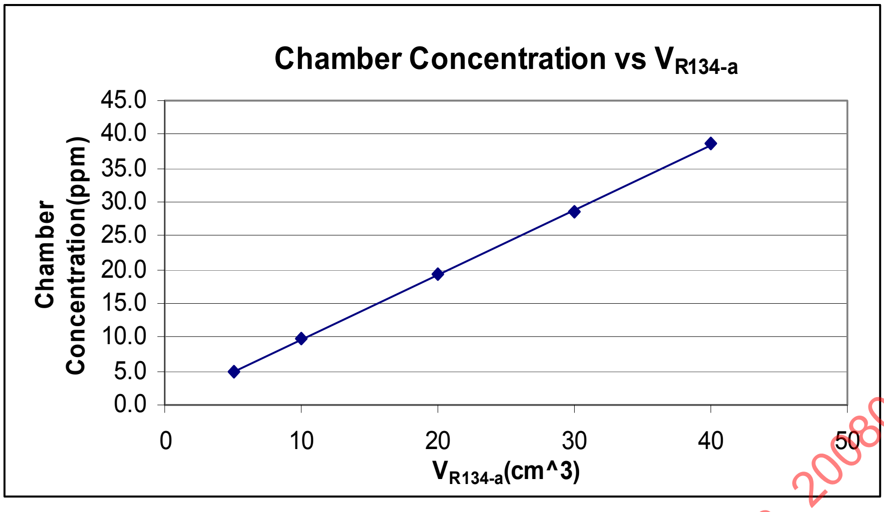

FIGURE 1 - R-134a EXAMPLE

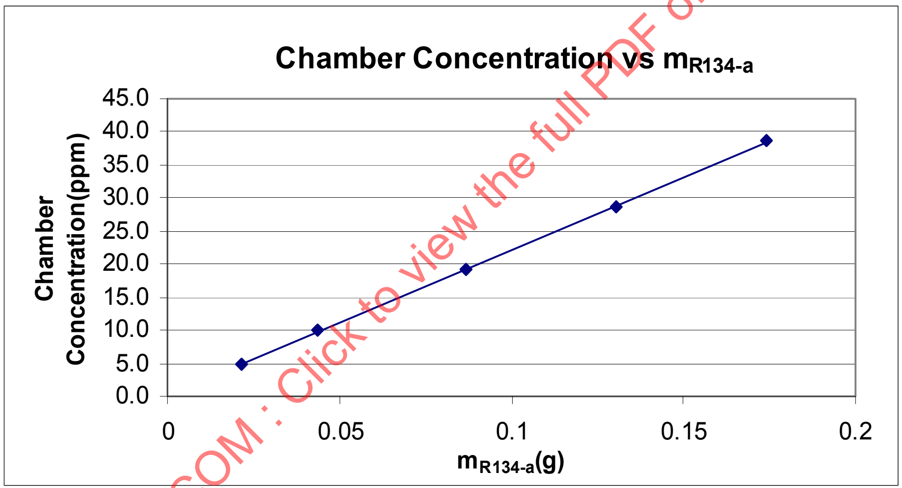

FIGURE 2 - R-134a EXAMPLE

3.4 System Charge and Leak Test

3.4.1 Charge the system with the specified production intent oil and refrigerant charges.

3.4.2 Optional step: Leak check all components and connections with a Leak Detector capable of measuring leaks at least as small as 4 g/yr to identify gross leaks requiring repair prior to further testing.

3.5 System Installation

3.5.1 Place test fixture into the Emission Test Chamber.

3.5.2 Purge chamber with fans. Flush the gas analyzer lines with dry nitrogen to remove any residual water vapor and refrigerant from the line sets.

3.5.3 Close door and record ppm. If above 5 ppm of refrigerant, open chamber, start fans to purge chamber. Repeat as necessary until the level drops below 5 ppm.

3.5.4 Stabilize the system at 20 °C chamber temperature for 1 hr, recording emissions.

3.6 Preconditioning Dynamic

3.6.1 Run per conditions in Table 1 (Break-in) recording emissions to verify proper assembly.

3.7 System Seasoning (Conforming to EU F-Gas Emission Regulations)

3.7.1 Transfer A/C system on the test fixture to an environmental chamber. Set temperature to 40 °C ± 2 °C and maintain for 20 days or set temperature to 50 °C ± 2 °C maintained for 10 days, then ramp to 40 °C ± 2 °C and maintain for 1 day. Duration of seasoning can be reduced if component emission stability is achieved prior to testing.

3.8 Long Term Static Emission (Conforming to EU F-gas Test Requirements)

3.8.1 Remove A/C system on the test fixture from environmental chamber. Install into Refrigerant Emission Chamber pre-stabilized at 40 °C ± 2 °C.

3.8.2 Optional step: Leak check all components and connections with a Leak Detector capable of measuring leaks at least as small as 4 g/yr to identify gross leaks requiring repair prior to further testing.

3.8.3 Flush the gas analyzer lines with dry nitrogen to remove any residual water vapor and refrigerant from the line sets.

3.8.4 Close chamber and record ppm. If above 5 ppm of refrigerant, open chamber, start fans to purge chamber. Close chamber and re-measure ppm. Repeat as necessary until the level drops below 5 ppm.

3.8.5 Leave system in chamber for 4 hr to achieve temperature stability.

3.8.6 With the A/C system in the chamber stabilized at 40 °C ± 2 °C, record ppm concentration for 24 hr. Subtract final ppm from initial ppm to yield net emissions. Duration of testing can be reduced if system emission stability is achieved.

3.8.7 Convert ppm concentration to mass emission using calibration curve, applying atmospheric pressure correction.

3.8.8 Calculate emission rate as g/yr.

3.9 Compressor Break In

3.9.1 Run per conditions in Table 2, recording emissions to verify proper assembly.

3.9.2 Reduce Chamber to 22.5 °C ± 2 °C over a 2 hr period.

3.9.3 Maintain 22.5 °C ± 2 °C conditions for 16 hr minimum (overnight) to condition system for CARB cycle testing.

3.10 Test Conditions

NOTE: Compressor and evaporator out pressures shown are for R-134a. For any refrigerant, the evaporator out pressure should provide a refrigerant out saturation temperature of –5 °C to +5 °C. For any refrigerant, the compressor out pressure should provide a saturated condensing temperature of 55 °C ± 10 °C at 2000 rpm and 80 °C ± 10 °C at 1000 rpm.

TABLE 1 - 20 °C CHAMBER TEMPERATURE - PRE-CONDITIONING DYNAMIC (R-134a EXAMPLE)

Type	Time (hr)	Compressor Speed (rpm)	Compressor Out Pressure (Mpag/psig)	Evaporator Out Pressure (Mpag/psig)	Chamber Temp (°C)
Static 1	1	0	Saturated	Saturated	20
Dynamic 1	0.5	2000 ± 10	1.28-1.48 / 187-215	0.14-0.28 / 20-40	20
Static 2	2	0	Saturated	Saturated	20

TABLE 2 - 35.6 °C CHAMBER TEMPERATURE - COMPRESSOR BREAK IN (R-134a EXAMPLE)

Type	Time (hr)	Compressor Speed (rpm)	Compressor Pressure Out (Mpag/psig)	Evaporator Pressure Out (Mpag/psig)	Chamber Temp (°C)
Static 1	1	0	Saturated	Saturated	35.6
Dynamic 1	0.5	2000 ± 10	1.28-1.48 / 187-215	0.14-0.28 / 20-40	35.6
Static 2	2	0	Saturated	Saturated	35.6

TABLE 3 - CARB DAY 1 TEMPERATURE PROFILE
PROGRAM LINEAR TEMPERATURE RAMP RATE BETWEEN SEGMENTS

Time (hr)	Temperature (°C)	Time (hr)	Temperature (°C)
0	22.5	11	33.2
1	24.2	12	31.4
1.67	26	13	29.7
2.17	50	14	28.2
2.67	43	15	27.2
3.17	35.5	16	26.1
4.17	35.5	17	25.1
4.84	35.5	18	24.3
5.34	50	19	23.7
5.84	43	20	23.3
6.34	35.5	21	22.9
7	35.4	22	22.6
8	35.6	23	22.2
9	35.3	24	22.0
10	34.5		

TABLE 4 - CARB DYNAMIC CONDITIONS (R-134a EXAMPLE)

Type	Time (hr)	Compressor Speed (rpm)	Compressor Pressure Out (Mpag/psig)	Evaporator Pressure Out (Mpag/psig)	Chamber Temp ±2(°C)
Dynamic 1	1-1.67	2000 ± 10	1.28-1.48 / 187-215	0.14-0.28 / 20-40	Per CARB Profile
Dynamic 2	4.17-4.84	1000 ± 10	2.42-2.62 / 350-380	0.14-0.28 / 20-40	Per CARB Profile

TABLE 5 - CARB DAYS 2-4 TEMPERATURE PROFILE
PROGRAM LINEAR TEMPERATURE RAMP RATE BETWEEN SEGMENTS

Time (hr)	Temp (°C)	Time (hr)	Temp (°C)	Time (hr)	Temp (°C)	Time (hr)	Temp (°C)
0	22.5	16	26.1	36	31.4	56	35.6
1	24.2	17	25.1	37	29.7	57	35.3
1.67	26	18	24.3	38	28.2	58	34.5
2.17	50	19	23.7	39	27.2	59	33.2
2.67	43	20	23.3	40	26.1	60	31.4
3.17	35.5	21	22.9	41	25.1	61	29.7
4.17	35.5	22	22.6	42	24.3	62	28.2
4.84	35.5	23	22.2	43	23.7	63	27.2
5.34	50	24	22.5	44	23.3	64	26.1
5.84	43	25	24.2	45	22.9	65	25.1
6.34	35.5	26	26.8	46	22.6	66	24.3
7	35.4	27	29.6	47	22.2	67	23.7
8	35.6	28	31.9	48	22.5	68	23.3
9	35.3	29	33.9	49	24.2	69	22.9
10	34.5	30	35.1	50	26.8	70	22.6
11	33.2	31	35.4	51	29.6	71	22.2
12	31.4	32	35.6	52	31.9	72	22.2
13	29.7	33	35.3	53	33.9		
14	28.2	34	34.5	54	35.1		
15	27.2	35	33.2	55	35.4		

SAE J2763 Mini-Shed Test Cycle

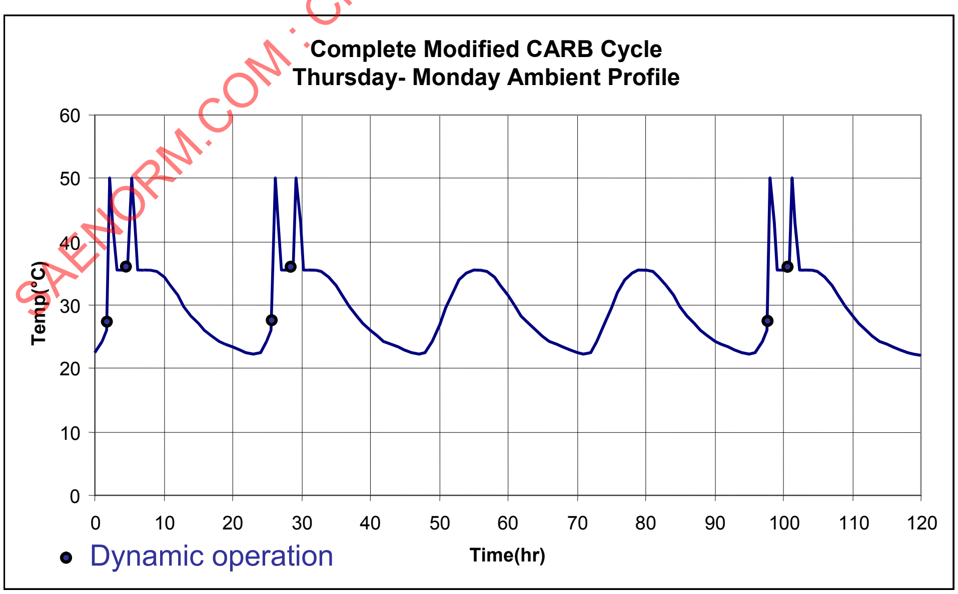

FIGURE 3 - MODIFIED CARB CYCLE

3.11 Test Instructions

3.12 CARB Profile Testing

Figure 3 - Testing to be run in sequence.

3.12.1 CARB Profile “Test Day 1” (Simulates a mid-weekday)

3.12.1.1 Flush the gas analyzer lines with dry nitrogen to remove any residual water vapor and refrigerant from the line sets.

3.12.1.2 Open the chamber and purge the chamber to ppm level less than 5.

3.12.1.3 Close chamber.

3.12.1.4 Record time, temperature, atmospheric pressure, refrigerant system pressure, and refrigerant concentration (ppm).

3.12.1.5 Initiate pre-programmed chamber temperature per Table 3 - CARB Profile Day 1.

3.12.1.6 Synchronize Dynamic Conditions with the temperature profile per Table 4 - CARB Dynamic Conditions.

3.12.1.7 Record refrigerant ppm, Chamber Temperature, Compressor Discharge Pressure, Compressor Suction Pressure, Evaporator Refrigerant Inlet Temperature, Evaporator Refrigerant Outlet Temperature, Condenser Refrigerant Inlet Temperature, Condenser Refrigerant Outlet Temperature, and Evaporator air out temperature.

3.12.2 CARB Profile Test “Days 2-4” (simulates Friday through Sunday)

3.12.2.1 Flush the gas analyzer lines with dry nitrogen to remove any residual water vapor and refrigerant from the line sets.

3.12.2.2 Open the chamber and purge the chamber to ppm level less than 5.

3.12.2.3 Close chamber.

3.12.2.4 Record time, atmospheric pressure, temperature, refrigerant system pressure, and refrigerant concentration (ppm).

3.12.2.5 Initiate pre-programmed chamber temperature per Table 5 - CARB Profile Days 2-4.

3.12.2.6 Synchronize Dynamic Conditions with the temperature profile per Table 4 - CARB Dynamic Conditions.

3.12.2.7 Record refrigerant ppm, Chamber Temperature, Compressor Discharge Pressure, Compressor Suction Pressure, Evaporator Refrigerant Inlet Temperature, Evaporator Refrigerant Outlet Temperature, Condenser Refrigerant Inlet Temperature, Condenser Refrigerant Outlet Temperature, and Evaporator air out temperature.

3.12.3 CARB Profile Test Day “5” (simulates Monday - after a period of non-operation)

3.12.3.1 Flush the gas analyzer lines with dry nitrogen to remove any residual water vapor and refrigerant from the line sets.

3.12.3.2 Open the chamber and purge the chamber to ppm level less than 5.

3.12.3.3 Close chamber.

3.12.3.4 Record time, atmospheric pressure, temperature, refrigerant system pressure, and refrigerant concentration (ppm).

3.12.3.5 Initiate pre-programmed chamber temperature per Table 3 - CARB Profile Day 1.

3.12.3.6 Synchronize Dynamic Conditions with the temperature profile per Table 4 - CARB Dynamic Conditions.

3.12.3.7 Record refrigerant ppm, Chamber Temperature, Compressor Discharge Pressure, Compressor Suction Pressure, Evaporator Refrigerant Inlet Temperature, Evaporator Refrigerant Outlet Temperature, Condenser Refrigerant Inlet Temperature, Condenser Refrigerant Outlet Temperature, and Evaporator air out temperature.

3.13 CARB Refrigerant Emission Calculation

3.13.1 Determine the net chamber refrigerant concentration (ppm) increase (final-initial concentration) for “Day 1”, “Days 2-4”, and “Day 5”. As shown below in the graph Figure 4:

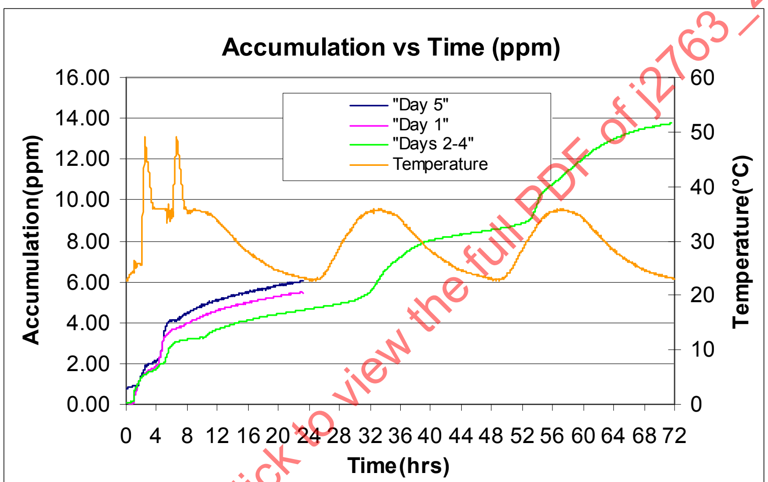

FIGURE 4 - NET CHAMBER REFRIGERANT CONCENTRATION INCREASE (ppm)

3.13.2 Convert ppm concentration to mass emission using the calibration curve, adjusting for any difference in atmospheric pressures.

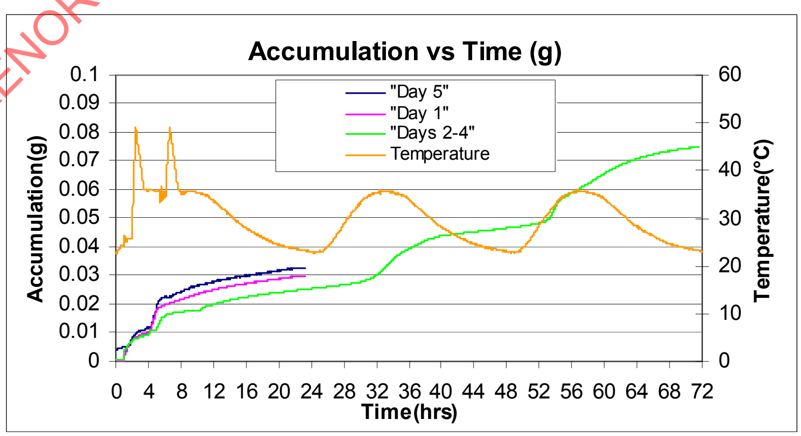

FIGURE 5 - NET CHAMBER REFRIGERANT MASS EMISSION (GRAMS)