



SURFACE VEHICLE STANDARD

J2297™

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Superseding J2297 JAN2013

(R) Leak Detection: Stability and Compatibility Criteria of
Fluorescent Refrigerant Leak Detection Dyes for
Mobile Air-Conditioning Systems

RATIONALE

This SAE Standard is being revised to add the requirements for certification according to SAE J2911 and move to a universal refrigerant usage.

1. SCOPE

This SAE Standard applies to dyes intended to be introduced into a mobile air-conditioning system refrigerant circuit for the purpose of allowing the application of ultraviolet leak detection. In order to label any product(s), they shall meet SAE J2297, the certification process as described in SAE J2911 must be followed, and the documentation described in Appendix A shall be submitted to SAE.

1.1 Purpose

The purpose of this document is to establish testing and acceptance criteria to evaluate fluorescent leak detection dye stability in, and compatibility with, mobile air-conditioning systems.

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 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 J2683 Refrigerant Purity and Container Requirements for Carbon Dioxide (CO₂ R-744) Used in Mobile Air-Conditioning Systems

SAE J2776 Refrigerant Purity and Container Requirements for New HFC-134a 1,1,1,2 - Tetrafluoroethane Refrigerant Used in Mobile Air-Conditioning Systems

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https://www.sae.org/standards/content/J2297_202412/

SAE J2844 R-1234yf (HFO-1234yf) New Refrigerant Purity and Container Requirements Used in Mobile Air-Conditioning Systems

SAE J2911 Procedure for Certification that Requirements for Mobile Air-Conditioning System Components, Service Equipment, and Service Technician Training Meet SAE J Standards

Müller, Y., Feja, S., and Ulrich, G. (2011). *Electrical properties of the liquid phase of refrigerant/oil mixtures* [Conference paper]. SAE International Symposium 2011, Scottsdale, Arizona, USA.

2.1.2 ANSI Accredited Publications

Copies of these documents are available online at <https://webstore.ansi.org/>.

ANSI-ASHRAE 97-2017	Sealed Glass Tube Method to Test the Chemical Stability of Material for Use Within Refrigerant Systems
ANSI-ASHRAE GPC 38-2018	Guideline for Using Metal Pressure Vessels to Test Materials Used in Refrigeration Systems
ANSI-ASTM D445-2019	Standard Test Method for Kinematic Viscosity of Transparent or Opaque Liquids
ANSI-ASTM D664-2018	Test Method of Acid Number of Petroleum Products by Potentiometric Titration
ANSI-ASTM D974-22	Standard Test Method for Acid and Base Number by Color-Indicator Titration
ANSI-ASTM D1169-2019	Standard Test Method for Specific Resistance (Resistivity) of Electrical Insulating Liquids
ANSI-ASTM D3233-2019	Method for Measurement of Extreme Pressure Properties of Fluid Lubricants (Falex Method)
AHRI Standard 700- 2019	Standard for Specifications of Refrigerants

2.1.3 ASHRAE Publications

Available from ASHRAE Headquarters, 1791 Tullie Circle, NE, Atlanta GA 30329, Tel: 800-527-4723 (U.S. and Canada only) or 404-636-8400, www.ashrae.org.

ASHRAE 2017 Fundamentals Handbook, Chapter 29

3. SPECIFICATION AND GENERAL DESCRIPTION

3.1 The dye shall be certified that it meets this specification by a qualified, independent laboratory. The manufacturer shall maintain documentation of testing to this specification for each change in formulation certified for a period of 5 years following the end of the production run for a certified dye. Either the performing laboratory shall provide documentation that includes all relevant calibration data and equipment calibration dates, or shall keep this information on record for 5 years post-SAE J2297 testing.

3.2 The dye package shall be labeled "This dye certified to meet SAE J2297 for use with "refrigerant"/"lubricant" where refrigerant and lubricant are the tested refrigerant and lubricant types as appropriate.

3.2.1 A dye package meeting all requirements of this specification and intended for use with multiple refrigerants shall list those refrigerants on the label. For example, dyes for use in both R-134a and R-1234yf systems with PAG lubricants shall be labeled "This dye certified to meet SAE J2297 for use with R-134a/PAG and R-1234yf/PAG."

3.3 Dyes intended for use with electrical compressors shall be labeled "This dye certified to meet SAE J2297 for use with "refrigerant"/"lubricant" for all systems: belt drive and electric compressor."

4. PREPARATION OF DYE

4.1 The manufacturer of the dye shall specify the preparation of the dye and the concentration of manufacturer recommended dosage per lubricant quantity used.

5. TESTING OF FLUORESCENT LEAK DETECTION DYES

5.1 These test procedures and requirements shall be used to determine the stability and the compatibility of a leak detection dye within a mobile air-conditioning system. A dye must meet all of the acceptance criteria for each test to be certified to this specification.

5.2 The same refrigerant and lubricant per 6.1.1 per 6.1.2 shall be used in all the tests defined in this specification.

5.3 Rank order analysis is to be used as the acceptance criteria for the fluorescent leak detection dyes evaluated to the specifications defined by this document or as specified in subsections below. Rank order analysis shall be defined as ordering both the three control groups' and the three test samples' results. A test failure is defined as a total separation of the results of the sample and the control groups where the sample's results negatively affected the desirable properties of the lubricant. A passed test is defined as having overlapping sets of results of the sample and control groups, or a total separation of the results of the sample and the control groups where the sample's results positively affected the desirable properties of the lubricant.

6. STABILITY TESTING

6.1 Stability testing shall be performed by preparing samples as per ANSI-ASHRAE Standard 97 or using metal pressure cells per ANSI-ASHRAE GPC 38. The samples are to contain an equal mass of liquid refrigerant and lubricant sample as well as metal catalysts as specified below.

6.1.1 The refrigerant sample is to be composed of the associated SAE purity specification or AHRI Standard 700 purity specification.

6.1.1.1 R-134a per SAE J2776; R1234yf per SAE J2844; or R-744 per SAE J2683.

6.1.1.2 For alternative refrigerants not listed above (heavy duty, off-road, buses, aftermarket, etc.), use AHRI Standard 700 if an SAE purity specification has not yet been developed.

6.1.2 The lubricant sample shall be composed of an OE lubricant per the desired refrigerant with and without dye for control per 4.3. The lubricant type shall match the OE designation on the charging label.

6.1.2.1 For R-134a applications, a PAG lubricant must be one commonly used in the mobile air-conditioning industry in OEM R-134a systems (examples include Idemitsu PAG 46, Denso ND8, Shrieve RFL-46X, etc.). A POE must be one recommended for use in the mobile air-conditioning industry in OEM R-134a systems (examples include Denso ND-11 or Shrieve RL85HM).

6.1.2.2 For R-1234yf applications, a PAG lubricant must be one recommended for use in the mobile air-conditioning industry in OEM R-1234yf systems (examples include Denso ND12, Idemitsu PS-D1, or Shrieve HD46). A POE must be one recommended for use in the mobile air-conditioning industry in OEM R-1234yf systems (examples include Denso ND-11 or Shrieve RL85HM).

6.1.2.3 For R744 applications, a PAG lubricant must be one recommended for use in the mobile air-conditioning industry in OEM R-744 systems. A POE must be one recommended for use in the mobile air-conditioning industry in OEM electric R-744 systems.

6.1.2.4 For other refrigerant applications, the lubricant must be of a type and quality designated by the original manufacturer of the equipment and the tests carried out accordingly.

6.2 Six samples shall be tested. Three shall be composed of neat lubricant and three shall be composed of the same lubricant containing double the recommended service concentration of the dye.

6.2.1 The metal catalysts shall consist of standard rectangular metal specimens consisting of 3 by 19 mm coupons of steel and copper, separated by aluminum so that the copper is not in direct contact with the steel. The metals shall be steel 1000, oxygen-free copper, and aluminum 1100. The above surface area shall be per 50 cc or less of lubricant sample tested. The coupon surface area shall either be proportionally enlarged for more lubricant or multiple coupons of copper, steel and aluminum shall be used.

6.3 These samples shall be aged at $175^{\circ}\text{C} \pm 3^{\circ}\text{C}$ for 14 days.

6.4 Acceptance stability criteria shall consist of three separate determinations.

6.4.1 The presence of the dye shall not cause an increase of refrigerant and/or lubricant decomposition when compared to the neat samples via rank order analysis of total acid number (TAN) increase. It is permissible for the dye to reduce the TAN of the aged mixture based on rank order analysis.

6.4.1.1 The total acid number of each sample is to be determined according to ASTM D664 to a final pH of 9.0 before and after aging. ASTM D974 may also be used with phenolphthalein as the color indicator.

6.4.2 The presence of the dye shall not cause an increase of corrosion or copper plating of the tested metal coupons when compared to those tested in the neat samples via rank order analysis based on visual observation.

6.4.3 The presence of the dye shall not cause an increase in particles, precipitates in the tubes when compared to those tested in the neat samples via rank order analysis via visual observation.

7. FLUORESCENCE TESTING

7.1 Fluorescence testing shall be performed by preparing sealed tubes as per ANSI-ASHRAE 97. These sealed tubes are to contain an equal mass of liquid refrigerant and lubricant sample as well as metal catalysts.

7.1.1 The metal catalysts shall consist of standard rectangular metal specimens consisting of 3 by 19 mm coupons of steel and copper, separated by aluminum so that the copper is not in direct contact with the steel. The metals shall be steel 1000, oxygen-free copper, and aluminum 1100. The above surface area shall be per 50 cc or less of lubricant tested. The coupon surface area shall either be proportionally enlarged for more lubricant or multiple coupons of copper, steel, and aluminum shall be used.

7.2 Two samples shall be tested. One shall be composed of refrigerant and lubricant containing the recommended service concentration of the dye, and one shall be composed of the same lubricant containing double the recommended service concentration of the dye.

7.3 The doubly dosed sample shall be aged at $175^{\circ}\text{C} \pm 3^{\circ}\text{C}$ for 14 days. The service concentration sample is to remain at room temperature during this time period.

7.4 Acceptance criteria shall consist of having the dye in the thermally aged sample exhibit a visual intensity (brilliance) at least equal to that of the un-aged control sample under identical incident UV irradiation and in identical ambient lighting and temperature conditions.

8. NON-METALLIC MATERIALS COMPATIBILITY TESTING

8.1 Stability testing shall be performed by preparing sealed tubes as per ANSI-ASHRAE 97 or using metal pressure cells per ASHRAE GPC 38.

8.2 Non-metallic materials compatibility testing shall be performed to determine the compatibility of the dye with elastomers and plastic materials typically used in mobile A/C systems.

8.3 Materials to be tested shall be representative samples of those used in current OEM vehicle A/C systems.

- a. PTFE commercial grade skived sheet.
- b. Nylon 66.
- c. Polyester (PBT).
- d. HNBR O-ring.
- e. Neoprene WRT O-ring.
- f. EPDM O-ring.
- g. Butyl (IIR) (e.g., hoses materials).

8.4 Six samples shall be prepared from each material. Three shall be tested with neat lubricant and three shall be tested with the neat lubricant containing double the recommended service concentration of the dye.

8.5 Before and after the aging procedure, materials shall be tested for hardness by Shore M.

8.6 The test temperature shall be 125°C and a pressure corresponding to the saturation pressure at 70 °C (-0, +0.25 MPa). For refrigerants that have a critical temperature less than 70 °C, 7.5 MPa shall be used.

8.6.1 Informational: 2.1 MPa for 30 days for R134a and R1234yf; R744 samples are to be aged at 125 °C and a pressure of 7.5 MPa for 30 days.

8.7 Acceptance criteria shall consist of three separate determinations.

8.7.1 The presence of the dye shall not cause greater than $\pm 10\%$ change in hardness when compared to those tested in the neat oil via rank order analysis.

8.7.2 The presence of the dye shall not cause an increase in particles, precipitates in the tubes when compared to those tested in the neat samples via rank order analysis via visual observation.

8.7.3 The presence of the dye shall not cause greater than 10% increase or 5% decrease in volume when compared to those tested in the neat oil via rank order analysis.

9. WEAR TESTING

9.1 Wear testing shall be performed as per a modified Falex test procedure ASTM D3233-93.

9.1.1 The test oil shall be sparged by bubbling the appropriate refrigerant through it at 1 atmosphere pressure for 30 minutes prior to the test run and continuously during the test run.

9.1.2 A run-in period of 2 minutes at 68 kg direct load is to be applied.

9.1.3 The test load shall be 113 kg, and held at that level throughout the 5-hour run period.

9.1.4 Steel pins (AISI 3135) and aluminum V-blocks (die cast 390) shall be used. The mass of the pins must be recorded before the test run.

9.2 Six samples shall be tested. Three shall be composed of neat lubricant and three shall be composed of the same lubricant containing double the recommended service concentration of the dye.

9.3 Acceptance criteria shall consist of two separate determinations:

9.3.1 The presence of the dye shall not cause an increase of pin weight loss when compared to the neat samples via rank order.

9.3.2 The presence of the dye shall not cause an increase of block wear scar during the 5-hour run, measured microscopically, when compared to the neat samples via rank order analysis.

10. VISCOSITY EFFECT TESTING

10.1 The lubricant selection, per 6.1.2, the kinematic viscosity shall be determined via the Procedure defined by ASTM D445. The kinetic viscosity shall be measured at both 40 °C and 100 °C.

10.2 Six samples shall be prepared. Three shall be tested with neat lubricant and three shall be tested with the neat lubricant containing the recommended service concentration of the dye.

10.3 Acceptance shall consist of having the presence of the dye not decrease the kinematic viscosity in centistokes by more than 4% when compared to the neat sample nor increase the kinematic viscosity in centistokes by more than 10%.

11. ELECTRICAL TESTING

11.1 To be labeled for "electric" use, lubricants with a double recommended service concentration of dye shall be greater than $5 * 10^9 \Omega \cdot \text{cm}$ per ASTM D1169.

11.1.1 Informational: This minimum value was selected to take into account the variability in the ASTM D1169 test method based on a liquid volumetric resistivity of R1234yf of $1 * 10^{10} \Omega \cdot \text{cm}$ (refer to Müller et al., 2011).

Table 1

Pure Refrigerant	Volumetric Resistivity $\Omega \cdot \text{cm}$
R134a	$2 * 10^{12}$ (1)(2)
R1234yf	$1 * 10^{10}$ (1)
CO ₂	Use R134a value

(1) Refer to Müller et al. (2011).

(2) Refer to ASHRAE 2017.

12. COMPLIANCE

12.1 For compliance, this SAE Standard shall meet SAE J2911. This SAE Standard provides manufacturers, testing facilities, and technician knowledge requirement providers with a procedure of certifying compliance with the appropriate SAE Standard. Only certifying to SAE J2911 allows those verifying compliance to advertise their product as "Certified to the appropriate SAE Standard." Industry, interested parties, and regulatory agencies will have access to the SAE International public website posting of the results in the official SAE database.

12.2 The compliance information for this SAE Standard, SAE J2297, shall be recorded, verified in Table A1, and supplied to SAE. The responsible committee shall establish the required certification information.

12.3 Upon completion of testing, certification, and recording with SAE, dyes are permitted to include on their labels as having met the requirements of SAE J2297 ONLY for the refrigerant(s) and lubricant types for which the certification testing has been performed.

12.4 Dyes intended for electric compressor application and having passed the optional electrical testing (see Section 11) may include on their labels of having met the requirements of SAE J2297 for electric compressor application ONLY for the refrigerant(s) for which the certification testing has been performed.