



SURFACE VEHICLE RECOMMENDED PRACTICE

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Fuel Components and Systems Leak Tightness Specifications
and Test Practices (or Methods)

RATIONALE

This technical report is being Stabilized because it covers technology, products, or processes which are mature and not likely to change in the foreseeable future.

The leak tightness requirements, test methods, and specifications are derived from current regulated fuel available in the market and hydrocarbon emission requirements (Zero HC Emission) which are not likely to get relaxed.

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1. SCOPE

This SAE recommended practice specifies a standard geometry leak channel to set the leak threshold and compare results from a variety of leak test technologies and test conditions. This practice applies to fuel system assemblies and components which have a risk of allowing regulated fuel or fuel vapors to continuously escape to atmosphere. A component or assembly tested to this standard has a zero HC leakage threshold because the selected leak channel (Equivalent Channel) will self-plug and will not emit measurable hydrocarbon liquid or vapors. Therefore this standard eliminates leaks as a source of evaporative emission. This practice was primarily developed for pressurized and non-pressurized fuel systems and components containing liquid hydrocarbon based fuels.

1.1 Purpose

- 1.1.1 Provide generic leak tightness specifications based on an Equivalent Channel (or maximum allowed micro-channel type of defect).
- 1.1.2 Define specific Equivalent Channel sizes for fuel line assemblies, vapor management components and fuel tank assemblies that will result in no hydrocarbon SHED detectable emission due to leaks..
- 1.1.3 Specify Leak Test Methods' Requirements and Practices to set up and qualify a leak test methods and compare dissimilar test conditions.

NOTE: It should be noted that fuel components and systems normally exposed to fuel fluids (liquid and vapor) are tested to meet HC emission requirements with test methods utilizing compressible, non-hazardous gases such as air, nitrogen, and helium.

2. REFERENCES

2.1 Applicable Documents

The following publications are for reference only. 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 724-776-4970 (outside USA), www.sae.org.

SAE J2587 Appendix C- Fuel System Components Leak Test Specifications issued 2005

SAE J2045 Appendix A- Fuel System Components Leak Test Specifications issued 2012

2.1.2 ASTM and ISO Publications

Available from ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959, Tel: 610-832-9585, www.astm.org

Available from International Organization for Standardization, ISO Central Secretariat, 1, ch. de la Voie-Creuse, CP 56, CH-1211 Geneva 20, Switzerland, Tel: +41 22 749 01 11, www.iso.org.

ASTM E1316-07 Standard Terminology for Nondestructive Examinations-Section E

ISO/IEC 17025-2005 General requirements for the competence of testing and calibration laboratories

2.2 Related Publications

The following publications are provided for information purposes only.

M.J. Harrigan, "Fuel System Components/Module Leak Tightness Specification No.: ES YU5A-9000AC" Ford Motor Company Standard, released April, 2006.

Charles J. Armentrout, Carl E. Strandberg and Karen Golchert, *Correlations of Fuel and Helium Flow for Holes with Very Small Leak Rates*, J. of Fuel and Lubricants, SAE 1997 Transactions, Section 4-Volume 106 (1997)

Code of Federal Regulations (CFR) 40 (Protection of Environment), part 86 (Control of Emissions from New and In-Use Highway Vehicles and Engines).

FMVSS 301 (Fuel Systems Integrity).

California Code of Regulation Title 13, Division 3 (ARB), Chapter 1, Article 1, section 1976 (Standards and Test Procedures for Motor Vehicle Fuel Evaporative Emissions).

Bishop & Sagi, *Development of Leak Tightness Specifications for Automotive Fuel System Components as Required to meet Hydrocarbon Emission Regulations using the Equivalent Channel Concept and its Implementation Method for Production Leak Testing*, SAE International 2010-01-1104, published April-12-2010.

3. DEFINITIONS

3.1 Equivalent Micro-Geometry (EMG)

Maximum allowed single leak path geometry (diameter (d) and length (L)) that will not allow continuous hydrocarbon emission/leakage that exceeds the regulatory or customer requirements. Two types of EMGs are commercially available which represent the two extreme conditions for a potential real life defect/leak. One is a Sharp Edge Orifice where the L/d is small (such as laser drilled hole on a thin film). The second is a Micro-Channel type (Equivalent Channel) with larger L/d ratio. The Equivalent Channel represents a more likely defect in a fuel system and is also a more conservative selection when performing a production leak testing. Therefore, this recommended practice uses the Equivalent Channel as the selected Equivalent Micro-Geometry.

3.2 Equivalent Channel (EC)

A smooth and round micro-channel where $L \gg d$ ($L/d \sim 100$). Diameter is specified in micron-meters (microns). Roundness and diameter imperfection must be held to $\pm 10\%$ of diameter across that micro-channel length. Tolerance on EC diameter must be held to ± 1 micron. Length tolerance is ± 0.25 mm.

Flow curves of various ECs with test air in the viscous (continuum) flow regimes are included in Appendix A. EC flow rates will vary due to common dimensional tolerances and manufacturing methods. However, flow rates to be within $\pm 10\%$ at the test conditions as specified in Appendix A.

3.3 Flow Regimes

Flow regimes are estimated by using the Knudsen (Kn) dimensionless number which is the ratio of the mean free flow path in meters to the EC diameter in meters. Typically 4 flow regimes are recognized:

- Viscous (Continuum) flow regime where $Kn < 0.01$. At high inlet pressure and barometric outlet condition, the gas flow characteristic will change into choked flow (where the speed of sound is reached inside the EC).
- Slip flow condition where $0.01 < Kn < 0.1$
- Transitional flow regimes where $0.01 < Kn < 1$
- Molecular flow regimes, where $Kn > 1$

The actual flow regime is dependent of gas mixture/type, inlet and outlet pressure and EC diameter. The EC is designed to operate at all of these flow regimes. Various leak test method uses all of these flow regimes.

3.4 HC Permeation

Hydrocarbon transport (in mg/day) through a wall of a fuel component due to HC solubility for that material and HC defusibility. The permeation rate is a function of the component (wall) material and thickness, operating temperature and the HC fluid properties. HC Permeation is not a leak, but rather another mechanism for HC emission, which is dependent on the fuel component design. Therefore, this standard does not cover HC Permeation requirements.

3.5 Leak

A hole, or void in the wall of a Unit Under Test (UUT), capable of passing liquid or vapor gasoline from inside of the fuel component/system side of the wall to the atmosphere under action of pressure and concentration differential existing across the wall, independent of quantity of fluid flowing.

3.6 STP- Standard Temperature and Pressure

The pressure and temperature to which an actual compressible fluid's volumetric flow rate is normalized to yield the same mass flow at actual pressure and temperature of that fluid. This standard uses standard pressure of: 101.325 KPa Absolute Pressure and 20°C as STP conditions. (other STP conditions used are 0 deg. C, 70 Deg. F, 1 bar, etc.)

3.7 Leakage Rate (Leak-Flow)

The flow rate of a liquid or gas through a leak at a given temperature as a result of a specified pressure differential across the leak. Leak flow rates are expressed in numerous measurement units. It is recommended to use SI measurement units for volumetric or mass flow rates. Sometimes leak flow rates are normalized to Standard Temperature and Pressure conditions (STP). There is no "one standard" for STP and different STP conditions can result in flow rate variations up to 8% for a given leak flow rate.

3.8 Leak Tightness (or Leak Tightness Specification)

The maximum allowed Equivalent Channel in a single fuel component, enabling this component to meet its performance requirements under defined operating conditions.

3.9 Virtual Leak

A leak that does not have a true leak path from the inside to outside, but appears to the test instrument as a leak. Typically virtual leaks are small narrow gaps, cracks, threads, or hidden crevices that take a long time to be pressurized or evacuated.

4. SYMBOLS

4.1 HC - Hydrocarbon

5. MEASUREMENT UNITS – DEFINITIONS

5.1 Flow Measurement Units:

5.1.1 mL/min

Volumetric flow (Q) in 10⁻³ liters per minute (or cc/min, ccm) should be specified with the gas type, pressure, and temperature at which it is measured.