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SURFACE VEHICLE RECOMMENDED PRACTICE		Issued	2014-02

SURFACE VEHICLE RECOMMENDED PRACTICE

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

RATIONALE

Fuel components and systems must have no Hydrocarbon (HC) leakage, to support compliance with certain HC emission regulatory requirements. This practice recommends use of a standard geometry leak channel (Equivalent Channel) to set the leak threshold for fuel components and systems. The method enables usage of multiple leak test technologies and test conditions, as long as they comply with the specified test practices and requirements.

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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. Strandbergand 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>>d (L/d>~100). Diameter is specified in micron-meters (microns). Roundness and diameter imperfection must be held to ± 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 ± 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:

a.   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).

b.   Slip flow condition where 0.01<Kn<0.1

c.   Transitional flow regimes where 0.01<Kn<1

d.   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 20^0C 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.

NOTES:

a. If temperature is not specified, it is assumed as 20^0C. The temperature effect on actual flow is in absolute temperature, which has a smaller influence and sometimes not mentioned in leakage measurements.

b. If gas type is not mentioned it is assumed to be air or nitrogen.

c. Since gas is a compressible fluid, its volumetric flow will change across the leak flow path due to changes in gas density.

5.1.2   Mg/min

Mass Flow ($\dot{m}$) in 10^{-3} grams per minute (or 10^{-6} Kg/min).

NOTE: Mass Flow is unchanged across the leak flow path at steady state conditions (mass conservation law).

5.1.3   SCCM/SCCS

Actual Volumetric flow (at a given pressure, temperature, and gas type) in mL/min or mL/sec normalized to STP conditions to yield the same mass flow of that given gas. This is a popular flow measurement unit but is not an SI recognized measurement unit.

NOTE: Time based units which are part of the flow measurement units can be minutes or seconds.

5.1.4   mbar*liter/sec

Actual volumetric flow normalized to its pressure (PressureXVolume Flow, or PXQ). Flow rate of 1 Atm-cc/sec at 20^0C can be interpreted to be 1 sccs of the same gas.
Note: This measurement unit is common with Helium (or other tracer gas) Mass Spectrometers.

5.2   Pressure (P) Units

5.2.1   Absolute Pressure (P-abs)

Pressure units relative to 0 pressure, noted as KPa-ABS (psia, psi absolute).

5.2.2   Gage Pressure (P-g)

Pressure units relative to existing barometric pressure, which varies and is noted as KPa-gauge, KPa-g (psig, psi gauge).

6.   TERMINOLOGY

6.1   Unit Under Test (UUT)

The fuel system component or system under test

7. BACKGROUND

7.1   This recommended practice is based on the requirement that there will be "no HC detectable SHED emission" due to leaks, in order to support compliance with HC emission regulatory requirements (see section 2.2 for example of such regulatory requirements).

This recommended practice is based on test data (see section 2.2 references from M.J Harrigan, C. Armentrout and Bishop& Sagi work) indicating that fuel system micro-channels under a critical size will plug over time. Effectively, micro-leaks plug to a near zero hydrocarbon emission level as measured in a SHED and mini-SHED. The plugging mechanism is thought to be caused by additives, debris, or contaminants in fuel, partial evaporation from the defect surface, electrostatic, and capillary forces. The plugging phenomenon is dependent on leak path diameter and length. The Equivalent Channel is the largest size leak channel that will self-plug during its operating conditions and therefore it is the Leak Tightness requirement, which will comply with the "no HC detectable SHED emission" requirement.

7.2   Fuel systems and components are tested at various conditions, from high pressure to hard vacuum, with multiple gases. Therefore, the applicable leakage flow rate is dependent on test method and parameters (flow regimes). Complex formulas are required to calculate flow rates in different test conditions and flow regimes. Helium hard vacuum testers operate in the molecular flow regime. Other test methods apply high or low pressure inside the tested part. High or Low pressure leakage to atmosphere testing results in viscous and/or slip flow regimes. The flow rates in the viscous flow regime are higher by order of magnitude from flow rates obtained from the same EC at the molecular flow regime. The implementation of an EC prevents the need to use complex mathematical models to properly estimate gas micro leak flow rate for the various test methods.

7.3   Flow measurement units and method are a great source of confusion for design and manufacturing engineers. The usage of an EC eliminates this confusion. The EC can be used to correlate leak test limits between different test methods and parameters. Correlation of leak limits is very beneficial when the assembly cannot be tested using the same parameters as the subassemblies.

7.4   The HC emission rate through an EC is a function of fluid type, pressure and temperature. Less effect is attributed to the hydrophilic/hydrophobic reaction between the fuel and the component material. Therefore, usage of the EC as a leak tightness specification allows for universal leak tightness, independent of a specific component/system design or manufacturing process.

7.5   Establishing the critical EMG/EC for a new fluid or application is possible with properly designed test, as mentioned in the reference, section 2.2. When new fluids and new pressure levels are introduced, Fuel System Designers are encouraged to empirically establish the EC for each new application.

8. LEAK TIGHTNESS REQUIREMENTS

It is recommended that a fuel component or assembly shall not include defects larger than the Equivalent Channel size as outlined in Table A or otherwise as specifically agreed between the OEM and Supplier.

The recommended EC geometry (diameter and length) to obtain "no HC Detectable SHED emission" is specified based on fluid type and phase (liquid vs. vapor), maximum operating pressure, and temperature.

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 ± 10% at the test conditions as specified in Section 9 and Appendix A.

NOTE: Other calibrated leaks with flow and pressure performance curves as Equivalent Channel (per Appendix A) are acceptable. The dynamic response (rate by which flow developed at given pressure differential) of such an orifice must match the applicable EC.

TABLE A - MAXIMUM ALLOWED EC FOR FUEL COMPONENTS AND ASSEMBLIES:

No	Product Type	Fuel Phase (1)	Max. operating Pressure (KPa-gage) at sea level	EC diameter and Length (micronsXmm)
1	Liquid Fuel Assemblies and Components	Liquid	485	15X3
2	Liquid & Vapor Management Assemblies, and Components	Vapor or Liquid	13.8	15X1.5

(1) Gasoline, diesel or evaporative emission regulatory fuel as applicable to actual use.

NOTE:

When a complex assembly (e.g., fuel tanks) is tested, the component supplier to that assembly may be required to test to a tighter specification, as per table A item 1 (15 micron diameter EC 3 mm long instead of 15 micron diameter EC 1.5 mm long) or other specification as agreed upon between assembly suppliers and its component supplier

9.   LEAK TEST METHODS AND TECHNOLOGIES

Leak test methods and technology/type used must be non-destructive and capable of measuring leakage from an EC (per Section 8 Table A) when the EC is attached to an actual part at the agreed upon test parameters.

This recommended practice is applicable for Fuel Components/subassemblies (e.g., fuel hoses and fuel tank assemblies) leak testing during Product Validation (PV) and In-Process (IP) as part of a quality control program. These tests are to be performed with an inert non-corrosive gas (e.g., air, nitrogen, and helium) as the test fluid.

The components/subassembly PV and IP leak tests can be divided into 3 categories:

a.   Hard vacuum tracer gas testing with the UUT inside a vacuum chamber (chamber at 0.1 KPa Abs, UUT up to 13.8 KPa absolute pressure).

b.   Low pressure - equal or less than ± 68 KPa-gage (± 10 psig) pressure.

c.   High pressure - higher than 345 to 1034 KPa-gage (50 to 150 psig) pressure.

Technologies that were qualified and commonly used are tracer gas (most common is helium) in hard vacuum and accumulation mode, air/nitrogen micro-flow and mass extraction methods, and pressure differential decay. Pressure decay or thermal mass flow are used for applications where the part is tested at high pressures (345 KPa-gage and higher).

Most leak test methods are cumulative where multiple leaks on the same part are added together and are displayed as one overall leak rate. To minimize cumulative effects, testing at the most basic sub assembly level is recommended whenever practical. Typically, leakage will occur from one location on the UUT and cumulative effects are not significant for fuel components.

Test Medium: The UUT can be evacuated and/or pressurized with gas such as dry air, nitrogen, or helium (including helium mixtures). Any concentration of gas is acceptable as long as the test demonstrates capability per sections 9.1 and 9.2.

Methods subjected to operator interpretation of pass or fail such as Air Under Water (AUW), manual tracer gas sniffing methods (defined as operator dependent go/no-go test methods) are not recognized as a suitable test methods for production in-process testing to qualify a UUT's leak tightness per this standard. AUW and other go/no-go test methods can be used for locating the point of leak and for diagnostics and troubleshooting if properly performed at a high pressure.

Other test method technologies can be acceptable as agreed between supplier and customer or as long as they comply with the conditions defined in this Recommended Practice.

The following sections 9.1 and 9.2 are applicable to Set-up and test system validation and qualifications, commonly done during initial Leak Test process set up and qualification for a new product or change in test process.

Section 9.3 is applicable to qualified test systems and set up, used during routine IP or PV leak testing,

Appendix C includes recommended practices for initial set up, fixture design and routine IP leak testing applications.

9.1   Leak Test Process Set Up and Method Validation Requirements

9.1.1   Test process must be a non-destructive test method as agreed between supplier and customer.

9.1.2   Supplier must have an adequate quality system to ensure that parts rejected during the leak test are segregated and not shipped to the customer. One poka yoke to ensure only passed parts are shipped is to include a value added operation on the leak test machine. This can include adding a clip or bend onto the UUT. Other poka yoke methods include addition of a stamp or mark upon completion of a successful leak test or locking a failed UUT onto the leak test machine, requiring a different person to release and segregate that failed UUT.

9.1.3   The calibration of devices used to set up and calibrate the leak test instruments (such as ECs) must be by an accredited laboratory complying with ISO 17025.

9.1.4   Test Pressure

a.   The UUT leak test pressure differential (between UUT test pressure and ambient) must be agreed upon by the supplier and customer.

b.   Pressure differential used for testing should be equal to or higher than component operating pressure.

NOTE: In some cases test pressure over operating pressure may seal up a leak. This phenomenon is typical for crimp joints and where flexible components attach to rigid lines.

9.1.5   First time test set-up and equipment validation:

An EC as defined in section 8 Table A will be connected directly onto the UUT. The EC can also be connected to a pneumatic line connected to the UUT. Capability per section 9.2 must be demonstrated. System set up must allow:

a.   One or more master parts + EC connected must be rejected by the leak test machine/system.

b.   The master parts without EC must be accepted.

c.   Dynamic test ("signature test") is common and allowed, to increase throughput.

Measurement values and acceptance/rejection limits must demonstrate clear and capable measurement difference or separation between a "master" UUT and a "master" UUT with EC attached to it.

A "master" UUT (or master part) is a part representing the part to be tested including fixturing and connections as it is used during the intended use of the equipment, independently qualified at steady state conditions to be less than 10% of the EC leak flow rate at that given inlet and outlet pressure, temperature and gas type.

9.1.6   Guideline for Test Methods and Equipment Requiring EC (or other calibrated leak) for Calibration

a.   For test methods and equipment that require calibration with final set up, the EC and a master UUT can be used for set up calibration as outlined in Appendix B. A few important "to-do" and "not to-do" points when performing this calibration. The EC or any other calibrated leak must be certified as outlined in section 9.1.3.

b.   Use the same gas mixture and inlet and outlet pressure as used during the actual test.

c.   Most leak test measurements are dynamic measurements. Therefore, use the same test sequence and timing parameters as during production.

d.   The EC must be fully vented to air at its inlet and outlet before the test/calibration starts. Air has lower viscosity than helium, so there is a time delay before the full helium flow is realized.

e.   This is normally a 2 point calibration (0% and 100% of acceptance range), which does not allow for compensation of linearity and hysteresis errors. Expanded measurement uncertainty is difficult to establish.

f.   Ensure that background leakage will not significantly bias the "0 %" Point, as outlined in Appendix B.

g.   When tracer gases are used, tight control of ambient gas concentration must be applied in order to avoid high background tracer gas concentration, which could bias the 0% measurement.

9.2   Measurement System Capability

This section of Measurement System Capability is to ensure system is repeatable, and not necessarily indicate compliance to all measurement analysis requirements.

NOTE: R&R requirements are to be agreed upon between customer and supplier.

9.2.1   Suggested minimum requirements are as follow:

Using a master UUT and EC (per section 9.1.5), perform complete leak test of the master UUT+EC, minimum 50 consecutive times, same as during normal production run.

When permeation of the test fluid (e.g.: Helium) influencing the study, the study may-be performed with a test chamber and EC attached to the chamber, and fed with the same gas as the uut. In this case the limit setting must be validated with a UUT (e.g.: tank assembly) with an EC built in.

a.   Minimum of 1.33 CPk using ±15% specification limits is required to pass this R&R test.

Upper Specification Limit = Target Leak Rate + 15% of Target Leak Rate

Lower Specification Limit = Target Leak Rate – 15% of Target Leak Rate

$$CP(upper) = (UpperSpecificationLi\,mit - Average)/3\sigma$$
$$CP(lower) = (Average - LowerSpecificationLi\,mit)/3\sigma$$

CPk = smaller of the calculated CP values

9.2.2   Using a master UUT (per section 9.1.5), perform a complete leak test a minimum of 50 consecutive times. The same as during normal production runs. Calculate the average and the Average + 3 Std. Deviation (3σ).

9.2.3   Ensure clear separation between Master UUT and Master UUT + EC- the test method is capable of detecting leaks within 99% of confidence level:

Average (master UUT+EC) -3σ >Average (master UUT) +3σ

When the requirements of section 9.2.1 and 9.2.3 are met, this specific measurement system and specific set up are in compliance to the Capability requirements per this section.

9.3   Leak Test Requirements (PV and IP tests)

Leak test equipment must be qualified per section 9.1 including documented statistical capability as defined in 9.2.

9.3.1   A UUT with a defect equal to or larger than the EC per table A section 8 must be rejected.

9.3.2   The ECs geometrical values (and reference flow values at calibration conditions) of all ECs per section 8 table A must be clearly labeled and attached to each EC as calibrated by the manufacturer. Flow values are derived values from EC geometry, test inlet and outlet pressure, and gas mixture used

9.3.3   Rejection Limit specifications must be set as outlined per section 9.1.5. If any test parameter is changed, the system must be re-qualified per section 9.1.and 9.2

9.3.4   It is recommended that the complete test system will be periodically verified using an EC per section 8 (table A). The verification process may vary depending on leak test technology and test system design and may require calibration per section 9.1.6. The verification test must ensure that an accepted UUT (or master UUT) is rejected when an EC is attached to that same UUT using the same gas mixture and test parameters.

For this on-going IP verification the EC will be built into the test circuit, and not necessarily attached to the master UUT. The test equipment will be designed to automatically vent the EC inlet and outlet or air upon completion of the test. The test equipment must ensure that the same gas supply going to the UUT will be supplied at same pressure to the EC.

9.3.5   If the leak test system fails verification with an EC, the quality system must apply corrective actions, per ISO/TS 16949 requirements.

10. NOTES

10.1   Marginal Indicia

A change bar (l) located in the left margin is for the convenience of the user in locating areas where technical revisions, not editorial changes, have been made to the previous issue of this document. An (R) symbol to the left of the document title indicates a complete revision of the document, including technical revisions. Change bars and (R) are not used in original publications, nor in documents that contain editorial changes only.

PREPARED BY THE SAE FUEL SYSTEMS STANDARDS COMMITTEE

APPENDIX A - FLOW CURVES OF COMMON EQUIVALENT CHANNELS

A.1 EC DIAMETER: 15 MICRON AIR FLOW (INLET PRESSURE TO ATMOSPHERE).

Average Air Temperature: 70 Deg. F, Flow measurement units are in actual mL/min (cc/min) at the indicated pressure.
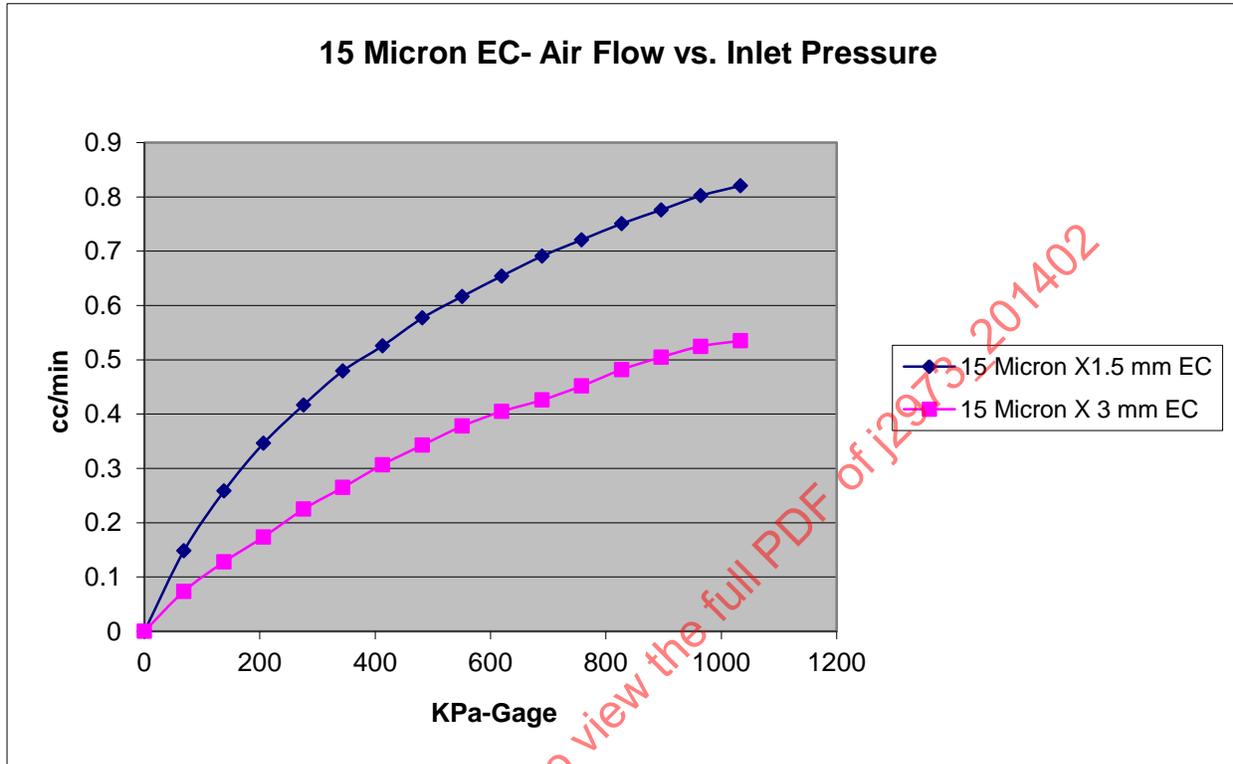
Inlet Pressure	Inlet Pressure	EC Air Flow : 15 micron dia. L=1.5 mm			EC Air Flow: 15 micron dia. L=3.0 mm		
Kpa-Gage	Psig	cc/min	Min. (cc/min)	Max. (cc/min)	cc/min	Min. (cc/min)	Max. (cc/min)
0	0	0	0	0	0	0	0
69	10	0.149	0.134	0.164	0.0737	0.066	0.081
138	20	0.259	0.233	0.285	0.128	0.115	0.141
207	30	0.346	0.311	0.381	0.174	0.157	0.191
276	40	0.417	0.375	0.459	0.225	0.203	0.248
344	50	0.48	0.432	0.528	0.265	0.239	0.292
413	60	0.526	0.473	0.579	0.307	0.276	0.338
482	70	0.577	0.519	0.635	0.343	0.309	0.377
551	80	0.617	0.555	0.679	0.378	0.340	0.416
620	90	0.655	0.590	0.721	0.405	0.365	0.446
690	100	0.691	0.622	0.760	0.426	0.383	0.469
758	110	0.721	0.649	0.793	0.452	0.407	0.497
827	120	0.751	0.676	0.826	0.482	0.434	0.530
896	130	0.776	0.698	0.854	0.505	0.455	0.556
965	140	0.802	0.722	0.882	0.525	0.473	0.578
1034	150	0.821	0.739	0.903	0.535	0.482	0.589

A.2 HELIUM (100% COMMERCIAL GRADE HE) FLOW RATE GUIDELINE FOR HARD VACUUM TESTING WHEN
       THE INLET PRESSURE IS 13.789 KPA-ABS (2 PSIA) AND OUTLET IS 0.2 KPA-ABS OR LESS ARE:

	Equivalent Channel Nominal size d(micro-meter) XL (mm)	Helium flow rate mbar*lit/sec (*)		
			Min.	Max.
1	15 micron X 1.5 mm	1.25×10^{-4}	1.125×10^{-4}	1.375×10^{-4}
2	15 micron X 3 mm	7.05×10^{-5}	6.345×10^{-5}	7.755×10^{-5}

(*) - Refer to section 5.1.1 for measurement unit definitions.