SURFACE VEHICLE STANDARD

J2727™ NOV2020

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Superseding J2727 APR2013

(R) Mobile Air Conditioning System Refrigerant Emission Charts
for R-134a, R-1234yf, and R-152a

RATIONALE

This document is being updated to include leakage calculations for R-152a (HFC-152a) and to add formal and consistent Excel worksheets that shall be used in calculating leak rates of various refrigerants.

1. SCOPE

The "system emissions chart" contained herein is intended to serve as a means of estimating the annual refrigerant emission rate (grams per year) from new production A/C systems equipped with specified component technologies. It provides emission values for various component technologies that are currently available, and can be expanded as new technologies are commercialized. This document provides the information to develop an Excel file template "system emissions chart" for system emission analysis. The chart includes automotive compressor technologies for conventional mobile air conditioning systems, as well as those using semi-hermetic compressors. This standard can be considered a companion document to SAE J2763. SAE J2727 estimates system emissions, taking into account production assembly variation and accounts for components that are 100% helium leak tested prior to vehicle final assembly. The results from SAE J2064 are used to better represent permeation emissions from different hose material and coupling configurations in this version. SAE J2763 may be used to quantify emissions from properly assembled 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 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 +1 724-776-4970 (outside USA), www.sae.org.

SAE J2064 Coupled Automotive Refrigerant Air-Conditioning Hose Assemblies

SAE J2763 Test Procedure for Determining Refrigerant Emissions from Mobile Air Conditioning Systems

TO PLACE A DOCUMENT ORDER: **Tel: 877-606-7323 (inside USA and Canada)**
Tel: +1 724-776-4970 (outside USA)
Fax: 724-776-0790
Email: CustomerService@sae.org
SAE WEB ADDRESS: **http://www.sae.org**

For more information on this standard, visit
https://www.sae.org/standards/content/J2727_202011

3. ASSUMPTIONS FOR THE EMISSIONS CHART SPREADSHEET

3.1 General Assumptions

3.1.1 Real-world refrigerant emission rates will not be universally consistent for any given system design due to assembly variations and customer climate and usage patterns.

3.1.2 The values in this standard apply to systems assembled in new production vehicles and include an allowance for the expected normal variation for most OEM vehicle and component assembly plants except in the case where the components are 100% helium leak tested to assure proper assembly prior to assembly in the vehicle.

3.1.2.1 Fitting technologies vary in their ability to contain refrigerant and in their inherent ability to be properly assembled. Emission rates were assigned to each technology based on laboratory testing and field repair experience.

3.1.3 This standard accounts for normal design assembly of refrigerant system connections. The assigned value for each fitting technology reflects its potential for miss-assembly.

3.1.3.1 The correlation to field test results is based on vehicles properly assembled in the typical vehicle assembly plant. The laboratory correlations are based on properly assembled components in a laboratory environment.

3.1.4 The chart can be modified as new components and leak testing technologies are developed and evaluated for their robustness and ability to assure reduced system emissions.

3.2 System Joints (Connections)

All connections (aka, joints, fittings) of all components attached to the A/C system, in sub-assemblies or in the vehicle assembly plant, must be listed under the appropriate heading in the system joints section. Connections must be accounted for in one of two ways:

1. Those connections (with higher emissions than seal washers) made and subsequently leak tested by helium mass spectrometry should be totaled and listed in the special (stippled) box under the seal washer category on Line 9.

   NOTE: To use the credit for helium leak testing after assembly, 100% of all joints for which the credit is claimed must be helium leak tested. Audit sampling, or any other form of non-continuous sampling, shall not be used in place of 100% component leak testing with helium.

2. All other connections made must be separately accounted for under the specific connection type on Line 8. All system joints (connections) made on the vehicle production line shall be listed under the specific connection type on Line 8.

3.2.1 Emission values for fittings relate to their potential for production miss-assembly. O-rings are significantly more difficult to properly assemble than, for example, seal washers. Accordingly, O-ring fitting technologies have been assigned higher emission default values.

3.2.1.1 A single, radially sealed O-ring has the inherent potential for twisting the O-ring during initial assembly, and then twisting (or cutting) it again when the mating surfaces slide over one another to close the joint and consummate the seal.

3.2.1.2 An axially sealed O-ring is similar to a captured O-ring, in that the seal is first placed into position and then the mating surface compresses the seal axially without the opportunity for further seal movement (Figure 15). These seal technologies present only one opportunity for miss-assembly, i.e., when the seal is first placed into position prior to joint closure. Thus, axially sealed O-rings and molded seals are considered equivalent to a captured O-ring.

3.2.2 It is assumed that properly designed and assembled O-ring fittings will have emission rates comparable to properly designed and assembled seal washers, hence the special consideration given to those O-ring fittings that have been verified as properly assembled via helium mass spectrometry. Given the above, SAE J2727 may overestimate O-ring fitting emissions not helium leak tested after assembly for those vehicle manufacturers capable of exceptionally reliable production A/C system O-ring assembly. This may be taken into consideration when interpreting the emission values calculated in the spreadsheet.

3.3 Devices with Other (Non-Joint) Emission Paths

The assumption is that all of these devices are helium leak tested prior to assembly in the vehicle.

3.3.1 Service Ports

Service fittings are assumed to have sealing caps in place. Non-connection emissions are those that occur through the valve core assembly and, ultimately, through the service port valve cap seal. Assigned emission rates are based on the cap with seals properly assembled and torqued, and system location, i.e., high pressure or low pressure side of the system. Connection emissions from a service port must be accounted for if the service port requires a seal for attachment purposes (e.g., O-ring) and that seal must be included in the system joints section. Such a port is often referred to as a “two-piece” service port.

3.3.2 Line-Mounted and Compressor-Mounted Devices (e.g., PRV, Switches, Transducers)

These devices may include different internal sealing technologies (e.g., O-rings, seal washers, diaphragms, and gaskets) Assigned values in the spreadsheet account for emissions from these internal seals and the location of the device in the system, i.e., high pressure or low pressure side of the system. Assigned values account for emissions exclusive of fitting connections. Connections/fittings used to install the device onto the system plumbing are to be accounted for in the system joints section.

3.3.3 Refrigerant Flow Devices

These devices, e.g., thermal expansion valves, may include different internal sealing technologies (as noted in 3.3.2) that create non-joint emission paths. Assigned values account for these emissions, exclusive of fitting connections. All joints used to connect the refrigerant flow device to the system are to be included in the system joints section.

NOTE: Orifice tube flow devices mounted inside flexible hose assemblies or rigid pipes have zero emissions. Connection(s) to install/service such devices are to be included in the system joints section.

3.4 Flexible Hose

3.4.1 Hoses technologies differ in refrigerant permeation rate due to different hose materials used and construction methods employed in their manufacture. Hose permeation rate is a function of the refrigerant, internal refrigerant temperature and pressure, hose material, hose construction, hose inner surface area, and location on the system. Hose permeation rates (kg/m^2/year) measured at 80 °C per the requirements of SAE J2064 shall be entered in the spreadsheet for each system hose type. The permeation rate multiplied by the internal surface area of the hose and the conversion factor yields the annual emission rate for the specific hose. Relative emission rates of system high-side hoses are greater than low-side hoses. In addition, permeation rates are based on the assumption that the A/C system “on” time usage is 5 to 7%, i.e., 440 to 620 h/year.

3.4.2 Flexible hose assemblies include tube, hose, and coupling. Emissions occur through the hose and at the couplings, which are accounted for in this section. Emissions from the tube fitting connections at either end of the hose are to be included in the system joints section.

3.4.3 High-side and low-side, pressure hose inner diameter, hose construction type, and exposed hose length must be identified in the flexible hose section of the emissions chart.

3.5 Heat Exchangers, Mufflers, Receiver/Driers, and Accumulators

3.5.1 Heat exchangers (HX) are considered to be robust and the emissions chart assigns each a relative emission rate. Internal Heat Exchangers are to be included in this category. Emissions from fittings to connect HX components to the system are to be included in the system joints section. Mufflers, receiver/driers, and accumulators are considered to be emission-free except for the emissions from the fittings to connect them to the system. Such fittings are to be included in the system joints section. Any serviceable connections on any of the above components, such as fittings for servicing desiccant, are also to be included in the system joints section.

3.6 Compressor

3.6.1 It is assumed that multiple lip shaft seals are better than single lip seals. It is assumed that gasket-housing seals are better than O-rings. Dust lips in the shaft seal shall not count as secondary refrigerant seals unless shown to reduce emission levels.

3.6.2 The major refrigerant emission paths of a belt-driven compressor are the shaft seal and housing (body) seals.

3.6.2.1 Compressor shaft seal(s). The number of lips on the shaft seal is defined by the number of individual sealing elements in contact with the compressor shaft. Common seal materials are PTFE and HNBR.

3.6.3 Semi-hermetic compressors are expected to emit less refrigerant than belt-driven compressors and are so accounted for. The shaft is fully enclosed within the compressor body. Semi-hermetic compressors contain one or more housing seals. All connections that are not hermetic are to be included in the system joints section.

3.6.4 Compressor emission is a function of the number of housing sealing joints that are used, the number of lips on the shaft seal (if non-hermetic), and number and type of non-hermetic connections. The type of design shall be identified in the compressor section of the spreadsheet.

3.6.5 Some compressors use fitting adaptor plates between the compressor body and the rigid pipe fittings. Adaptor plates are sealed to the housing by a captured O-ring or molded-in-place seal. Adaptor plate seals are assumed to perform similar to single axial O-ring joints. Those not helium leak tested must be accounted for in the system joints section as equivalent to an axial O-ring joint. Those leak tested by helium-mass spectrometry following assembly are to be listed in the compressor body section.

3.6.6 Compressor sealing surfaces to be accounted for in this section are:

3.6.6.1 Number of lips on the shaft seal.

3.6.6.2 Number of O-ring housing seals.

3.6.6.3 Number of molded housing seals; O-ring material molded into a specific shape.

3.6.6.4 Number of gasket housing seals fitting.

3.6.6.5 Adaptor plate (e.g., European style), unless not helium leak tested and listed in the system joints section.

3.6.7 To use the spreadsheet for emissions estimation, 100% of compressors shall have been helium leak tested prior to assembly onto the vehicle. For compressors that are helium leak tested as above, replace the “2” in cell D40 with ”1.”

3.6.7.1 For compressors that are not helium leak tested:

3.6.7.1.1 All compressor seal types used shall be entered on Line 38 of the table and the number “2” in cell D40 shall remain unchanged.

Line H38 = (B39/B38+C39*C38+D39*D38+E39*E38+F39*F38)*0.522*D40

3.6.7.1.2 No entries shall be made on Line 9 for any compressor mounted devices. Such devices shall be accounted for on Line 8.

3.6.8 Compressor mounted devices, specifically the compressor control valve (just the last seal to the atmosphere), pressure relief valve (PRV), and switches are to be accounted for in both the system joints section and the devices with other emission paths section, as noted in 3.3. If such devices are helium leak tested after assembly to the compressor, their connection should be accounted for on Line 9 as equivalent to a seal washer connection.

3.6.9 See Section 9 notes for additional compressor definitions.

4. CORRELATING SYSTEM EMISSION RATINGS (SPREADSHEET) WITH FIELD TEST AND MINI-SHED TEST RESULTS

4.1 Mini-shed testing of systems, with and without the compressor, was performed per SAE J2763 to establish the emission rate of properly assembled A/C systems and the relative contribution of the compressor and hoses. Fleet tests were also conducted in Japan and Europe by JAMA and ACEA, respectively. The spreadsheet has been correlated to the field test results and bench testing done per SAE J2763.

4.2 The customer usage profile assumed herein combines 5 months of usage under SAE J2763 mini-shed test conditions (weighted average ambient of 31 °C) with a 7-month non-use period at an average ambient of 5 °C, during which emissions are 0.18 times those in the mini-shed test based upon pressure squared. This combination results in a correction factor 0.522 that is applied to all components' emission formulas.

5. CORRELATING SYSTEM EMISSIONS WITH RANDOMLY CHOSEN PRODUCTION VEHICLES

5.1 The "systems emissions chart" spreadsheet directly calculates the estimated annual emissions from production assembled systems using the component technologies comprising the system.

5.2 The emission estimates provided by this spreadsheet correlated well with the measured refrigerant losses from field test vehicles in Japan and Europe. (Refer to the presentation made at the 2006 SAE Alternate Refrigerants Symposium June 28, 2006, "Revising SAE J2727.") (Note: The changes made to this standard do not significantly affect this correlation.)

5.3 This procedure can be used to predict annual grams per year emission rates for new vehicle systems and may be used as a basis for compliance with governmental requirements. Estimates are conservative, include an accounting for potential miss-assembly of fittings, and may slightly overestimate actual measured emission values.

6. BASIS FOR ESTIMATING R-1234YF AND R-152A EMISSIONS

6.1 While the original spreadsheet was, and is, intended to estimate R-134a mass-based emissions, it has been modified to estimate emissions of R-1234yf and R-152a. With the exception of hose permeation, refrigerant emission is a volume flow and is dependent upon vapor pressure and inversely dependent upon the viscosity of the escaping vapor (see Table 1). Volume flow can be converted to mass flow using molecular weight. Given the equivalence of R-134a, R-1234yf, and R-152a vapor pressures, R-134a emissions can be corrected to estimate those of R-1234yf and R-152a by multiplying R-134a emission values by the ratio of molecular weights and the inverse ratio of gas viscosities. The contribution of hose assembly emissions is directly accounted for by requiring the measurement of refrigerant permeation per SAE J2064 for the specific refrigerant. Hence, applying the conversion factor determined by molecular weight and viscosity ratios to all emissions except hose emissions, followed by adding refrigerant specific hose emissions, will convert the R-134a emission values to R-1234yf or R-152a emissions. Using the following equation (where R-x is either R-1234yf or R-152a) and values in Table 1 for visocities and molecular weights, the emission ratios are 1.03 and 0.74 for R-1234yf and R-152a respectively.

$$Emission\ Ratio = \frac{(MolWt_{R-x})(\mu_{R-134a})}{(MolWt_{R-134a})(\mu_{R-x})}\Big|_{\mathrm{Tconstant}}$$

Table 1 - Viscosity and molar mass of selected gases and refrigerants

Gas/Refrigerant	Dynamic Viscosity at 15 °C µin Pa x s	Molecular Weight MolWt in kg/kmol
Nitrogen	17.4×10^{-6}	28
Helium	19.3×10^{-6}	4
Air	18.0×10^{-6}	29
R-744	14.5×10^{-6}	44
R-134a	11.1×10^{-6}	102
R-1234yf	12.0×10^{-6}	114
R-152a	9.7×10^{-6}	66

7. EMISSIONS CALCULATION WORKBOOK

A workbook template is included with this document. This workook template consists of an example and instructions sheet and six different emission chart calculation sheets (R-134a Belt Driven Compressor, R-134a Electric Compressor, R-1234yf Belt Driven Compressor, R-1234yf Electric Compressor, R-152a Belt Driven Compressor, and R-152a Electric Compressor). The example and instructions worksheet is shown in Figure 1 of 8.1 and the formulas for developing the calculation spreadsheets, including assigned values and assumptions, are listed in Appendix C.

7.1 Example and Instructions Worksheet, Figure 1

Identify model year, program, powertrain, single or Duel, etc. Also identify date when sheet is completed.

SAE J2727 GENERIC TEMPLATE for For R-1234yf Refrigerant Systems
Model:17MY Awesomemobile 2.0L Turbo
Date: December 6, 2019

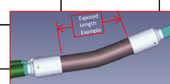
Be sure to use the template for the correct refrigerant and compressor type as shown the tab label. Duplicate as needed, one sheet per unique powertrain or system design.

	December 5, 2019 Template							COMMENTS / REQUIREMENTS
Leakage Chart for Systems with Belt-Driven Compressors								
Enter data only in cells of this color							Calculated Emissions	
System Joints (a.k.a. Fittings & Connections)								
EACH & EVERY JOINT Used to Attach Components to the A/C System MUST be Accounted for in either Row 8 or Row 9	Single Radial O-ring	Single Captured O-ring / Single Axial O-ring / Molded Seal	Multiple O-ring	Seal Washer	Dual Seal Washer / Seal Washer with O-ring	Metal Gasket		Joints are those sealing technologies separating the refrigerant from the atmosphere
Relative Emission Value	1.250	0.750	0.500	0.100	0.050	0.010		Use comments to identify joint location
Insert Total Number of Joint Types E6, F6, and G6. Also enter the Total Number of Joints B6, C6, and D6 *NOT* Helium Leak Checked After Component Sub-Assembly	1			4	1	5	0.94	Joints NOT Helium Leak Tested After Assembly
Joint Types B6, C6, and D6 That Are Helium Leak Checked After Component Sub-Assembly Are Considered Equivalent to Seal Washers. List The Total Number of Such Seals only in E9				4			0.22	Joints that ARE Helium Leak Tested After Component Sub-Assembly. Note: To use this cell, 100% of all joints must be so tested.
						Connections Total	1.16	
Devices with Other Emission Paths								Devices with emission paths other than at the connecting joint, e.g. thru the valve core and cap of a service port
Service Ports (non-joint emissions)		High Side		Low-Side				Note: List all sealing connections to the atmosphere in Line 8 or 9
	Insert number of service valves	1	Insert number of service valves	1			0.27	Note: If a two piece core is used with an internal o-ring, this o-ring must be included in row 8 or 9 above.
Line-mounted PRV, Switches, Transducers (non-joint emissions)		Located on High Side		Located on Low-Side				
Transducer	number of devices	1					0.16	Note: List all sealing connections to the atmosphere in Line 8 or 9
Thermal Expansion Device Refrigerant Control (non-joint emissions)								Note: ALL four connections for a block style thermal expansion valve [TXV] need to be accounted for in rows 8 and 9 above!
	number of devices	1					0.11	Note: List all sealing connections to the atmosphere in Line 8 or 9
Compressor Mounted Devices (non-joint emissions)		PRV, Control Valve, Switches						
PRV, ECV	number of devices	2					0.22	Note: List all sealing connections to the atmosphere in Line 8 or 9
						Other Emission Paths Total	0.75	

Single O-rings not Helium Mass Spec. Leak Checked.

Must be 100% Helium Mass Spec. Leak Checked. Examples: PRV, IRD Plug, Pressure Transducer, Compressor MCV or ECV, RD to Condenser Joints. TXV to Evap Joints

Description of applicable devices required



List part number (optional), hose material and supplier

Flexible Hoses								
	Hose	Hose	Calculated					Permeation Rate Unit = Kg/m**2/year
Includes Hose and Hose Coupling Crimps [End Connections included in Component Connection]	Exposed Length (Between Crimps) [mm] [mm]	Diameter Inner [mm]	Surface Area Do Not Enter Data [mm^2]	Enter SAE J2064 Refrigerant Permeation Rate at 80C in Column F For Each System Hose			Do Not Enter Data	Use Only Exposed Length of Hose Between Crimps. Coupling emission is accounted for in this calculation
High pressure line 1: Part # 123456-89 (Super A Hose)	470	10.7	15755		0.30		0.066	Enter length to the nearest millimeter
High pressure line 2: Part # 123456-90 (Super A Hose)	242	8.2	6252		0.40		0.035	Enter diameter to the nearest tenth of mm.
High pressure line 3	0	0.0	0		0.00		0.000	
High pressure line 4	0	0.0	0		0.00		0.000	
Low pressure line 1: Part # 123456-91 (Super A Hose)	590	19.4	36033		0.60		0.202	
Low pressure line 2: Part # 123456-93 (no hose)	0	0.0	0		0.00		0.000	
Low pressure line 3	0	0.0	0		0.00		0.000	
Low pressure line 4	0	0.0	0		0.00		0.000	
						Hose Total	0.30	
Heat Exchangers (HX's)								
			Number of Heat Exchangers	3		HX Total	0.40	Include all Condensers, Evaporators and Internal Heat Exchangers Note: 100% of such components must be Helium leak tested.
Compressor Body								
Exclusive of Attached Devices			Type of Seal					
123456-86 Compressor	Number of lips on shaft seal	Number of O-Ring Housing Seals	Number of Molded Housing Seals	Number of Gasket Housing Seals	Fitting Adaptor Plate Seal		Do Not Enter Data	Account for All Attached Devices (e.g., HPRV, HPCO, Drain Plug) on Lines 8 or 9
Insert Number of Each Type of Seal in Compressor	2			3		Compressor Total	5.65	Note: 100% of compressors must be Helium Leak Tested: If NOT, emissions are doubled
Relative Emission Value	15	3	2	1	0.4			
IF Compressors ARE Helium Leak Tested, change the number in Cell D40 from 2 to 1			1					

Include: Condenser, Front Evap, Rear Evap, Battery Chiller, IHX. Use comments.

List part number (optional), compressor model and supplier

For Electric compressor this cell is NA. Use correct template.

Must be changed from a 2 to a 1

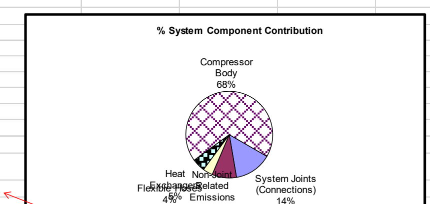
Do not use unless adaptor plate is helium mass spec leak checked. Instead use Cell B8.

Summary	% Contribution	grams/year
System Joints (Connections)	14.0%	1.2
Non-Joint Related Emissions	9.1%	0.8
Flexible Hoses	3.7%	0.3
Heat Exchangers	4.9%	0.4
Compressor Body	68.3%	5.6
Total	100.0%	8.3

Approximate Total System Refrigerant Emission Grams/Year	8.3

System Layout

Presentation



NOTE: Entries made in stippled boxes represent components/connections Helium Leak tested for leak tightness after assembly

Insert a Powerpoint slide or add an attached picture to the workbook which shows the system layout, part numbers(optional), hose lengths, hose material, joint quantities and types. See example.

Figure 1

7.2 Reference Component Illustrations

7.2.1 Hose Construction

Figure 2

Figure 3

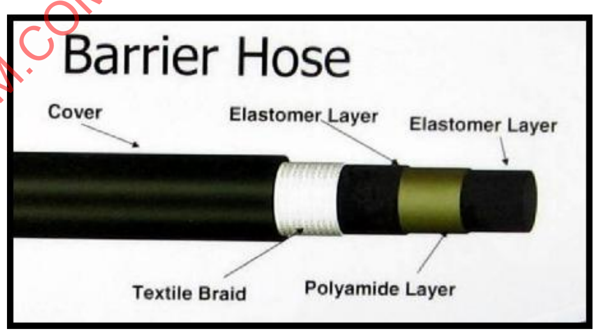


Figure 4

7.2.2 Fittings

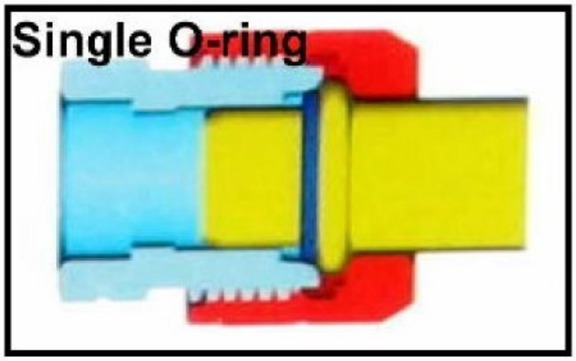


Figure 5

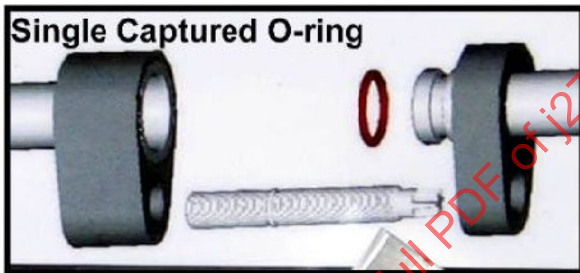


Figure 6

Figure 7

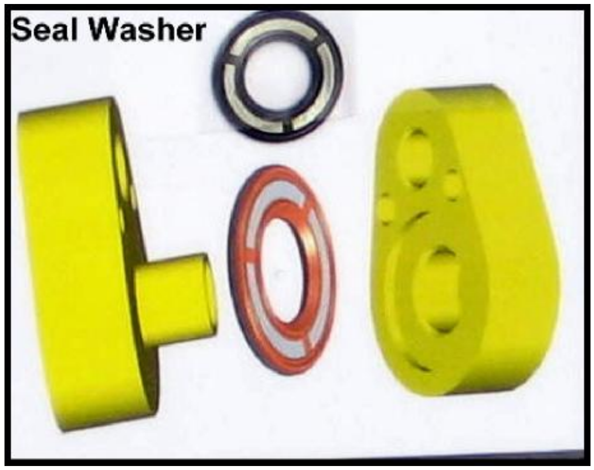


Figure 8

Figure 9

Figure 10 - Seal washer

Figure 11 - Metal seal fitting (metal gasket)

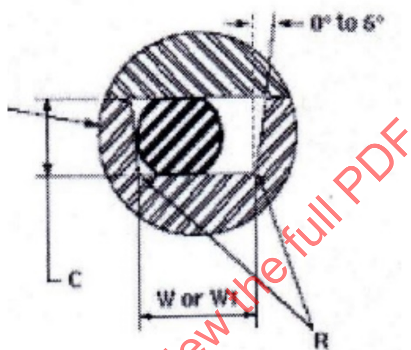


Figure 12 - Axial O-ring seal

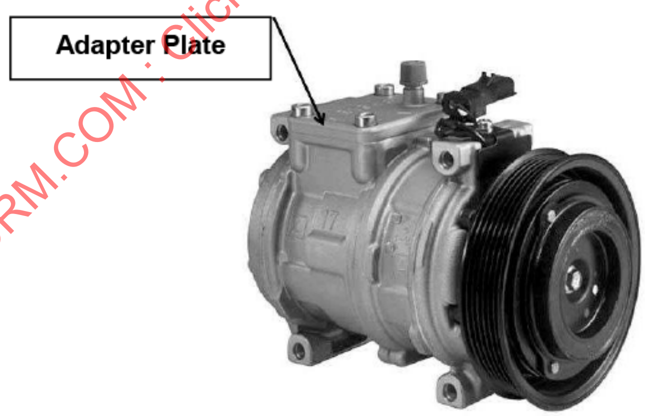


Figure 13 - Compressor adapter plate

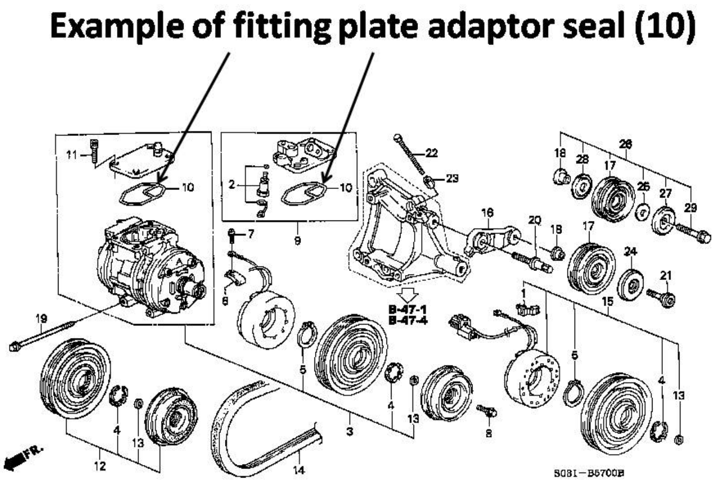


Figure 14 - Adaptor plate seal

7.2.3 Compressor Lip Seals

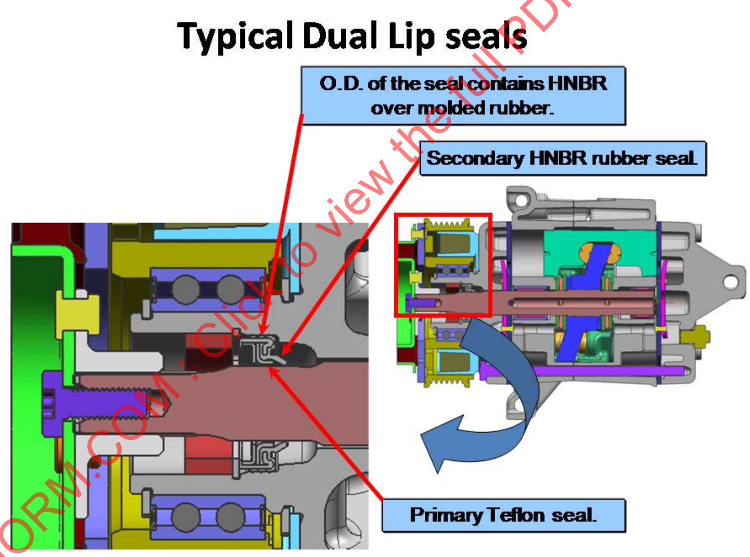


Figure 15 - Compressor shaft sealing

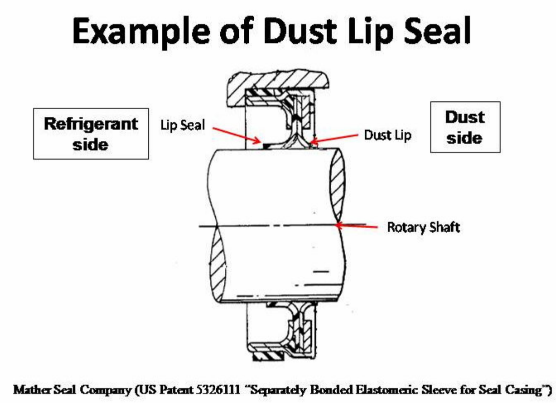


Figure 16 - Shaft sealing

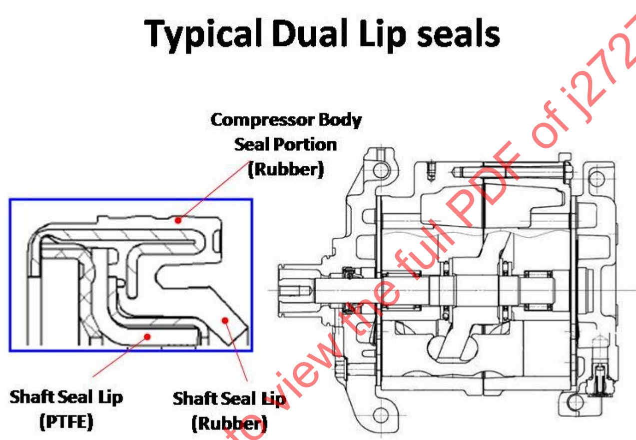


Figure 17 - Shaft sealing

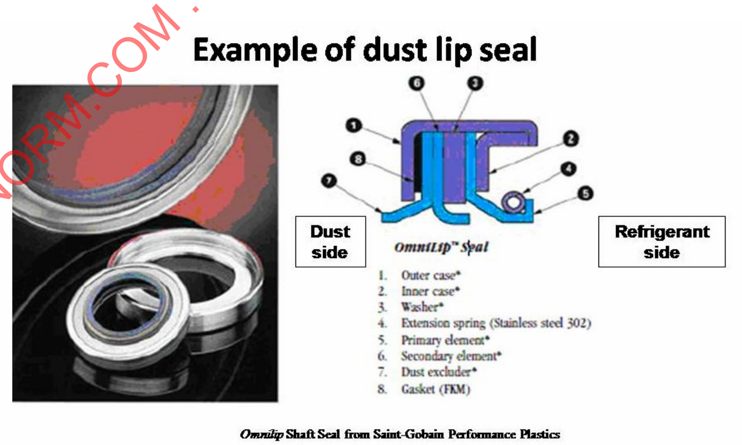


Figure 18 - Shaft sealing

7.2.4 Compressor Housing Seals

Example of gasket housing gaskets
(Metal or metal over molded housing gaskets)

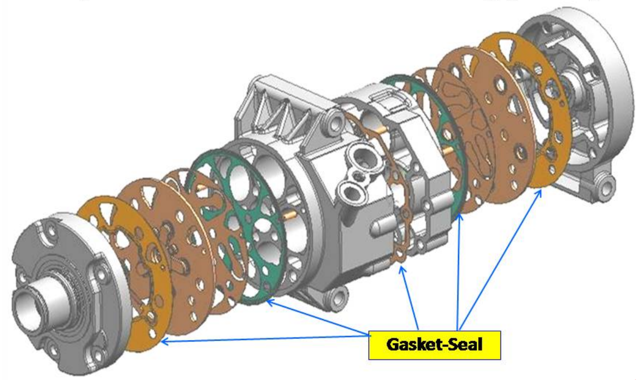


Figure 19 - Housing sealing

Examples of O-ring housing seal

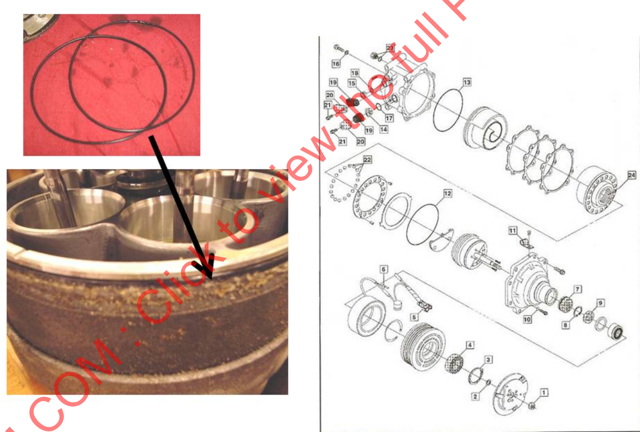


Figure 20 - Housing sealing

Example of molded compressor seals
(any custom molded elastomeric housing seal/gasket)

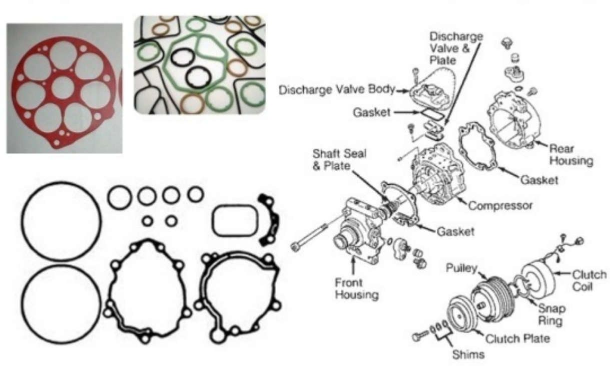
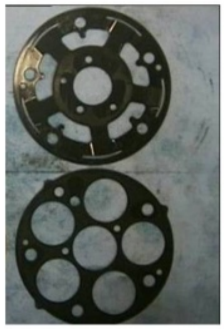


Figure 21 - Housing sealing

Additional examples of gasket housing gasket
(Metal or metal over molded housing gasket)



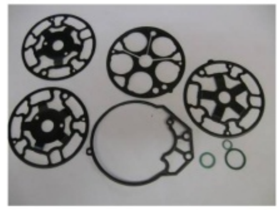


Figure 22 - Housing sealing

8. NOTES

8.1 Additional Compressor Seal Definitions

8.1.1 Compressor assembly bolts, where the bolt and casting mating surfaces are machined, are considered to act as metal-to-metal gaskets and are assumed to have insignificant emissions. Any other type of seal should be included in the system joints section.

8.1.2 A housing seal is defined as the seal between castings that separates internal refrigerant pressure from the atmosphere, i.e., refrigerant pressure on one side of the seal and the atmosphere on the other.

8.1.3 The compressor shaft seal is defined as the entire lip seal assembly, including the assembly-to-housing seal. Thus, for the lip seal assembly, only the number of lips in contact with the shaft must be identified in the spreadsheet.

8.2 Revision Indicator

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 INTERIOR CLIMATE CONTROL STANDARDS COMMITTEE

APPENDIX A - RATIONALE FOR MODIFYING A/C HOSE PERMEATION FROM 2008 DEFAULT VALUES TO UTILIZING ACTUAL SAE J2064 PERMEATION RATES

Three classes of hoses (described below) are defined in SAE J2727 (2008). The classes are based on materials and construction and permeation rates measured according to SAE J2064 at 80 °C.

- All rubber hose: Hose without a barrier layer having a maximum permeation rate of 15 kg/m^2/year at 80 °C.

- Standard barrier or veneer hose: Hose, with a barrier layer (typically nylon), having a maximum permeation rate of 5.0 kg/m^2/year at 80 °C.

- Ultra-low permeation barrier or veneer hose: Hose, with a barrier layer (typically nylon), having a maximum permeation rate of 1.5 kg/m^2/year at 80 °C.

Hoses within each classification can exhibit permeation rates well below the maximum for their class up to the maximum, thus allowing for a rather broad range of outcomes, e.g., hoses falling in the Standard Barrier Hose Class could have a range from 1.51 to 5.0 kg/m^2/year.

The SAE J2727 (2008) permeation factors were based on lab and field data for hoses typically used in the industry during that time period. Those hoses had average permeation rates in kg/m^2/year at 80 °C per SAE J2064, as reported by several hose manufacturers, as follows:

- All rubber hose: Average 8.05.

- Standard barrier or veneer hose: Average 2.00.

- Ultra-low barrier or veneer hose: Average 0.85.

These average rates are significantly lower than the maximum permitted in each class per SAE J2064. Thus, to effectively use SAE J2064 permeation data, new correlations were needed.

The goal was to develop new correlation factors instead of class default correlation factors that would allow the use of actual SAE J2064 permeation data and be in full accord with emissions that formed the basis of the 2008 default correlation factors.

For loss rate calculations, the SAE J2727 (2008) factor is multiplied by the hose internal surface area (mm^2) and then divided by 100, then multiplied by 0.522 (field data correlation factor).

$$(\text{area})\ (\text{factor}/100)\ (0.522) = \text{loss rate (g/year)}$$

Since the area and 0.522 remain constant, the new correlation factor must closely approximate the 2008 (factor/100) to provide emissions equivalent to the 2008 spreadsheet (i.e., predict the same emissions for the same vehicles as SAE J2727 (2008)).

APPENDIX B - COMPARISON OF CORRELATION FACTORS

Hose Class High Side	**Permeation Rate kg/m^2/year at 80 °C**	**Multiplier**	**SAE J2727 (2012) Factor**	**SAE J2727 (2008) Factor/100**
All Rubber	8.05	2.68×10^{-5}	0.000216	0.000216
Standard Barrier and Veneer	2.00	2.68×10^{-5}	0.000054	0.000054
Ultra-Low Perm Barrier or Veneer	0.85	2.68×10^{-5}	0.0000228	0.0000225
Hose Class Low Side	**Permeation Rate kg/m^2/year at 80 °C**	**Multiplier**	**SAE J2727 (2012) Factor**	**SAE J2727 (2008) Factor/100**
All Rubber	8.05	1.79×10^{-5}	0.000144	0.000144
Standard Barrier and Veneer	2.00	1.79×10^{-5}	0.000036	0.000036
Ultra-Low Perm Barrier or Veneer	0.85	1.79×10^{-5}	0.0000152	0.0000167

SAE J2727 (2012) predicts refrigerant emissions equivalent to SAE J2727 (2008).

Vehicle	**SAE J2727 (2008)**	**SAE J2727 (2012)**
GM-W	1.513	1.511
Corolla	2.374	2.372
VW	2.775	2.731
Odyssey	2.690	2.688
D-C Minivan	0.653	0.649
F-150	0.832	0.827

Result: Excellent agreement; within 4/100 of a gram per year.

APPENDIX C - SPREADSHEET EMISSION RATE FORMULAS

C.1 SPREADSHEET INFORMATION AND FORMULAS FOR R-134A REFRIGERANT SYSTEMS

NOTE: Each line in the chart is separately accounted for below. Wording to be included in each cell is shown in quotation marks after the cell coordinates, e.g., B6 "Single O-Ring."

	A	B	C	D	E	F	G	H	I
4	**Enter data only in cells of this color**							**Calculated Emissions**	
5	**System Joints (a.k.a. Fittings & Connections)**								
6	**EACH & EVERY JOINT Used to Attach Components to the A/C System MUST be Accounted for in either Row 8 or Row 9**	**Single Radial O-ring**	**Single Captured O-ring / Single Axial O-ring / Molded Seal**	**Multiple O-ring**	**Seal Washer**	**Dual Seal Washer / Seal Washer with O-ring**	**Metal Gasket**		**Joints are those sealing technologies separating the refrigerant from the atmosphere**
7	**Relative Emission Value**	**1.250**	**0.750**	**0.500**	**0.100**	**0.050**	**0.010**		
8	**Insert Total Number of Joint Types E6, F6, and G6. Also enter the Total Number of Joints B6, C6, and D6 *NOT* Helium Leak Checked After Component Sub-Assembly**							0.00	**Joints NOT Helium Leak Tested After Assembly**
9	**Joint Types B6, C6, and D6 That Are Helium Leak Checked After Component Sub-Assembly Are Considered Equivalent to Seal Washers. List The Total Number of Such Seals only in E9**							0.00	**Joints that ARE Helium Leak Tested After Component Sub-Assembly. Note: To use this cell, 100% of all joints must be so tested.**
10						**Connections Total**		**0.00**	

C.2 FITTINGS AND CONNECTIONS

C.2.1 Line 6, A6 "Each and Every Joint Used to Attach Components to the A/C System MUST be Accounted for in Either Rows 8 or 9."

C.2.2 Line 6 lists different sealing technologies, i.e.,

	B	C	D	E	F	G
6	Single radial O-ring	Single captured O-ring/ single axial O-ring/ molded seal	Multiple O-ring	Seal washer	Dual seal washer/ seal washer with O-ring	Metal gasket

Line 6, I6 "Joints are those sealing technologies separating the refrigerant from the atmosphere."

C.2.3 Line 7, A7 "Relative Emission Value" Columns 7B to 7G contain the values, i.e.,

	B	C	D	E	F	G
7	1.250	0.750	0.500	0.100	0.050	0.010

C.2.4 Line 8, A8 "Insert Total Number of Joint Types E6, F6, and G6. Also enter the Total Number of Joints B6, C6, and D6 NOT Helium Leak Checked After Component Sub-Assembly."

List appropriate number in cells 8B through 8G.

Equation for H8 = (B7*B8+C7*C8+D7*D8+E7*E8+F7*F8 +G7* G8)*0.522

I8 "Joints NOT Helium Leak Tested After Assembly."

C.2.5 Line 9, A9 "Joint Types B6, C6, and D6 That Are Helium Leak Checked After Component Sub-Assembly Are Considered Equivalent to Seal Washers. List the Total Number of Such Seals only in E9."

E9 is a stippled cell to denote helium leak tested connections.

Equation for H9 = (E7*E9)*0.522

I9 "Joints Helium Leak Tested After Assembly. NOTE: To use this cell for helium leak testing after assembly, 100% of all joints for which the credit is claimed must be so tested."

C.2.6 Line 10, F10-G10 "Connections Total."

Equation for H10 = SUM(H8,H9)

C.3 LINE 11, A11-G11 "DEVICES WITH OTHER EMISSION PATHS" I11 "DEVICES WITH EMISSION PATHS OTHER THAN AT THE CONNECTING JOINT, E.G., THRU THE VALVE CORE AND CAP OF A SERVICE PORT."

	A	B	C	D	E	F	G	H	I
11	**Devices with Other Emission Paths**								Devices with emission paths other than at the connecting joint, e.g. thru the valve core and cap of a service port
12	**Service Ports** (non-joint emissions)		High Side		Low-Side				Note: List all sealing connections to the atmosphere in Line 8 or 9
13		Insert number of service valves		Insert number of service valves				0.00	Note: If a two piece core is used with an internal o-ring, this o-ring must be included in row 8 or 9 above.
14	**Line-mounted PRV, Switches, Transducers** (non-joint emissions)		Located on High Side		Located on Low-Side				
15		number of devices						0.00	Note: List all sealing connections to the atmosphere in Line 8 or 9
16	**Thermal Expansion Device Refrigerant Control** (non-joint emissions)								Note: ALL four connections for a block style thermal expansion valve [TXV] need to be accounted for in rows 8 and 9 above!
17		number of devices						0.00	Note: List all sealing connections to the atmosphere in Line 8 or 9
18	**Compressor Mounted Devices** (non-joint emissions)		PRV, Control Valve, Switches						
19		number of devices						0.00	Note: List all sealing connections to the atmosphere in Line 8 or 9
20						Other Emission Paths Total		0.00	

C.3.1 Line 12, A12 "Service Ports (non-joint emissions)"; C12 "High Side"; E12 "Low Side"; I12 "Note: List all sealing connections to the atmosphere in Line 8 or 9."

C.3.2 Line 13, B13 "Insert number of service valves"; D13 "Insert number of service valves."

Equation for H13 = (SUM(C13*0.3)+SUM(E13*0.2))*0.522

I13 "Note: If a two piece core is used with an internal O-ring, this O-ring must be included in Rows 8 or 9 above."

C.3.3 Line 14, A14 "Line-mounted PRV, Switches, Transducers (non-joint emissions)"; C14 "Located on High Side."

E14 "Located on Low Side"

C.3.4 Line 15, B15 "number of devices."

Equation for H15 = (SUM(C15*0.3)+SUM(E15*0.2))*0.522

I15 "Note: List all sealing connections to the atmosphere in Line 8 or 9."

C.3.5 Line 16, A16 "Thermal Expansion Device Refrigerant Control (non-joint emissions)"; I16 "Note: ALL four connections for a block style thermal expansion valve [TXV] need to be accounted for in Rows 8 and 9 above!"