



SURFACE VEHICLE STANDARD

J2727™

SEP2023

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Superseding J2727 NOV2020

Mobile Air Conditioning System Refrigerant Emissions Estimate for Mobile Air Conditioning Refrigerants

RATIONALE

This revision added the description of a schematic that identifies the air conditioning system components and refrigerant joint design content related to the emissions estimate. This schematic is required for compliance with some regulatory reporting requirements. In addition, a description of a serial production helium leak test (HLT) leak test was added. The scope was updated for non-applicable refrigerants. An option was added for fully hermetic compressors and the method to characterize new fitting technologies was added. Also, the standard and the associated Excel emissions estimate template were updated to make each adaptable to applicable mobile refrigerants without further update to this standard.

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. Fully hermetic compressors contain the working electric compressor within a welded housing that allows little if any typical emissions and the emission value for this type of compressor is added as low, fixed value. 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.

This estimate does not apply to systems that use sealing technology that has not been characterized and included in the spreadsheet calculation, such as R-744 sealing designs.

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For more information on this standard, visit

https://www.sae.org/standards/content/J2727_202309/

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

SAE J2842 R-1234yf and R744 Design Criteria and Certification for OEM Mobile Air Conditioning Evaporator and Service Replacements

Yu, Y. and Clodic, D. (2007). Measurement of leak flow rates of mobile air conditioning (MAC) components—how to reach a generic approach (Paper no. 2007-01-1186). *SAE International*. <https://doi.org/10.4271/2007-01-1186>

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.
- 3.2.3 Seal design technology not currently part of this standard can be included in the emission assessment of this standard once they are properly characterized for their typical emissions using the methodology of SAE J2763. The entity that desires a new sealing technology be included should contact a testing laboratory that is certified to conduct an SAE J2763 evaluation and report the results. This data can then be submitted to the OEM committee for review and consideration for inclusion in an emissions estimate.

3.3 Devices with Other (Non-Joint) Emission Paths

The assumption is that all of these devices are helium leak tested with helium or other acceptable leak detecting tracer gas prior to assembly in the vehicle. A HLT is a process, applied to 100% of series production parts, that checks each part for leak tightness integrity. A detailed method for setting HLT limits on leak rates is described in SAE J2842 for evaporators. Other components will need to follow a similar method to establish leak test limits. For this standard, simple description of the HLT process is included for reference only:

- Production part is connected to a line set at its normal production interface connection. This connection seals to the part as it would be sealed in its vehicle installed condition and covers both the inlet and outlet of the part.
- Part is then inserted into a sealed chamber and a vacuum is pulled on both the part and the chamber to remove residual air.
- Part is then exposed to a “proof pressure” typically equal to the maximum operating pressure for that part, typically with a gas such as nitrogen (N), then a vacuum is again pulled on the part, removing the gas.
- Part is then exposed to helium (He) gas at a pressure designed to induce, over a given time of exposure, a leak at a targeted leak rate such that, if that leak rate is sensed by monitoring the He concentration, the part will be rejected. If the monitored He concentration is below the target value, the part is “passed” indicating part integrity. Helium is then removed from the parts.
- Part is removed from the chamber, permanently marked as “passed” or “failed” for the He leak test and the part is then handled appropriately in the production part process flow.

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 ($\text{kg}/\text{m}^2/\text{year}$) 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 Fully hermetic compressor are electrical compressors that have the operating compressor and motor fully contained inside a welded housing and thus has no typical sealing path for refrigerant emissions. In addition, the hermetic compressor must be helium (or equivalent tracer gas) tested as part of the regular production process. For this type of compressor, data and compressor leak specifications show typical emissions rates are low and are set for 0.5 g/year in the SAE J2727 Worksheet for Electric Compressor if the hermetic compressor option of "3" is selected in spreadsheet cell D40.
- 3.6.5 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.
- 3.6.6 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 leaks tested by helium-mass spectrometry following assembly are to be listed in the compressor body section.
- 3.6.7 Compressor sealing surfaces to be accounted for in this section are:
- 3.6.7.1 Number of lips on the shaft seal.
- 3.6.7.2 Number of O-ring housing seals.
- 3.6.7.3 Number of molded housing seals; O-ring material molded into a specific shape.
- 3.6.7.4 Number of gasket housing seals fitting.
- 3.6.7.5 Adaptor plate (e.g., European style), unless not helium leak tested and listed in the system joints section.
- 3.6.8 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."
- 3.6.8.1 For compressors that are not helium leak tested:
- 3.6.8.1.1 All compressor seal types used shall be entered on Line 38 of the table and the number "2" in cell D40 shall remain unchanged.
- $$\text{Line H38} = (\text{B39/B38} + \text{C39} \cdot \text{C38} + \text{D39} \cdot \text{D38} + \text{E39} \cdot \text{E38} + \text{F39} \cdot \text{F38}) \cdot 0.522 \cdot \text{D40} \quad (\text{Eq. 1})$$
- 3.6.8.1.2 No entries shall be made on Line 9 for any compressor mounted devices. Such devices shall be accounted for on Line 8.

3.6.9 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.

3.6.10 See Section 9 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 that 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 EMISSIONS FOR REFRIGERANTS OTHER THAN R-134a

6.1 R-1234yf

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 such that estimates are consistent with past versions of this standard as they may be used for regulatory compliance. 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. For consistency with past versions of this standard and related regulatory submissions, R-134a and R-1234yf vapor pressure differences are ignored and R-134a emissions can be corrected to estimate those of R-1234yf 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 emissions. Using Equation 2 and the values in Table 1 for viscosities and molecular weights, the emissions rate (ER) ratio for R-1234yf is 1.03.

$$\text{ER ratio} = \frac{(\text{MolWt}_{\text{R-1234yf}})(\mu_{\text{R-134a}})}{(\text{MolWt}_{\text{R-134a}})(\mu_{\text{R-1234yf}})} |_{\text{Tconstant}} \quad (\text{Eq. 2})$$

Table 1 - Viscosity and molar mass of the refrigerants

Refrigerant	Dynamic Viscosity at 15 °C μin Pa x s	Molecular Weight MoWt in kg/kmol
R-134a	11.1 x 10 ⁻⁶	102
R-1234yf	12.0 x 10 ⁻⁶	114

6.2 Refrigerants Other Than R-1234yf

For refrigerants other than R-1234yf, as described in 6.1, which is not included in this section to maintain consistency with past emissions estimates and any associated regulatory related submissions, estimates of the refrigerant emissions for applicable mobile refrigerants are based on the estimate for R-134a corrected by an emissions rate (ER) ratio per the rationale described below. If the refrigerant is a blend, the user is responsible for defining the appropriate input values of the nominal blend concentration recognizing selective permeation may be a consideration.

For R-744, this standard is not currently set up to evaluate the system emissions. This is because the type of fittings used in R-744 systems have not been characterized and, thus, the values resulting from this version of the worksheet will not be representative of the typical R-744 system emissions.

In determining the ER ratio and with the exception of hose permeation, refrigerant leakage is assumed to be laminar flow through channels of small diameter. This leakage can be estimated using the Hagen-Poiseuille equation (also known as Poiseuille's Law) as described in Yu and Clodic (2007). Assuming that the vapor density of refrigerant follows the ideal gas law and that the leakage is under isothermal conditions (constant dynamic viscosity), the Hagen-Poiseuille equation can be written relating mass flow to pressure difference, viscosity, temperature, and molar mass.

$$\dot{m} = \frac{\pi r^4}{8\mu} \int_0^L -\rho \frac{dP}{dz} \quad (\text{Eq. 3})$$

$$\dot{m} = \frac{\pi r^4 M}{8\mu RT} \int_0^L -P \frac{dP}{dz} \quad (\text{Eq. 4})$$

$$\dot{m} = \frac{\pi r^4 M (P_{in}^2 - P_{out}^2)}{16\mu LRT} \quad (\text{Eq. 5})$$

where:

$\dot{m}$ = mass flow rate [kg/s]

r = equivalent leak path radius [m]

ρ = density [kg/m³]

μ = dynamic (absolute) viscosity [Pa-s]

L = effective leak path length [m]

M = molar mass [kg/kmol]

R = universal gas constant = 8.3145 [kJ/kmolK]

T = temperature [K]

P_{in} = inlet pressure [Pa A]

P_{out} = outlet pressure [Pa A]

For a given temperature and assuming P_{in} is equivalent to P_{sat} of the refrigerant and that P_{out} is equal to $P_{amb} = 101.325$ kPa, this relationship is used to convert emission rates of the non-hose sources from R-134a to the refrigerant under consideration, R-x. This emissions rate ratio (ER_{ratio}) is shown in Equation 6.

$$ER_{ratio} = \frac{\dot{m}_{R-x}}{\dot{m}_{R-134a}} = \left(\frac{M_{R-x}}{M_{R-134a}} \right) \left(\frac{\mu_{R-134a}}{\mu_{R-x}} \right) \left(\frac{(P_{sat-R-x}^2 - P_{amb}^2)}{(P_{sat-R-134a}^2 - P_{amb}^2)} \right) | T = \text{Constant} \quad (\text{Eq. 6})$$

An average exposure temperature of MAC systems is selected to be 15 °C. This temperature is based on the weighting of 5 months of usage at the I-MAC mini-shed testing average temperature of 31 °C and 7 months of non-use at an average temperature of 5 °C. As an example, at this temperature, the emissions rate ratio is 0.60 for R-152a. The property values used to evaluate the R-152a emissions rate ratios (ER_{ratio}) are listed in Table 2.

Table 2 - Viscosity and molar mass of selected refrigerants

	Molar Mass - M kg/kmol	P_{sat} at 15 °C kPa A	P_{amb} kPa A	Dynamic Visc - μ Pa-s	LR_{ratio} ---
R-134a	102	488	101	11.3×10^{-6}	
R-152a	66	439	101	9.7×10^{-6}	0.60

The contribution of A/C hose assembly emissions is accounted for by requiring the measurement of refrigerant permeation per SAE J2064 for the specific refrigerant. Hence, to convert the R-134a chart emissions for other mobile refrigerants, the above ER_{ratio} conversion factor for the refrigerant under consideration is applied to all emissions except hose emissions, followed by adding the applicable hose emissions.

7. SCHEMATIC AND DESCRIPTION OF REFRIGERANT LINE SET DESIGN

For emissions estimate reports that require detailed definition of the design content of the air conditioning system components and joints, there are two sample schematics that include details on how the component and joint content information is documented. These example schematics are included in the Emissions Calculation Workbook under a separate tab labeled "Schematic Example." The entity completing the emissions estimate for submission to a regulatory body should create a schematic which includes information consistent with one of the examples shown in the sample. The completed schematic can either be embedded in the cell shown (C50) or it can be inserted in the spreadsheet tab labeled "Ref. Schematic."

8. EMISSIONS CALCULATION WORKBOOK

A workbook template is included with this document. This workbook template consists of an example and instructions sheet and two different emission chart calculation sheets (Belt Driven Compressor, Electric Compressor). For both sheets, inputs for the type of refrigerant and its associated saturation pressure and dynamic viscosity at 15 °C along with the molecular weight (MW). Note that the pressure correction for R-1234yf is ignored to maintain backward consistency for regulatory compliance. The example and instructions worksheet are shown in Figure 1 and the formulas for developing the calculation spreadsheets, including assigned values and assumptions, are listed in Appendix C.

8.1 Example and Instructions Worksheet, Figure 1

Identify model year, program, powertrain, single or Dual, etc. Also identify date when sheet is completed. Data values for example only.

SAE J2727 GENERIC TEMPLATE For Mobile Refrigerant System using Refrigerant R-152a

Model: 17MY Awesomemobile 2.0L Turbo
Date: December 6, 2022

Duplicate as needed, one sheet per unique powertrain or system design.

Leakage Chart for Systems with Belt-Driven Compressors

Enter data only in cells of this color

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 O-ring
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

Relative Emission Value

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

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

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.

Comments Total

Devices with Other Emission Paths

Service Ports (non-joint emissions)

High Side

Low-Side

Line-mounted PRV, Switches, Transducers (non-joint emissions)

Transducer

Thermal Expansion Device Refrigerant Control (non-joint emissions)

Description of applicable devices required

Compressor Mounted Devices (non-joint emissions)

PRV, ECV

Other Emission Paths Total

Permeation Rate Unit = Kg/m²/Year

Use Only Exposed Length of Hose Between Crimps. Coupling emission is accounted for in this calculation

Enter length to the nearest millimeter

Enter diameter to the nearest tenth of mm.

Heat Exchangers (HX's)

Number of Heat Exchangers

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

HX Total

Compressor Body

Exclusive of Attached Devices

123456-86 Compressor

Number of tips on shaft seal

Number of O-Ring Housing Seals

Type of Seal

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

Note: 100% of compressors must be Helium Leak Tested: If NOT, emissions are doubled. If the compressor is hermetically sealed, the emissions value is 0.5g/yr.

Relative Emission Value

If Compressors ARE Helium Leak Tested, change the number in Cell D40 from 2 to 1. If compressor is hermetic type, enter 3.

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

Must be changed from a 2 to a 1 for 100% leak testing. Cell =3 if compress is hermetic

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

A special hermetically sealed electric compressor type is available under the Electric Compressor tab. To be hermetic, the operating compressor must be contained in a welded housing and be 100% mass spec. leak tested in production.

Summary

	% Contribution	grams/year
System Joints (Connections)	11.1%	0.7
Non-Joint Related Emissions	7.1%	0.4
Flexible Hoses	4.9%	0.3
Heat Exchangers	3.8%	0.2
Compressor Body	73.2%	4.6
Total	100.0%	6.2

System Layout

Approximate Total System Refrigerant Emission Grams/Year

6.2

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

One option for including the line set schematic is to embed a pdf in this cell. Or the schematic can be included in the separate tab labelled "Reference Schematic" in the Workbook.

% System Component Contribution

Compressor Body 73%
System Joints (Connections) 11%
Heat Exchangers 4%
Non-Joint Related Emissions 7%
Flexible Hoses 5%

Figure 1

8.2 Reference Component Illustrations

8.2.1 Hose Construction



Figure 2



Figure 3

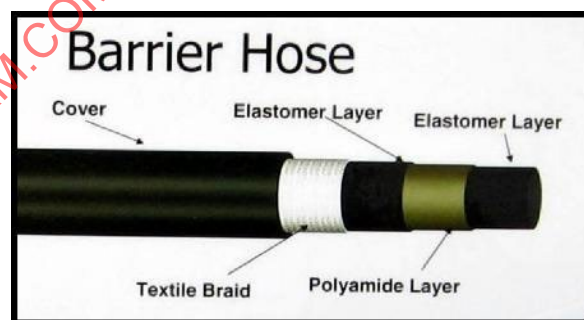


Figure 4

8.2.2 Fittings

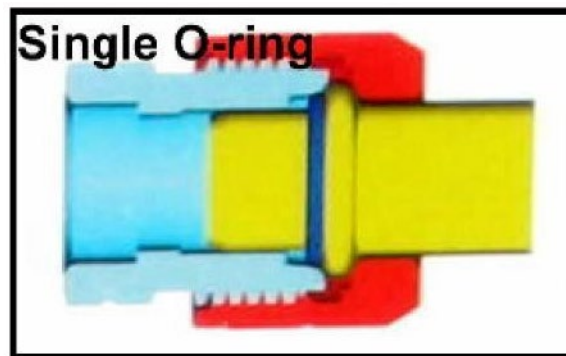


Figure 5

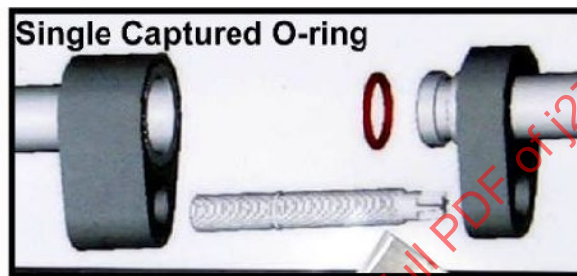


Figure 6



Figure 7

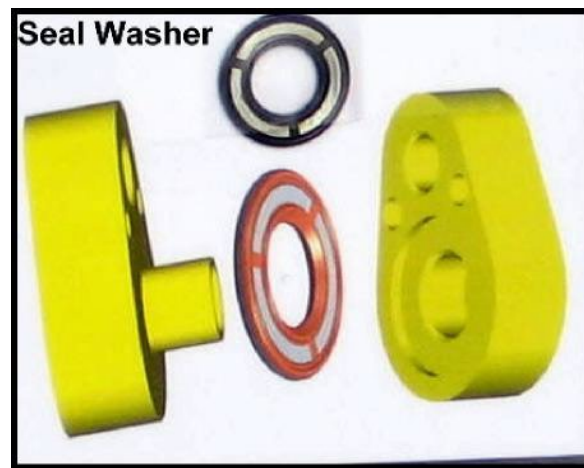


Figure 8



Figure 9



Figure 10 - Seal washer

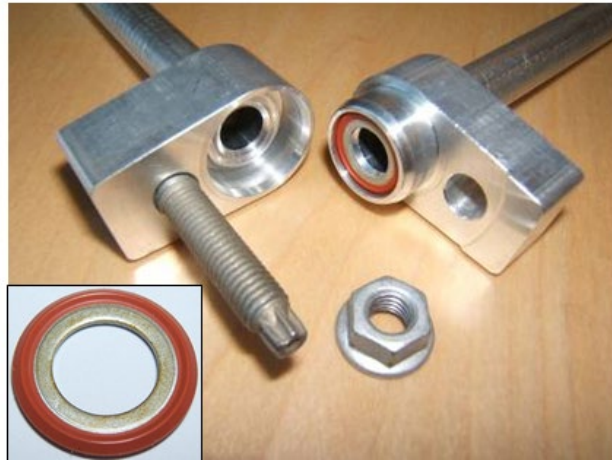


Figure 11 - Metal seal fitting (metal gasket)

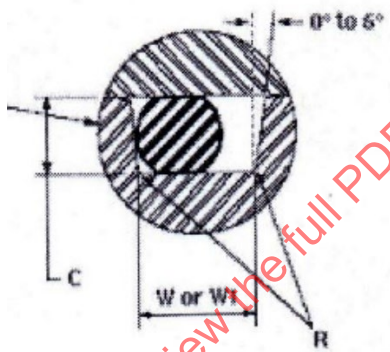


Figure 12 - Axial O-ring seal

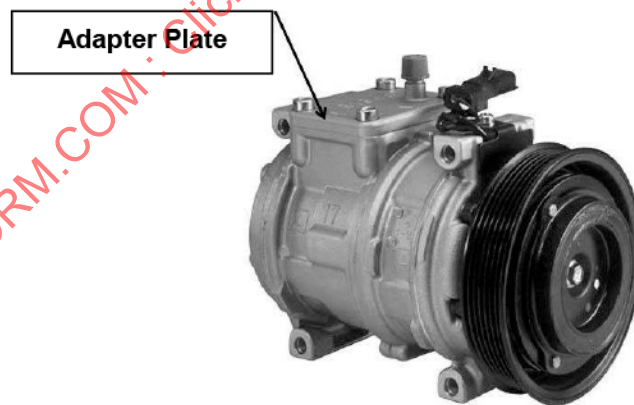


Figure 13 - Compressor adapter plate

Example of fitting plate adaptor seal (10)

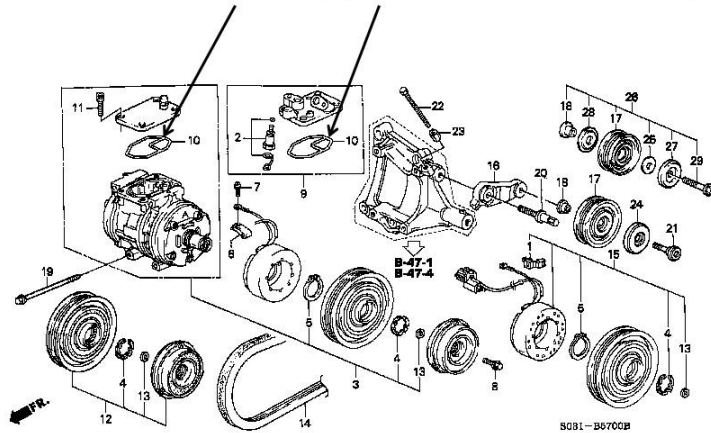


Figure 14 - Adaptor plate seal

8.2.3 Compressor Lip Seals

Typical Dual Lip seals

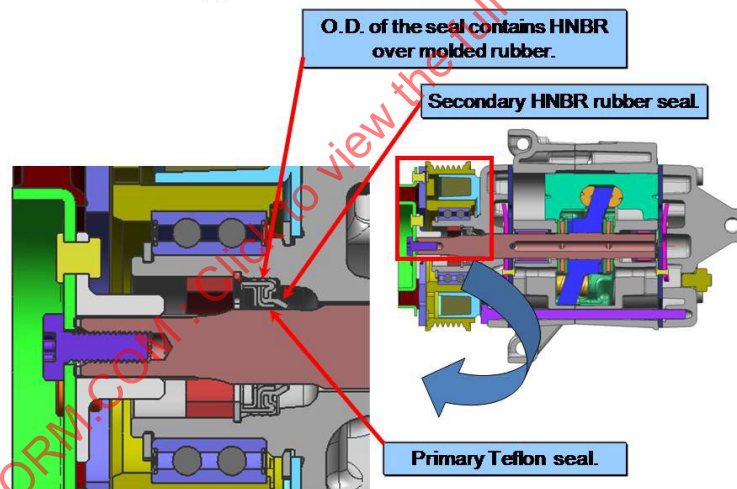
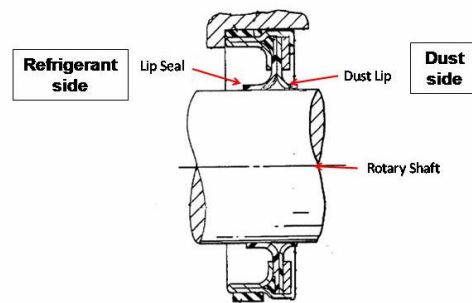


Figure 15 - Compressor shaft sealing

Example of Dust Lip Seal



Mather Seal Company (US Patent 5326111 "Separately Bonded Elastomeric Sleeve for Seal Casing")

Figure 16 - Shaft sealing

Typical Dual Lip seals

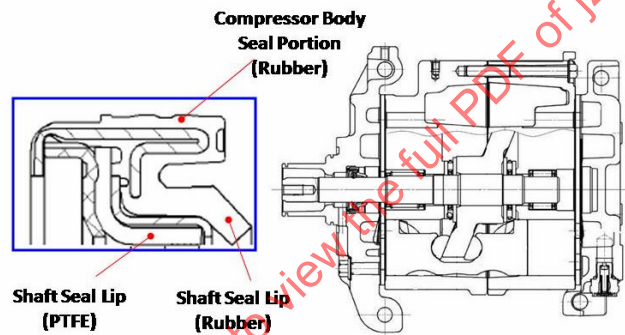
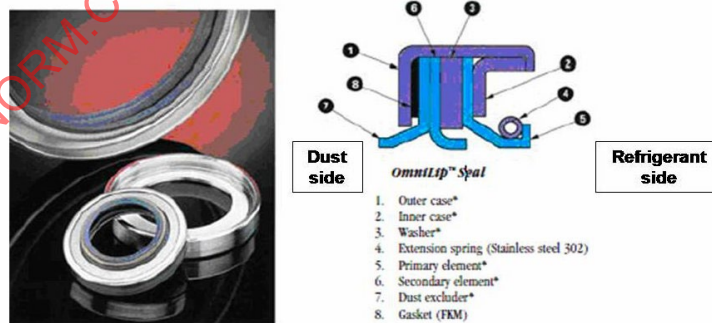


Figure 17 - Shaft sealing

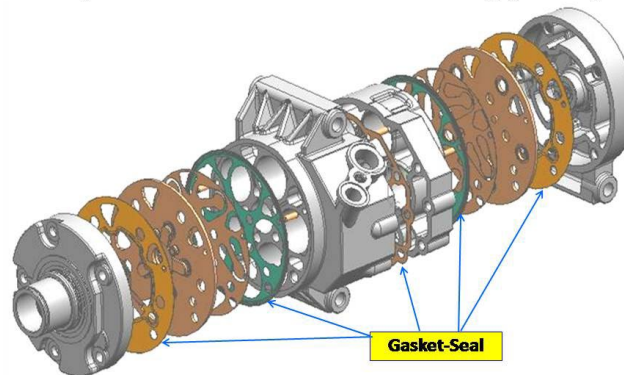
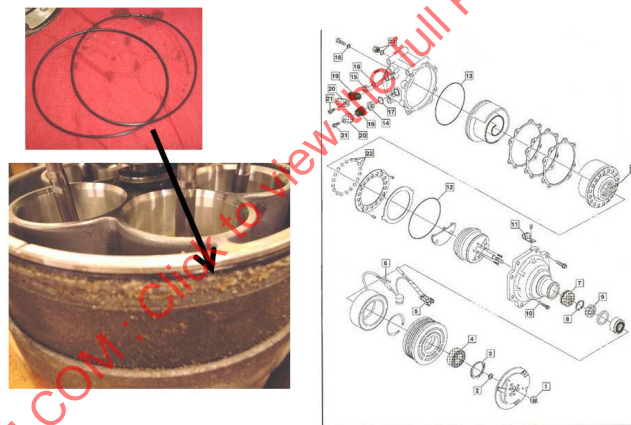
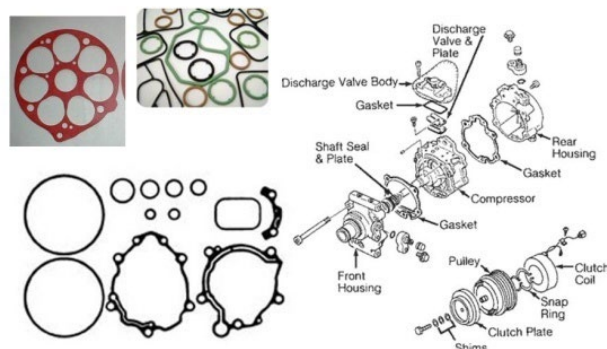
Example of dust lip seal



Omnitlip Shaft Seal from Saint-Gobain Performance Plastics

Figure 18 - Shaft sealing

8.2.4 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)**

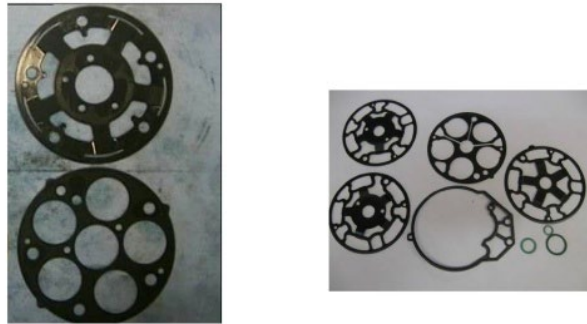


Figure 22 - Housing sealing

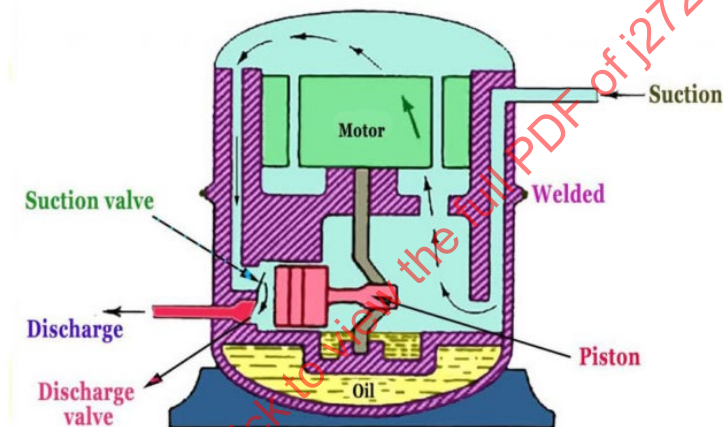


Figure 23 - Typical fully hermetic type compressor schematic

8.2.5 Additional Compressor Seal Definitions

- 8.2.5.1 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.
- 8.2.5.2 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.
- 8.2.5.3 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.

9. NOTES

9.1 Revision Indicator

A change bar (|) 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 SAE INTERIOR CLIMATE CONTROL VEHICLE OEM COMMITTEE

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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/m²/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/m²/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/m²/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/m²/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/m²/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 (mm²) and then divided by 100, then multiplied by 0.522 (field data correlation factor).

$$(\text{area}) (\text{factor}/100) (0.522) = \text{loss rate (g/year)} \quad (\text{Eq. A1})$$

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

Table B1

Hose Class High Side	Permeation Rate kg/m²/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/m²/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).

Table B2

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 g/year.