WORLDWIDE ENGINEERING STANDARDS	General Specification	GMW14319

Air Conditioning (A/C) Hose and Coupling Assemblies R134a and R1234yf

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

Note: Unless otherwise stated as gauge, pressures listed within this specification are absolute.

1.1 Scope. This specification establishes the minimum requirements for the Air Conditioning (A/C) Hose and Coupling assemblies intended for use in GM automotive air conditioning systems with liquid and gaseous refrigerant:

- R134a (GM Part Number 9985751 or equivalent).
- R1234yf (GM Part Number 9986319 or equivalent, see Global Product Description System/Area Parts Manager-(GPDS/APM)).
- Polyalkylene Glycol (PAG) compressor oil. (GM Part Number 9985752 or equivalent).
- Polyolester (POE) compressor oil. (GM US Part Number 88862657 or equivalent and GM Canada Part Number 88862658 or equivalent).

The functions, performance, reliability, qualification tests and shipping requirements for Air Conditioning (A/C) Hose and coupling assemblies are defined in this document.

1.2 Mission/Theme. Not applicable.

1.3 Classification. Not applicable.

1.4 Note. PAG and POE compressor oil formulations are unique to each A/C compressor manufacturer. In order to evaluate the entire spectrum of compressor oil formulations and refrigerants (R134a and R1234yf) used in GM vehicles, the A/C hose and coupling assembly Supplier shall perform the material compatibility tests with the compressor oil formulations and refrigerant type confirmed by the responsible GM Global Thermal Bill of Materials (BOM) Family Owner (BFO).

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

ASHRAE 97	ISO 48	ISO 1817	SAE J2064
ASTM D380	ISO 188	ISO 7111	
DIN 8905-1	ISO 815	ISO 11357	
ISO 37	ISO 1431-1	SAE J639	

2.2 GM Standards/Specifications.

9985751	GMW3172	GMW15272	GMW16331
9985752	GMW8758	GMW15760	
GMW3059	GMW14573	GMW15786	
GMW3116	GMW14872	GMW15862	

2.3 Additional References.

CG2987

GM1738

GM Part Number 9986319
GM Part Number 12346303
GM Part Number 52458086
GM Part Number 52458087
GM Part Number 52458090
GM US Part Number 88862657
GM Canada Part Number 88862658
Vehicle Technical Specification (VTS)

3 Requirements

All requirements of this standard must be met in order to demonstrate compliance with Design Validation (DV), Product Validation (PV) and In-Process evaluations.

3.1 System/Subsystem/Component/Part Definitions.

3.1.1 Hose. Element used in A/C systems to attenuate the forces resulted of relative movement between two moving components (e.g., engine and chassis). This element can also be used to attenuate some types of noise coming from moving sources (e.g., A/C compressor), and to help manufacturing assembly.

- **Normal Temperature Hose:** Hose used in A/C systems in low side pressure (between thermostatic expansion valve (TXV) or evaporator outlet and compressor inlet).
- **High Temperature Hose:** Hose used in A/C systems in high side pressure (between compressor outlet and TXV or orifice tube inlet).

There are three types of A/C Hoses covered by this standard:

3.1.1.1 Type A: Rubber (Low Noise Vibration Harshness (NVH)) Hose. Hose having a seamless rubber lining, and a reinforcement consisting of one or more plies of textile yarn adhered to the inner tube and outside cover. The outside rubber cover shall be heat and ozone resistant. See Figure 1.

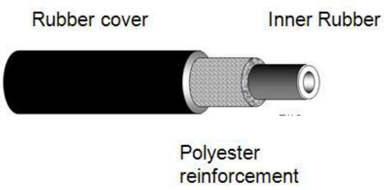


Figure 1: Rubber Type Hose

3.1.1.2 Type B: Standard Permeation (Barrier or Veneer) Hose. Hose having an inner thermoplastic barrier layer (veneer type hose) or an inner layer of rubber adhered to the thermoplastic barrier layer (barrier type hose), a rubber layer, and a reinforcement consisting of one or more plies of textile yarn adhered to the rubber layer underneath and to the outside rubber cover. The outside cover shall be heat and ozone resistant. See Figure 2.

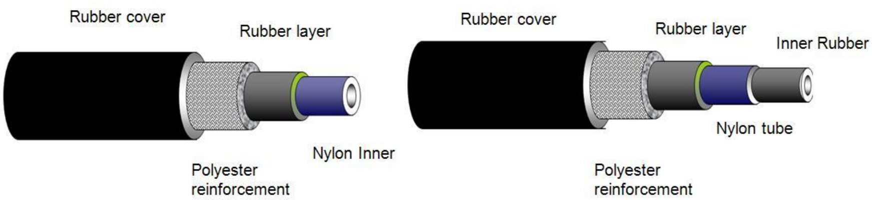


Figure 2: Standard Permeation Type Hose (Left: Veneer Type, Right Barrier Type)

3.1.1.3 Type C: Low Permeation (Barrier Layer) Hose. Hose having a thermoplastic barrier layer, a rubber layer, and a reinforcement consisting of one or more plies of textile yarn adhered to the rubber layer underneath and to the outside rubber cover. The outside cover shall be heat and ozone resistant. This hose shall have an inner layer of rubber adhered to the thermoplastic barrier layer. See Figure 3.

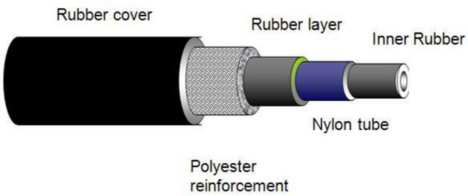


Figure 3: Low Permeation Type Hose

Coupling Assembly (Crimping): An element used in A/C systems to join a rubber hose with an aluminum line to improve flexibility and avoid failures due to stress added by A/C moving components.

Shell: Metal to maintain connection between hose and tube end form fitting.

3.1.2 Content.

3.1.2.1 Physical Content. An A/C hose and coupling assembly consists of an aluminum line crimped to an A/C hose. See Figure 4.

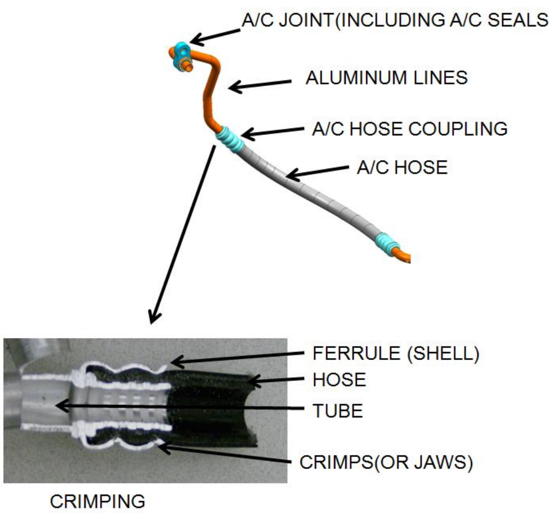


Figure 4: A/C Hose and Coupling Line

3.1.2.2 Functional Content. The A/C hose and coupling assembly must provide a connection interface between A/C plumbing hard lines and A/C flexible hoses.

3.1.3 Ambient Environment. The A/C hose and coupling assembly is expected to be fully functional under ambient conditions of:

- Ambient temperature: -40 °C to +130 °C for Normal Temperature hose and -40 °C to +140 °C for High Temperature hose.
- Relative Humidity (RH): 5% to 100%.

3.1.4 Interfaces. A/C hose and coupling assemblies interface with A/C hose, end form pipe and in few cases, with sleeve attachments such as plastic straps.

3.1.5 Usage Definition. Not applicable.

3.2 Product Characteristics.

3.2.1 Performance Requirements.

3.2.1.1 Dimensional. When evaluated per 4.3.1, minimum internal coupling diameter (B) at the end form fitting must meet Table 1. See Figure 5.

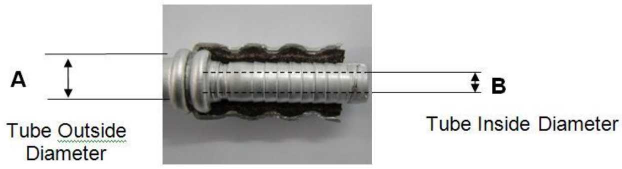


Figure 5: Coupling Construction

Table 1: Reduction in Cross Sectional Area in Coupled Hose

		A		B	
Hose Nominal Diameter	**DIN Specification**	**Tube Size (mm)**	**Tube Size (inches)**	**Minimum Internal Crimp Diameter for Type A (Rubber) Hose**	**Minimum Internal Crimp Diameter for Type B and Type C (Thermoplastic) Hose**
8 mm (5/16 in)	8905-1	8 × 1.00	3/8 × 0.039	Not applicable	4.2 mm (insert may be required to reach minimum diameter)
		10 × 1.00			
		10 × 1.25	3/8 × 0.049		
10 mm (13/32 in)	8905-1	12 × 1.25	1/2 × 0.049	Not applicable	6.1 mm (insert may be required to reach minimum diameter)
		12 × 1.65	1/2 × 0.065		
12.7 mm (1/2 in)	8905-1	12.7 × 1.25	1/2 × 0.049	Not applicable	8.6 mm (insert may be required to reach minimum diameter)
		12.7 × 1.65	1/2 × 0.065		
16 mm (5/8 in)	8905-1	16 × 1.49	5/8 × 0.057	11.2 mm (insert may be required to reach minimum diameter)	
		16 × 1.65	5/8 × 0.065		
		19 × 1.49	3/4 × 0.057	13.5 mm (insert may be required to reach minimum diameter)	
		19 × 1.65	3/4 × 0.065		
19 mm (3/4 in)	8905-1	19 × 1.65	3/4 × 0.057	14.0 mm (insert may be required to reach minimum diameter)	
		19 × 1.65	3/4 × 0.065		

3.2.1.2 Material. When tested per 4.3.2, material requirements for finished parts are summarized in Table 2a, Table 2b, and Table 2c.

Table 2a: Material Requirements for the Lining

Property	Value	Unit
Hardness	To be reported	International Rubber Hardness Degree (IRHD)
Elongation at Break	150 (minimum)	%
Tensile Strength	7 (minimum)	MPa
Stress at a Given Strain (100% Modulus)	3 (minimum)	MPa

Property	Value	Unit
Age Resistance (Heat Aging) Change in Hardness Change in Elongation at Break Change in Tensile Strength Change in Stress at a Given Strain	 ± 5 (maximum) -45 (maximum) -20 (maximum) +30 (maximum)	 IRHD % % %
Fluid Resistance Refrigerant: Primary Compressor Oil (PAG or POE Oil) = 90:10 Change in Hardness Change in Volume Change in Elongation at Break Change in Tensile Strength Change in Stress at a Given Strain	 ±15 (maximum) +10 (maximum) -45 (maximum) -30 (maximum) -20 (maximum)	 IRHD % % % %
Fluid Resistance Refrigerant: Primary Compressor Oil: Secondary Compressor Oil = 89:10:1 Change in Hardness Change in Volume Change in Elongation at Break Change in Tensile Strength Change in Stress at a Given Strain	 ±10 (maximum) +10 (maximum) -20 (maximum) -20 (maximum) -20 (maximum)	 IRHD % % % %
Thermogravimetric Analysis (TGA)	Must conform to released compound	
Glass Transition T_g (DSC)	-40 or lower	°C

DSC = Differential Scanning Calorimetric

Table 2b: Material Requirements for the Cover

Property	Value	Unit
Hardness	To be reported	International Rubber Hardness Degree (IRHD)
Elongation at Break	200 (minimum)	%
Tensile Strength	7 (minimum)	MPa
Stress at a Given Strain (Modulus) σ_{100}	3 (minimum)	MPa
Age Resistance (Heat Aging) Change in Elongation at Break Change in Tensile Strength	 -45 (maximum) at 72 hours or -65 at 500 hours -20 (maximum) at 72 hours or -35 at 500 hours	 % %
Ozone Resistance	No cracks permitted	
Thermogravimetric Analysis (TGA)	Must conform to released compound	
Glass Transition T_g (DSC)	-50 or lower	°C

DSC = Differential Scanning Calorimetric

Table 2c: Material Requirements for the Construction

Property	Value	Unit
Compression Set	-45 (maximum) for Normal Temperature Hose -55 (maximum) for High Temperature Hose	% %

3.2.1.3 Leakage. When tested per 4.3.3, the A/C hose and coupling assembly (including the two crimps) must not exceed a leak rate equivalent to 0.5 g/year of R134a or R1234yf refrigerant.

3.2.1.4 Bending Rigidity. When tested per 4.3.4, the maximum tensile force shall be the value shown in Table 3.

Table 3: Bending Rigidity

Nominal Diameter	Test Value
8 mm (5/16 in)	13.0 N (maximum)
10 mm (13/32 in)	15.0 N (maximum)
12.7 mm (1/2 in)	17.5 N (maximum)
16 mm (5/8 in)	20.0 N (maximum)
19 mm (3/4 in)	25.0 N (maximum)

3.2.1.5 Kink Resistance. When tested per 4.3.5, the difference between the hose nominal outer diameter (OD) and dimensions d_k and d_g shall not exceed the values shown in Table 4.

Table 4: Kink Resistance

Nominal Diameter	**OD - d_k** and **OD - d_g**
8 mm (5/16 in)	± 0.6 mm
10 mm (13/32 in)	± 0.8 mm
12.7 mm (1/2 in)	± 0.9 mm
16 mm (5/8 in)	± 1.75 mm
19 mm (3/4 in)	± 2.0 mm

3.2.1.6 Moisture. When tested per 4.3.6, free moisture must not exceed 0.10 g.

3.2.1.7 Crystallization, Low Temperature Embrittlement and Vacuum Flattening. When tested per 4.3.7, the A/C hose and coupling assembly must meet the following requirements:

3.2.1.7.1 Crystallization. (W1 - W2) - (W1' - W2') must be < 0.3 g.

3.2.1.7.2 Low Temperature Embrittlement. (W1 - W2) < 0.2 g.

No visible external degradation (such as cracking, delamination, etc.) is acceptable.

3.2.1.7.3 Vacuum Flattening.

a. The minimum diameter dimension shall not be less than 80% of the minimum hose outside diameter as measured in Section 4.3.7.3.1 in the U shape prior to the application of the vacuum.

b. The maximum permissible pressure increase is 0.8 mm Hg/minute.

c. Any visible signs cracking or degradation in the hose outer and/or inner surface are not permitted.

3.2.1.8 Tensile. When tested per 4.3.8, the hose samples with fittings shall meet the minimum tensile forces specified in Table 5.

Table 5: Tensile Test

Nominal Diameter	Hose Type	
	Type A (Rubber Hose)	Type B and Type C (Barrier Layer Hose)
	Minimum Tensile Force	
8 mm (5/16 in)	Not applicable	1500 N
10 mm (13/32 in)	Not applicable	2500 N
12.7 mm (1/2 in)	Not applicable	3000 N
16 mm (5/8 in)	2450 N	Not applicable
19 mm (3/4 in)	4500 N	Not applicable

3.2.1.9 Pressure. When tested per 4.3.9, there shall be no evidence of hydraulic fluid leakage from the crimp couplings or the body of the hose. Any signs of leakage constitute a nonconformance.

3.2.1.10 Decompression. When tested per 4.3.10:

a. Leakage rate must meet 3.2.1.3

b. No visible degradation of adhesion between hose layers.

c. No visible cracks.

3.2.1.11 Refrigerant Emissions.

3.2.1.11.1 Short Term Loss Rate. When tested per 4.3.11.1, the maximum permissible refrigerant loss must not exceed the values in Table 6.

Table 6: Refrigerant Short Term Loss Rate

Temperature	Hose Type		
	Type A Rubber Hose	Type B Barrier Hose Standard Permeation	Type C Barrier Hose Low Permeation
80 °C	3.0 kg/m^2/year	2.0 kg/m^2/year	0.8 kg/m^2/year
90 °C	Not applicable	3.0 kg/m^2/year	1.0 kg/m^2/year

3.2.1.11.2 Long Term Loss Rate. When tested per 4.3.11.7, the maximum permissible refrigerant loss must not exceed the values in Table 7.

Table 7: Refrigerant Long Term Loss Rate

Temperature	Hose Type		
	Type A Rubber Hose	Type B Barrier Hose Standard Permeation	Type C Barrier Hose Low Permeation
80 °C	10.0 kg/m^2/year	4.0 kg/m^2/year	1.5 kg/m^2/year
90 °C	Not applicable	10.0 kg/m^2/year	2.0 kg/m^2/year

3.2.1.11.3 Long Term Loss Rate (Alternate Method for R1234yf). When tested per 4.3.11.9, the maximum permissible refrigerant loss must not exceed the values in Table 8.

Table 8: Refrigerant Long Term Loss Rate

Temperature	Hose Type		
	Type A Rubber Hose	Type B Barrier Hose Standard Permeation	Type C Barrier Hose Low Permeation
90 °C	0.6 kg/m^2/year	0.36 kg/m^2/year	0.36 kg/m^2/year

3.2.1.12 Moisture Vapor ingression. When tested per 4.3.12, the hose must not ingress moisture at a rate greater than specified in Table 9.

Table 9: Moisture Ingress Rate

Hose Type		
Type A Rubber Hose	Type B Barrier Hose Standard Permeation	Type C Barrier Hose Low Permeation
0.011 g/cm^2/year	0.030 g/cm^2/year	0.030 g/cm^2/year

3.2.1.12.1 The pH of the condensate shall not be less than 6.0. The pH shall be measured immediately to prevent CO_2 from dissolving in the collected water.

3.2.1.12.2 No more than 50 ppm of chloride is allowed in the condensate.

3.2.1.13 Internal Cleanliness. When tested per 4.3.13, no more than 210 mg per square meter (internal surface area) of foreign material per assembly shall be retained by the filtration system, after drying to a constant weight. Size of the contaminants shall not exceed 0.2 mm in any dimension for contaminants with a Brinell Hardness < 95 and 0.05 mm in any dimension (maximum) with Hardness Brinell Hardness > 95.

3.2.1.14 Extractables. When tested per 4.3.14:

a. The extractable material obtained shall not exceed 12 mg/cm^2 of tube surface.

b. No green/blue flame shall appear when the wire and extracts are placed in the Bunsen burner flame.

3.2.1.15 Chemical Compatibility. When tested per 4.3.15, the extractable material shall not cause refrigerant or lubricant decomposition when compared to the control sample containing no extract.

3.2.1.15.1 The visual rating (visual rating for lubricant and metals are additive) shall not exceed a total rating of three (3), and the gas chromatographic analysis shall not show a total decomposition of more than 0.5%.

3.2.1.15.2 Visual Ratings.

- Lubricant:
  0. No change
  1. Slight darkening
  2. Moderate darkening
  3. Extreme darkening
  4. Black, lubricant deposits
- Metals (Fe, Cu, Al):
  0. No change
  1. Discoloration/Tarnish
  2. Slight Cu plating/corrosion
  3. Moderate Cu plating/corrosion
  4. Heavy Cu plating/corrosion, pitting
- Gas Chromatography (GC)

  Analyze for decomposition products of refrigerant/lubricant (volatiles).

  (e.g., R134a + PAG = Refrigerant Decomposition (A or B) + Hafnium element (HF) Measured amount via GC)

Note: An (A) following the numerical rating value indicates a clear solution, while a (B) indicates a cloudy solution.

3.2.1.16 Anion. When tested per 4.3.16, if the concentration of any anion is greater than 200 ppm, the supplier must demonstrate that it does not contribute to the acidity of the system.

3.2.1.17 Change in Length/Angle. When tested per 4.3.17, the length changes and angle deviations shall not exceed the values specified in Table 10.This is consistent with the SAE J2064 recommended practice. See Table 10.

Table 10: Length Change, Angle Deviation

Change in Length	Deviation of Angle
(-4/+2)%	5 degrees/m (maximum)

3.2.1.18 Delamination. When tested per 4.3.18:

a. There shall be no evidence of blisters or separation of the inner rubber material from the plastic layer.

b. The adhesion between the inner rubber material and the plastic shall not be compromised and should result in a **stock tear** or failure of one of the layers rather than a separation of these layers.

c. 22 Nm (5 lb) minimum for both cover and reinforcement.

3.2.1.19 Burst Strength. When tested per 4.3.19, the burst strength of the coupled hose assembly shall be a minimum of 8.6 MPa (1250 psi) at room temperature. This pressure exceeds industry recommended safety practices for proper A/C system design, (e.g., SAE J639). In case of a failure, loosening/separation of any parts is not allowed.

3.2.1.20 Pressure Cycling and Vibration.

3.2.1.20.1 Pressure Cycling. When tested per 4.3.20.1:

a. After completion of the of pressure cycle test, there shall be no evidence of leaks, hose distress or degradation, tube material fatigue, or tube weld fatigue.

b. For tensile test, the hose shall retain a minimum of 80% of the required tensile strength.

c. For burst test, follow Acceptance Criteria per 3.2.1.19.

d. Pressure Cycle test results must demonstrate the required reliability as stated in 3.2.3.2.

3.2.1.20.2 Vibration. When tested per 4.3.20.2:

3.2.1.20.2.1 Allowable leakage is 0.6 g. See Note in 3.3.1.1.2.2.

a. When attempting to rotate the hose around the metal tubing by hand, there shall be no such rotation or movement. If a slight movement (slippage) occurs, re-leak test to ensure a leak path was not created.

b. If the refrigerant weight (minus variation control sample weight loss) loss after 100 h of vibration exceeds the values listed in Table 11, the hose fails. See the Note in Section 1.4 for refrigerant type used.

c. There shall be no evidence of hose distress, wrinkles, or degradation, tube material fatigue or tube weld fatigue.

If any of the acceptance criteria are not met, the supplier must determine the root cause and resolve the nonconformance and rerun the entire test procedure.

Table 11: Maximum Refrigerant Weight Loss

Hose Size, Inner Diameter (ID)	Maximum Weight Loss After 100 h
8 mm (5/16 in)	2.6 g
10 mm (13/32 in)	3.4 g
16 mm (5/8 in)	5.3 g
19 mm (3/4 in)	6.3 g

3.2.1.21 Coupling integrity. When tested per 4.3.21:

a. Weight loss per canister (two couplings) must not exceed the requirements listed in Table 12.

b. All post-interval flexing evaluations shall not produce hissing or visible oil loss.

c. When attempting to rotate the hose by hand around the metal tubing, there shall be no such rotation.

d. If imperfections or cracks exist after the hose is examined externally, the hose fails. If a loose cover exists, the hose fails.

e. No imperfections must result from 4.3.21.

f. If the shell has any cracks, the hose assembly fails.

g. If the assembly leaks, return it to the coupler for root cause analysis.

Table 12: Maximum Refrigerant Weight Loss (Grams)

	8 mm and 10 mm (5/16 in and 13/32 in)	16 mm (5/8 in)	19 mm (3/4 in)
Intervals			
4	3	4.5	6
Consecutive			
All 8	4	6	8

3.2.1.21.1 When tested using hose lines assembly:

a. Refrigerant weight loss shall not exceed the values shown in Table 13.

b. There shall be no visible oil loss and no visible signs of hose material degradation.

c. Refrigerant leakage rates shall not exceed 1 g/year anywhere in the connector assemblies during any of the 4 bending tests following the exposure intervals.

d. The two (2) hose assemblies that were subjected to Pressure Test per 4.3.9 and Leakage per Section 4.3.3, shall meet all requirements of those evaluations.

e. The percent (%) of Crimp difference must be not more than 5% of initial measurement

Table 13: Refrigerant Weight Loss, Exposure
(See Note in Section 1.4 for refrigerant type)

Nominal Diameter	Permissible Refrigerant Loss	
	After 4th Interval	After 8th Interval
8 mm (5/16 in)	3.0 g (maximum)	4.0 g (maximum)
10 mm (13/32 in)	3.0 g (maximum)	4.0 g (maximum)
12.7 mm (1/2 in)	6.0 g (maximum)	6.0 g (maximum)
16 mm (5/8 in)	6.0 g (maximum)	8.0 g (maximum)
19 mm (3/4 in)	8.0 g (maximum)	10.0 g (maximum)

3.2.1.22 Noise and Vibration. When tested per 4.3.22, the ratio of output acceleration (A2) to input acceleration (A1) must be less than shown below:

Frequency	Ratio (A2/A1)
200 Hz	0.10 (maximum)
600 Hz	0.03 (maximum)
1000 Hz	0.01 (maximum)

3.2.1.23 Thermal Pressure Resistance of Hose Line with Connected Canister. When tested per 4.3.23, all of the following criteria must be met in order to demonstrate compliance:

a. After performing 4.3.23.10, refrigerant weight loss shall not exceed twice (2×) the value per Table 7.
   Note: Adjust refrigerant weight loss with material weight loss of the control sample.
b. After performing 4.3.23.11, no visible degradation or damage is permitted.
c. After performing 4.3.23.12, % of Crimp difference must be not more than 5% of initial measurement.
d. After performing 4.3.23.13, leakage shall not exceed limits documented in 3.2.1.3.
e. After performing 4.3.23.14, no oil leakage or hose material degradation is permitted.

3.2.1.24 Corrosion Resistance. When tested per 4.3.24, the following requirements shall be met:

Underhood cosmetic corrosion requirements: Per GMW15272, Table A1 (Underhood - High Visibility, VTS Template Requirement Suffix G)

For functional corrosion: A/C Leak Test requirement per 3.2.1.3.

3.2.1.25 Heat Age. When tested per 4.3.25, maximum allowable leakage is 0.6 g. (See Note in 3.3.1.1.3).

3.2.1.26 Appearance. When tested per 4.3.26, all exterior and interior surfaces shall be clean and free of weld and/or braze splatter, flash, ridges, sharp edges, flux paste, scratches, roughness, manufacturing lubricants, and other contaminants that are not associated with the function of a coupled hose assembly.

3.2.2 Test Requirements.

3.2.2.1 Design Validation (DV). A/C Hose and Coupling assemblies shall be tested for conformance per the sections listed in Table 14.

Table 14: Design Validation (DV) and Product Validation (PV) Test Table [Note 1]

Section	Test	Number of Samples
3.2.1.1	Dimensional	10
3.2.1.2	Material	1 Batch
3.2.1.3	Leakage	10
3.2.1.4	Bending Rigidity	3
3.2.1.5	Kink Resistance	3
3.2.1.6	Moisture	3
3.2.1.7	Crystallization, Low Temperature Embrittlement and Vacuum Flattening	4
3.2.1.8	Tensile Strength	3
3.2.1.9	Pressure	3
3.2.1.10	Decompression	3
3.2.1.11	Refrigerant Emissions (Short Loss Rate and Long Loss Rate)	8 (4 samples each)
3.2.1.12	Moisture Vapor Ingression	4
3.2.1.13	Internal Cleanliness	4
3.2.1.14	Extractables	5
3.2.1.15	Chemical Compatibility	3
3.2.1.16	Anion	3
3.2.1.17	Change in Length/Angle	5
3.2.1.18	De-Lamination	4
3.2.1.19	Burst Strength	3
3.2.1.20	Pressure Cycling and Vibration	6 [Note 2]
3.2.1.21	Coupling Integrity	24 + 1 for volatility [Note 2]
3.2.1.22	Noise and Vibration	1
3.2.1.23	Thermal Pressure Resistance	6 [Note 2]
3.2.1.24	Corrosion Resistance	4
3.2.1.25	Heat Age	6
3.2.1.26	Appearance	10

Note 1: Applies for both DV and PV.
Note 2: See 3.2.3.2.

3.2.2.1.1 Design Validation (DV) Test Samples Requirements. A/C hose and coupling assemblies manufactured for DV tests shall be completely representative of production level dimensions and materials. The exceptions are those assemblies needing to be specially manufactured under extremes of dimensions and/or tolerances to meet the test requirements of the specification. Any exceptions to this requirement must be reviewed beforehand and approved by the GM Global Thermal BFO issuing the approval. All DV Test samples may be made available to the GM Global Thermal BFO for review upon request.

3.2.2.1.2 Design Validation (DV) Approval. DV approval shall be provided by the appropriate Tier 1 A/C line supplier or A/C hose supplier to the appropriate GM Global Thermal BFO and GM Global Thermal BFO and GM Global Thermal Validation Engineer through the Production Approval Process (PPAP).

3.2.2.2 Product Validation (PV). A/C hose and coupling assemblies shall be tested for conformance per the sections shown in Table 14. If required, each individual test shall be run with statistically based sample size per GMW15760, such that the reliability requirements stated in Section 3.2.3.2 are satisfied.

3.2.2.2.1 Product Validation Test Samples Requirement. A/C hose and coupling assemblies manufactured for Product Validation (PV) tests shall have dimensions, materials and manufacturing equipment representative from production level, potential variations from production tooling, process and place of manufacturing are evaluated as well. The test sampling accounts for production variation and forces production tolerances to be determined on the early stages of qualifications.

3.2.2.2.2 PV Approval. PV approval shall be provided by either the appropriate Tier one A/C line supplier or A/C hose supplier to the appropriate GM Global Thermal BFO and GM Global Thermal Validation Engineer through the PPAP process.

3.2.2.3 In-Process (IP) Evaluation. These tests shall be completed satisfactorily with parts randomly selected from production process per GMW15760.

Every 6 month period, or more frequently as required, the supplier shall run the tests listed in Table 15.

Table 15: In-Process Test Table

Section	Test	Number of Samples
3.2.1.1	Dimensional	Per GMW15760
3.2.1.2	Material	Each Batch Note 1
3.2.1.6	Moisture	Per GMW15760
3.2.1.8	Tensile Strength	Per GMW15760
3.2.1.9	Pressure	Per GMW15760
3.2.1.13	Internal cleanliness	Per GMW15760
3.2.1.18	De-lamination	Per GMW15760
3.2.1.19	Burst Strength	Per GMW15760
3.2.1.22	Noise and Vibration	Per GMW15760
3.2.1.25	Appearance	Per GMW15760

Note 1: See 4.3.2.3.

3.2.2.3.1 In-Process Approval. IP tests are self-approved by the manufacturer's supplier, subject to audit by GM Supplier Quality Engineering.

3.2.2.3.2 Alternative In-Process Compliance. Supplier may request an exception from IP testing, provided they can demonstrate that sufficient process controls are in place so as to make IP testing unnecessary. Approval to be provided by GM Supplier Quality Engineer (SQE) and/or the GM Global Thermal BFO. The period of testing (6 months) may vary, depending on data shown by supplier. GM Supplier Quality Engineering and the GM Global Thermal BFO will determine final IP period.

3.2.2.3.3 Lot Retention. In case of IP test nonconformance, the affected production lot shall be retained by the supplier until Root Cause Analysis (RCA) is completed. The supplier shall then decide the disposition of the affected production lot. The supplier has three (3) options for this retained lot; it shall be:

1. Scrapped; **or**
2. Corrected and certified (which may mean lot testing the revised part again) based on the root cause analysis, **or**
3. Shipped without correction if deemed to be acceptable based upon the root cause analysis.

In any event, GM Supplier Quality Engineering and/or the GM Global Thermal BFO shall be notified whenever any of the above options is exercised.

3.2.2.3.4 Record Retention All DV, PV, and IP test data must be retained by the manufacturer for a minimum of 10 years from date of test, and be subject to audit by the GM Global Thermal BFO and/or GM SQE.

3.2.2.3.5 Deviations from this Standard. Deviations from the requirements of this standard shall have prior written approval from the responsible GM Global Thermal BFO. Such requirements shall be specified on component GM drawings/part numbers, test certificates, reports, etc.

3.2.2.3.6 Audit Inspection Testing. If not defined otherwise, the testing required for Audit Inspection will be as indicated in 3.2.2.3.

3.2.2.4 Physical Characteristics. Physical Characteristics must conform to reference GM released drawings/part numbers indicated in 3.3.2.1.

3.2.2.5 Dimensions and Capacity. See 3.3.2.1.

3.2.2.6 Mass Properties. Not applicable.

3.2.3 Reliability.

3.2.3.1 Reliability Evaluation Point (REP). This standard as written provides a test exposure representing a REP of 10 years/160 000 km (100 000 mi) or 15 years/241 400 km (150 000 mi).

The GM Global Thermal BFO will inform the A/C hose and coupling assembly supplier which REP number must be used.

3.2.3.2 Reliability Requirements. This specification, as written, supports demonstration of the required minimum reliability of 97% at a 50% confidence (R97C50). This requirement is applicable for Pressure Cycling, Vibration, Coupling and Thermal Pressure resistance tests, using minimum samples for test lives shown in Analysis/Development/Validation Plan and Report (ADVP&R), CG2987.

3.2.3.3 Slope. To assess reliability, there is a need for certain parameters: test life, confidence level, sample size, and slope of failure distribution. Slope can be based on actual test data; data from past test results, or expected engineering distribution for the type of failure mechanism. A slope of 2 (for mechanical systems) is used as default value (value from historical data).

3.2.3.4 Accelerated Test Methods. GM encourages the use of appropriate Accelerated Test Methods, wherever possible; for example, the use of accelerated stress testing to reduce test time (reference GMW8758).

GM Global Validation Engineering shall review and accept Reliability demonstration test plans prior to the supplier submitting the Analysis Development Validation (ADV) Test Plan for approval.

3.2.4 Serviceability. Not applicable.

3.2.5 User System/Subsystem/Component/Part Interface. Not applicable.

3.3 Design and Construction.

3.3.1 Materials, Processes and Parts Selection Guidelines.

3.3.1.1 Material Guidelines. A/C hose and coupling assemblies materials supplied under this specification must be fabricated as per GM released drawings indicated in 3.3.2.1.

3.3.1.1.1 Recycling Guidelines. No recycling guidelines for rubber parts. Rubber cannot be recycled as material. Materials developed to this specification shall be optimized to provide maximum end-of-life cycle value utilizing the Recyclability Checklist and GM Recycling Design Guidelines. Recycled content shall be reported to the approving and procuring Materials Engineering Department utilizing the Recycled Content Report Form. Reference the Recyclability/Recoverability Guidelines, GMW3116.

3.3.1.1.2 Restricted and Reportable Substances for Parts. All materials supplied to this specification must comply with the requirements listed in GMW3059.

3.3.1.1.3 Material Compatibility. See 1.4 for details on fluids selected for tests. The acceptance requirements are identical for any combination of refrigerant and compressor oil.

The compatibility test shall perform one (1) time for each combination of refrigerant type and compressor oil formulation.

3.3.1.1.3.1 All A/C hose and coupling assemblies must be compatible with R134a and R1234yf refrigerants; and PAG and POE compressor oils.

3.3.1.1.3.2 Material compatibility tests shall comprehend any of the two refrigerant types R134a and R1234yf as well as any of the PAG and POE compressor oils. The acceptance requirements are identical for any combination of refrigerant and compressor oil. See Section 1.4 for details on fluids selected for tests.

3.3.1.2 Processes Guidelines. All production A/C hose and coupling assemblies must be manufactured with the same materials and processes used to manufacture the originally approved samples. No change is permissible without prior written approval from the responsible GM Global Thermal BFO. Suppliers shall use Statistical Process Control (SPC) and industry best practices for all manufacturing activities.

3.3.1.3 Parts Guidelines. Not applicable.

3.3.2 Design Guidelines and Constraints.

3.3.2.1 Drawing/Part Number Requirements. A/C hose and coupling assemblies supplied under this specification must be included in A/C lines assemblies drawings released by GM Design Release Engineer (DRE).

3.3.3 Identification and Marking.

3.3.3.1 Supplier Identification. A/C hose and coupling assemblies supplied under this specification must be visually identified in a manner exclusive and unique to each supplier to permit rapid identification of each respective manufacturer. Identification and markings shall be in accordance with GM design guidelines and approved by GM Labeling Engineering. If bar coding is required (only complete A/C line assembly), labeling shall be in accordance with GMW15862 Specifications for Part Identification and Component Bar-Codes.

Note: Other labeling requirements may include an adhesive type label, which is subject to GMW14573 and shall be applied as indicated on the assembly drawing. Graphics and/or color shall be coordinated through GM Label Engineering for all labels and marking. All labeling requirements must be in accordance with R134a or R1234yf Refrigerant Standards, depending upon the usage. Identification methods must be submitted to and approved by the GM Global Thermal BFO, such that they do not affect the function and/or performance of the part.

3.3.3.2 Hose Identification. All hose material shall be permanently identified with the type of refrigerant for which the hose was approved (R134a and/or R1234yf), nominal inside diameter in millimeters and inches (e.g., 16 (5/8)), manufacturer's identification, Julian date code (e.g., 25600 = 256th day of the year 2000) and shift of hose manufacture. This marking shall appear on the outside of the hose at intervals no greater than 30 cm (12 in).

3.3.3.3 Coupling Identification. At least one coupling per coupled hose assembly shall be permanently identified with the date of manufacture of the coupled hose assembly, manufacturer's identification, manufacturing location, and assembly part number.

3.3.3.4 Part Number Identification. All coupled hose assemblies shall be marked with the appropriate GM part number per GMW16331.

3.3.4 Workmanship. Key Product Characteristics (KPC) will be defined on the GM approved engineering drawings/part numbers. The A/C hose and coupling assemblies shall have manufacturing capability such that all dimensions are targeted at print nominal. The supplier shall submit a detailed improvement plan which describes how their manufacturing process for each part/operation shall achieve a process distribution of ± 6 sigma,, which must be less than or equal to the tolerance spread as specified on the detailed GM drawing/part number. The improvement plan shall be submitted to the GM Global Thermal BFO.

3.3.5 Interchangeability. Not applicable.

3.4 Documentation. Documentation released in DV and PV tests stage shall be approved by the GM Global Thermal BFO and GM Global Thermal prior to start of delivery of production level parts. IP tests documentation, see section 3.2.2.3. Documentation submitted for A/C hose material and coupling assemblies qualification shall include:

a. Hose type and code.
b. Hose material, outside diameter, thickness and weight, grams per centimeter (g/cm).
c. Coupling or crimp type/code, number of fingers and bands, cross sectional view.
d. Crimp diameter (minimum, maximum, and nominal).
e. Type and manufacturer of refrigerant used for validation performance.
f. Type and manufacturer of compressor oil used for validation performance.
g. Percent (%) of hose wall compression, as per Appendix A8.

3.4.1 Failure Mode and Effects Analysis (FMEA). Detailed design and process FMEAs shall be submitted to the GM Global Thermal BFO and GM Global Thermal Validation Engineer, and will be maintained as part of the records of the Design Validation and Product Validation. The FMEAs shall be updated each time a design change occurs. FMEAs shall be submitted with the GM PPAP documentation.

3.4.2 Design Validation and Product Validation. Documentation of DV and PV test reports shall be through the normal PPAP process. Any non-compliance during Design Validation or Product Validation phases must be documented and resolved before validation is considered complete.

3.4.3 Revalidation Requirements. Any change in design, function, material, manufacturing process, and/or location of manufacture facility from that previously approved for production, requires revalidation, as determined by the GM Global Thermal BFO.

3.4.3.1 If not otherwise agreed to, the entire validation test shall be repeated and documented by the supplier prior to start of delivery of the modified or changed product.

3.4.3.2 In some cases, a shorter test can be agreed by the responsible GM Global Thermal BFO.

3.4.3.3 After revalidation tests are completed, a new release approval document shall be issued. Carryover designs may be revalidated for subsequent model year production using the results of tests from previous years' production. It is the sole responsibility of the supplier to provide the customer, unsolicited, with documentation of any change or modification to the product/process, and to apply for a new release approval.

4 Validation

4.1 General.

4.1.1 Safety. This standard may involve hazardous materials, operations, and equipment. This standard does not propose to address all of the potential safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

Caution: This specification refers to the usage of testing pressurized vessels. Tests referred in this specification, should be performed only by properly trained qualified personnel in using equipment capable of withstanding the pressures, temperatures and exposure of these tests with adequate safety margins. Standard Laboratory Safety precautions must be followed to prevent accidental bodily injury. All material should be used in accordance with the manufacturer Material Safety Data Sheet (MSDS).

4.1.2 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

4.1.3 Alternatives. Alternative test facilities and equipment may also be used only if prior approval from GM Global Thermal BFO and GM Global Thermal Validation Engineer has been obtained. However, all measuring variables as specified in this specification shall be determined correctly with respect to its physical definition.

4.1.3.1 Equipment and Facilities. Conforming to the relevant test methods.

4.1.4 Test Fixtures. Four (4) types of fixtures are used to complete the tests in this standard.

1. A/C hose and coupling. (Figure A1).
2. A/C hose and coupling with canister (Figure A2).
3. Complete A/C assembly.
4. Samples for material test.

4.1.4.1 A/C Hose and Coupling (Figure A1). A/C hose and coupling tests, per Figure A1, must have nominal coupling crimp diameters except where noted as requirement of sample size to be crimped to the high and low limits of the dimensions(only DV stage). If using formed hoses, hose samples that are tested shall have a bend which conforms to the minimum radius to be used in the production design. (Coupling integrity samples shall be formed straight.) The length of hose and metal tube shall be per dimensions provided in Table A1. Each sample shall be capped at one end with a sealing element fitted with a safety guide for longitudinal and transversal movement, while the other end shall be fitted with a charge valve fitting to be able to be connected to a pressure source of gas as per Figure A3. Refer to Table A2 for the respective fasteners and tightening torques.

4.1.4.1.1 Prior to starting any charging operation or testing, all test fixtures must be leak tested per section 4.3.3 in order to prevent time lost due to poor welds, o-rings, crimping, fittings, etc.

4.1.4.1.2 After leak test is completed, the samples are now ready to complete the Charging Operation Procedure per 4.1.4.4.

4.1.4.2 A/C Hose and Coupling with Canister (Figure A2).

Note: Test canisters must have minimum burst strength of 8.6 MPa (1247 psi), consistent with SAE J639, with a recommended internal volume of 530 cm^3 (minimum). A volume of (1260 ± 25) cm^3 can be used with a wall thickness that can resist high pressures and fatigues due to the durability tests (Thermal tests).

4.1.4.2.1 Cleaning Procedures for Canisters and Plugs.

- Select a canister that has been dedicated for that system. The canister shall have charging connection.
- The charge port must not have a valve core at this part of the process (for easy cleaning).
- Turn canister upside down to allow any residuals to drain.
- Rinse the canister thoroughly with the appropriate solvent (Isopropanol at 70%) until all residues are removed. Solvent rinses should be done with adequate ventilation.
- Visually inspect to ensure that all contaminants are removed.
- Drain all excess solvent into an approved scrap solvent container.
- The canister should be flushed thoroughly with water. The flushed water should be visually inspected to ensure that all contaminants are removed. Drain all excess water. If any contamination is suspected, do not use the canister for testing.
- Place canister in an air dry oven at (+121 ± 3) °C ((+250 ± 4.5) °F)), for at least 3 hours of drying time.
- Remove canister from the oven and allow it to cool to room temperature (+23 ± 2) °C ((73.4 ± 3.8) °F) before starting assembly of the test system.

A/C hose and coupling assemblies that will be assembled to the canister shall be constructed per example shown in Figure A2 and must have nominal coupling crimp diameters except where noted as requirement of sample size to be crimped to the high and low limits of the dimensions(only DV stage). Each sample shall be capped at one end with a sealing element, while the other end shall be fitted to the canister. Refer to Table A2 for the respective tightening torques.

4.1.4.2.2 Prior to starting any charging operation or testing, all test fixtures must be leak tested per section 4.3.3 in order to prevent time lost due to poor welds, o-rings, crimping, fittings, etc.

4.1.4.2.3 After leak test is completed, the samples are now ready to complete the Charging Operation Procedure per 4.1.4.4.

4.1.4.3 Complete A/C Assembly. The purpose of these samples is to test the A/C hose and coupling design using vehicle ambient environment. There will be exceptions when the complete lines are too long and cannot be fit in the chamber test or when this condition will create a costly test setup. GM Global Thermal BFO, GM Global Thermal validation engineer and GM DRE for the selected program will indicate to the A/C hose and coupling supplier the design of the A/C line assembly routing to use.

4.1.4.3.1 Prior to the start of any charge operation or any testing, all test fixtures must be leak tested per section 4.3.3 in order to prevent loss of test time due to poor welds, O-rings, crimping, fittings etc.

4.1.4.3.2 After leak test is completed, the samples are now ready to complete the Charging Operation Procedure per 4.1.4.4.

4.1.4.3.3 After leak test is completed, the samples are now ready to complete the Charging Operation Procedure.

4.1.4.4 Charging Operation Procedure. All weights are to be measured at an ambient temperature of (+23 ± 3) °C ((68 to 79) ° F). See Note in section 1.4 for refrigerant and compressor oil combination.

4.1.4.4.1 Charging Operation Procedure for A/C Hose and Coupling (Figure A1).

- Obtain an initial tare weight to the nearest 0.01 g.
- Add the amount of lubricant indicated in each section (where applicable, within (± 0.5) g of the specified amount.
- Evacuate the assembly to 25 mm Hg absolute pressure (vacuum). Avoid removing any lubricant when pulling a vacuum (do not allow the lubricant to enter the Schrader valve or evacuation apparatus). This is required for ease of charging and removal of condensable and oxygen. (See Figure A3.) Sample may be

cooled to (+2 to +7) °C, ((36 to 45) °F) for ease of charging. **Caution:** Condensation will lead to erroneous results.

- Add the amount of refrigerant indicated in each section of this specification. Refer to 1.4 for proper refrigerant type.
- Weigh the assembly. All charges shall be within 1.0 g of the specified values.
- Invert the assembly several times to ensure mixing of the refrigerant and lubricant and wetting of all internal surfaces.

A/C hose and coupling assemblies are ready for tests.

At the completion of the tests, discharge refrigerant into an appropriate reclamation system.

4.1.4.4.2 Charging Operation Procedure for A/C Hose and Coupling with Canister (Figure A2).

- Evacuate each test canister to 3.3 kPa and charge each canister with the following fluids:
- Compressor Oil: Per each section. If no compressor oil is indicated, use a default of (17 ± 5) cc.
- Fluorescent Dye: (GM Part Number (P/N) 12346303 or equivalent): 0.25 mL.
- Charge the test fixtures with refrigerant ((± 10) g) to the levels in Table 16.

Table 16: Saturation Pressures/Temperatures (R134a/R1234yf Refrigerants)

Refrigerant Type	Saturation Pressure	Saturation Temperature	Approximate Refrigerant Amount (Reference Only)
R134a	2.0 MPa	65 °C	0.1 g/cm^3
R1234yf	2.0 MPa	70 °C	0.13 g/cm^3

These pressures are representative of refrigerant system pressures under extreme conditions (3100 kPa (450 psi) at +135 °C (+275 °F)).

Caution: Excess charge can result in higher pressures which could present a safety hazard. Canisters must be built with proper materials that can handle these high pressure conditions. For a canister size, internal volume of the assembly and the refrigerant charge in grams must be equal to the system volume (in cubic centimeters) × 0.125 g/cc of R134a (when required) 3.1 MPag (450 psig) at 135 °C (275 °F) or 0.076 g/cc of R134a (when required) 2.0 MPag (290 psig) at 125 °C (257 °F). Refrigerant charge in grams must be equal to the system volume (in cubic centimeters) × 0.13 g/cc of R1234yf (when required) 3.1 MPag (450 psig) at 135 °C (275 °F) or 0.083 g/cc of R1234yf (when required) 2.0 MPag (290 psig) at 125 °C (257 °F).

The volatility assembly must be evacuated and charged with nitrogen to one atmosphere pressure. The hose needs to be dry to obtain accurate weighing. Dryness can be ensured by placing the assembly in an oven at ((50 to 80) ± 2) °C (((122 to 176) ± 4) °F) for 2 h to 3 h. The tare is obtained by removing the assembly for a hot weighing.

After charging, agitate the assembly to ensure mixing of ingredients and to ensure the compressor oil is distributed and has coated all internal surfaces of the hose.

A/C hose and coupling assemblies with canister are ready for tests.

At the completion of the tests, discharge refrigerant into an appropriate reclamation system.

4.1.5 Artificial Aging. This is a preconditioning procedure for some individual functional tests.

Lay out the test sample in a hot chamber in accordance with the natural hose curvature. Apply a vacuum of 2 kPa (0.59 in Hg) for 72 h at (+110 ± 2) °C for normal temperature hoses and at (+125 ± 2) °C for high temperature hoses.

4.1.5.1 Age. The age at the start of mission shall be defined as zero at the time of delivery to the consumer.

4.2 Analysis/Development/Validation Plan and Report (ADVP&R). Reference CG2987.

4.3 Test Procedures.

4.3.1 Dimensional Verification Procedure. A/C hose and coupling assemblies are considered “black box” designs, and GM does not intend to request details of the construction. GM only requests a minimum internal diameter in the crimping to assure the coupling shall not significantly impede the free flow of the refrigerant.

4.3.1.1 Measure three (3) different places of the tube inside diameter in the A/C coupling section.

4.3.2 Material Verification Procedure.

4.3.2.1 Material Properties for Lining and Cover. Unless otherwise specified, samples are finished parts or to be taken from finished parts for all material qualification tests described in Table 17 and Table 18. Unless otherwise specified, the shape, size, and number of test pieces shall be in accordance with the relevant test method.

If not otherwise stated, mechanical properties in delivery state and after heat or fluid immersion are to be tested at ambient temperature (+23 ± 3) °C and with the same test methods. Unless otherwise stated, all other temperatures shall be held to (± 3) °C.

Note: ISO standards are referred in Table 17 and Table 18. Equivalent ASTM standards can be used with prior approval by GM Material Engineering and GM Global Thermal BFO.

Table 17: Material Properties for Lining and Cover

Property	Test Method
Hardness	ISO 48, Method M
Elongation at Break	ISO 37, Type 2 or Type 4 Dumbbell, (200 ± 20) mm/minute
Tensile Strength	ISO 37, Type 2 or Type 4 Dumbbell, (200 ± 20) mm/minute
Stress at a Given Strain (Modulus) σ_{100}	ISO 37, Type 2 or Type 4 Dumbbell, (200 ± 20) mm/minute
Age Resistance (Heat Aging)	ISO 188 Method B. Conditions for Lining: High Temperature Hoses: 140 °C for 168 h; or 135 °C for 500 h Normal Temperature Hoses: 130 °C for 168 h; or 125 °C for 500 h Change in Hardness Change in Elongation at Break Change in Tensile Strength Change in Stress at a Given Strain Conditions for cover: High Temperature Hoses: 140 °C for 72 h; or 135 °C for 500 h Normal Temperature Hoses: 130 °C for 72 h; or 125 °C for 500 h Change in Elongation at Break Change in Tensile Strength
Fluid Resistance Tests to be performed with compressor oil as determined by GM Global Thermal BFO See 3.3.1.1.3	ISO 1817 to Refrigerant : Compressor Oil (PAG or POE Oil) = 90:10 High Temperature Hose: 140 °C for 168 h; or 125 °C for 500 h Normal Temperature Hose: 125 °C for 168 h; or 100 °C for 500 h Change in Hardness Change in Elongation at Break Change in Tensile Strength Change in Stress at a Given Strain
Fluid Resistance Tests to be performed with compressor oil as determined by GM Global Thermal BFO See 3.3.1.1.3	ISO 1817 to Refrigerant : Compressor PAG Oil : Compressor POE Oil = 89:10:1 High Temperature Hose: 140 °C for 168 h; or 125 °C for 500 h Normal Temperature Hose: 125 °C for 168 h; or 100 °C for 500 h Change in Hardness Change in Elongation at Break Change in Tensile Strength Change in Stress at a Given Strain
Ozone Resistance (Cover only)	ISO 1431-1, 50 pphm, 20% strain, (40 ± 2) °C, (72 +0/-2) h Visual Examination
Thermogravimetric Analysis (TGA)	ISO 7111, (50 to 950) °C; first derivative
Glass Transition T_g (DSC)	ISO 11357, Part 2, To midpoint

Table 18: Material Properties for the Construction

Property	Test Method
Compression Set	ISO 815, Test Piece Type B High Temperature Hose: (+100 ± 3) °C, (22 +0/-2) h, 25% compressed Normal Temperature Hose: (+70 ± 3) °C, (22 +0/-2) h, 25% compressed

4.3.2.2 Design Validation Testing. Material properties (material/compound approval) are summarized in Table 17 and Table 18.

4.3.2.3 Product Validation/Audit - Inspection Testing. If not defined otherwise, the following testing should be done for production audit testing:

All tests per Table 17 and Table 18; except Ozone Resistance test, long term aging tests, long term fluid tests.

4.3.3 Leakage Verification Procedure. The test fixtures shall be evacuated at room temperature (+23 ± 3) °C) and then charged with a clean source of Helium gas, R134a or R1234yf refrigerant to reach a test pressure of (2000 ± 5) kPa ((290 ± 0.7) psi) for Normal Temperature hose crimp or (3100 ± 5) kPa ((450 ± 0.7) psi) for High Temperature hose crimp. Supplier may use Table 19 only as a reference for AC hose and coupling assemblies per Figure A1. The pressure must be applied for 1 hour. The addition of nitrogen or compressed air to raise the internal pressure is not permitted.

Table 19: Charge Weight (Reference Only)

Nominal Diameter	**Charge Weight**	
	Hose Length ≤ 500 mm	Hose Length > 500 mm
8 mm (5/16 in)	(19 +5/-0) g	(25 +5/-0) g
10 mm (13/32 in)	(31 +5/-0) g	(42 +5/-0) g
12.7 mm (1/2 in)	(49 +5/-0) g	(66 +5/-0) g
16 mm (5/8 in)	(80 +5/-0) g	(108 +5/-0) g
19 mm (3/4 in)	(134 +5/-0) g	(153 +5/-0) g

Use a Halogen Leak Detector calibrated to alarm at 0.1 g/year (0.000 22 lb/year) of refrigerant R134a or R1234yf. Inspect all joints during test. Scan at a rate of no more than 2.54 cm/second (1.0 in/second) at a distance of less than 0.635 cm (1/4 in) from, and normal to the surface. Other test methods (e.g., mass spectrometry; photo acoustic spectroscopy), may be acceptable with the approval from the responsible GM Global Thermal BFO and GM Global Validation Engineer.

4.3.4 Bending Rigidity Verification Procedure. A/C hose and coupling assemblies shall be clamped vertically in a suitable test device as per Figure 6. Refer to Table 20 for hose length setup. Each line shall be bent in all four directions (with and against the natural hose curvature, and left/right) out of the vertical, into the horizontal position. After a holding duration of 3 s, the required tensile force shall be measured using a suitable spring balance.

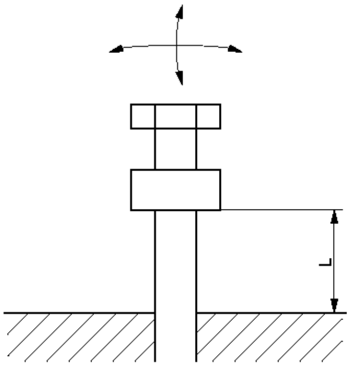


Figure 6: Bending Rigidity Test Setup

Table 20: Bending Rigidity

Nominal Diameter	Hose Length
8 mm (5/16 in)	(145 to 200) mm
10 mm (13/32 in)	(200 to 230) mm
12.7 mm (1/2 in)	260 mm
16 mm (5/8 in)	(200 to 300) mm
19 mm (3/4 in)	350 mm

4.3.5 Kink Resistance Verification Procedure. A/C hose and coupling assemblies having an exposed hose length of 30 × the hose OD shall be bent in annular form with overlapping fittings. Refer to Figure 7. In this condition, the smallest dimension d_k and the largest external dimension d_g of the hose shall be determined after a holding duration of 10 minutes.

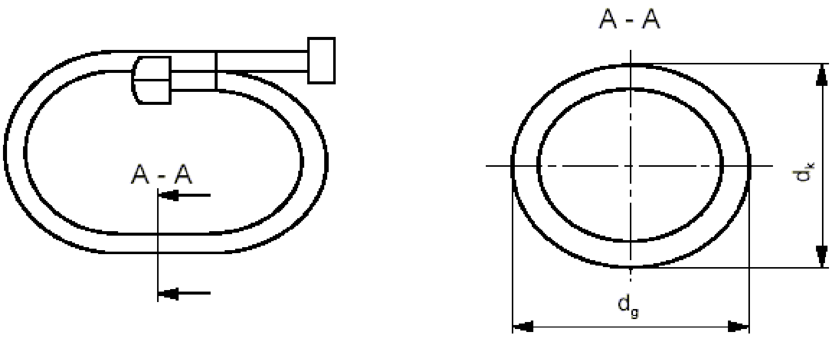


Figure 7: Hose Cross Section for Kink Resistance Test

4.3.6 Moisture Verification Procedure. Weigh completed A/C line assemblies selected from GM assembly plant to the nearest 0.01 g (weight W1). Place the lines assemblies into a thermal chamber at 107 °C (225 °F) for 30 minutes. Re-weigh the line assemblies (weight W2). Subtract W1 - W2.

4.3.7 Crystallization, Low Temperature Embrittlement and Vacuum Flattening Verification Procedure. A/C hose and coupling assemblies shall be built per 4.1.4.1. These samples shall be submitted for sequential tests and have the couplings crimped as follows:

1. A/C hose and coupling assemblies crimped to nominal.
2. A/C hose and coupling assemblies crimped to maximum production extreme (maximum compression).
3. A/C hose and coupling assemblies crimped to minimum production extreme (least compression).

4.3.7.1 Crystallization Verification Procedure. Specific polymers (after a time - low temperature exposure) can become temporarily less resilient and create a greater leakage potential at the hose coupling. This test was designed to evaluate the effect of a high degree of crystallization on the leakage of couplings fabricated at the minimum compression assembly level. This test also comprehends any dimensional changes (e.g., rubber shrinkage) that may result in leakage. This test is necessary to ensure system integrity during and after cold seasons. The hose lines shall be built per 4.1.4.1. These samples shall be submitted for sequential tests and shall have the couplings and preconditioned per 4.1.5.

4.3.7.1.1 Samples designated for testing shall be charged using the charging procedure in 4.1.4.4.1, with an amount of lubricant (see Note in Section 1.4 for type of lubricant) equal to 10% of the calculated refrigerant charge (see Table 21).

Note: One extra sample will remain uncharged, and will be used as a control to adjust for volatility.

Table 21: Refrigerant and Lubricant Charges

Hose ID	Refrigerant Charge Note 1	Lubricant Charge Note 1
8 mm (5/16 in)	20 g	2.0 g
10 mm (13/32 in)	50 g	5.0 g
16 mm (5/8 in)	70 g	7.0 g
19 mm (3/4 in)	90 g	9.0 g

Note 1: See “Note” in Section 1.4.

4.3.7.1.2 Weigh samples to obtain initial weights. (W1 = Charge Sample, W1' = Control Sample)

Place assembly at -17 °C (1 °F) for (168 ± 1) h. At the end of -17 °C (1 °F) storage, place at 80 °C (176 °F) for (1.0 to 1.5) h and obtain a hot weight (W2 for charged sample, W2' for control sample). This step is necessary to dry the assembly.

4.3.7.1.3 Visually inspect the outer cover of the hose.

4.3.7.2 Low Temperature Embrittlement Verification Procedure. This test exposes a refrigerant-charged hose assembly to mechanical motion after low temperature exposure to determine if the increased stiffness will result in cracking or leakage.

4.3.7.2.1 If the results of 3.2.1.7.1 were acceptable, immediately (within 4 hours) place the A/C hose and coupling assemblies in a chamber for 48 h at (+70 ± 2) °C according to the natural hose curvature. Next, place A/C hose and coupling assemblies in a straight position and the mandrel (the mandrel shall have a diameter eight times the nominal outside diameter of the hose; mandrels made to the nearest whole inch are acceptable) in a cold chamber set at (-40 ± 2) °C ((-40 ± 4) ° F) for 24 h. Immediately (within 15 s) after removing the hose and mandrel from the cold chamber, bend the hose sample (with the natural curvature of the hose) one time through 180 degrees over a mandrel within a time period of (4 to 8) s.

4.3.7.2.2 Remove the hose assembly from the mandrel and place it in a hot chamber set at 80 °C (176 °F) for (1 to 2) h and obtain a hot weight. (W2 = charge sample weight, W2' = control sample weight)

If the results of 3.2.1.7.2 were acceptable, exhaust the charge into a suitable refrigerant reclamation container and proceed with the vacuum flattening test. If the assembly leaked or exhibited visually observable degradation, the root cause must be determined and resolved prior to proceeding.

4.3.7.3 Vacuum Flattening Verification Procedure. Flattening of a hose restricts internal fluid flow. This test evaluates the hose construction at an elevated temperature (softer) condition for its ability to resist internal area reduction under vacuum conditions.

4.3.7.3.1 The coupled hose assembly used in 4.3.7.2 and mandrel shall be preheated for (2 to 3) h in a hot chamber set at (35 ± 3) °C ((95 ± 5) ° F). Immediately (within 15 s) after removing the hose and mandrel from the hot chamber, bend the hose sample (with the natural curvature of the hose) one time through 180 degrees over a mandrel within a time period of (4 to 8) s. The sample shall be bent (with the natural curvature of the hose) around a mandrel with. The mandrel shall have an OD equal to ten times the nominal outside diameter of the hose and shall have a relief notch for performing hose diameter measurements. Refer to Figure 8.

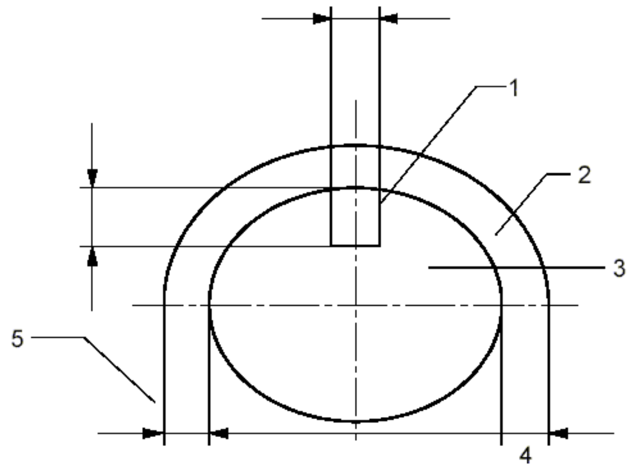
Exception: The mandrel OD for the 19.0 mm (3/4 in) hose shall be equal to twelve times (12 ×) the nominal outside diameter of the hose.

Measure the minimum outside diameter of the hose when the hose is wrapped around the mandrel (measurement is taken at the mandrel relief notch). Evacuate the hose to a pressure of (10 ± 5) mm Hg ((0.04 ± 0.020) in Hg). Maintain this pressure in the bent hose specimen for 2 minutes. At the end of the period, while the hose is still under vacuum, measure the minimum outside diameter of the hose when the hose is wrapped around the mandrel (cut gap in mandrel where measurement is taken, at the base of the “U”) in any plane at the base of the “U”.

4.3.7.3.2 Visually examine the hose external surfaces for cracks or other signs of degradation.

4.3.7.3.3 Conduct the Leakage Test per 4.3.3.

4.3.7.3.4 Following the Leakage Test, cut the hose off at the coupling and section longitudinally. Visually inspect the hose internal wall for blisters, delaminating, wrinkles, cracks or other surface imperfections.



Legend
1 Relief Notch for Measuring
2 Hose Line
3 Mandrel
4 Bending Force
5 Clamping

Figure 8: Low Temperature Embrittlement Test Setup

4.3.8 Tensile Verification Procedure.

4.3.8.1 A/C hose and couple assemblies constructed per Figure A1 with a length of 200 mm must be securely installed into a tensile test machine.

4.3.8.2 Apply an increasing tensile load at a rate of 25 mm/minute until failure occurs (either hose detaches from the coupling or the hose ruptures).

4.3.8.3 Record tensile data on a force deflection diagram (N vs. mm).

4.3.8.4 Record maximum tensile load and failure mode.

4.3.9 Pressure Verification Procedure.

4.3.9.1 Install A/C hose and coupling assemblies constructed as per Figure A1 (with couplings crimped to the minimum production extreme, i.e., least compression) into a pressure test fixture. The fixture shall have a pressure gage and pressure source. The test setup shall allow venting of all air from the hose and is to be enclosed in a suitable chamber to prevent injury in case a component should burst. The hose test sample shall be capped at one end (dead ended), with the other end attached to a hydraulic pressure source. Testing shall be performed with either PAG or POE oil that is free of air bubbles. The hose assembly test sample and the hydraulic fluid (test medium) shall both be at the same temperature for this test.

4.3.9.2 Apply a pressure of (8.6 ± 0.1) MPa for 1 minute at a temperature of (+23 ± 2) °C for a duration of 1 hour.

For Type A, Type B, and Type C Hoses that will be used as Normal Temperature Hoses: Precondition the hose assembly and the hydraulic fluid in a hot chamber set at (+125 ± 2) °C for a duration of 1 hour. Apply hydraulic pressure to the hose sample at a rate of 0.35 MPa/minute (50 psi/minute) until a pressure of (5.5 ± 0.1) MPa ((797 ± 14.5) psi) has been achieved. Hold this pressure for a duration of 5 minutes and then release.

For Type B and Type C Hoses that will be used as High Temperature Hoses: Precondition the hose assembly and the hydraulic fluid in a hot chamber set at (+135 ± 2) °C for a duration of 1 hour. Apply hydraulic pressure to the hose sample at a rate of 0.35 MPa/minute (50 psi/minute) until a pressure of (8.4 ± 0.1) MPa (1218 ± 14.5) psi) has been achieved. Hold this pressure for a duration of 5 minutes and then release.

4.3.10 Decompression Verification Procedure. A/C hose and coupling assemblies per Table A2 shall be tested. Each test hose sample shall be installed in a dual-pressure system with high pressure (HP) and low pressure (LP) connections. (HP is the test hose sample, LP is the container)

4.3.10.1 Charge test hose sample with liquid refrigerant (see “Note” in 1.4) at half the amount listed in Table 22 on the high pressure side.

4.3.10.2 Store in a heat chamber for 1.5 h at +80 °C.

4.3.10.3 Apply a vacuum of 2 kPa (0.59 in Hg) to the low pressure side. The high pressure in the test piece shall be reduced to ≈ 40 kPa (5.8 psi) in ≈ 0.1 s by connecting the high pressure and low pressure sides by means of a shutoff valve.

4.3.10.4 Recharge per 4.3.10.1 and decompress per 4.3.10.3 three more times for a total of 4 decompressions for this section.

4.3.10.5 Charge with liquid refrigerant (see “Note” in 1.4) at full amount listed in Table 21 on the high pressure side.

4.3.10.6 Store in a heat chamber for (12 to 16) h at +80 °C.

4.3.10.7 Decompress per 4.3.10.3.

4.3.10.8 Recharge per 4.3.10.1 and decompress per 4.3.10.3, three more times a total of 4 decompressions for this section. The complete test has 8 decompressions.

4.3.11 Refrigerant Emissions Verification Procedure. This test is designed to record the refrigerant emissions (hose and couplings) of a hose assembly at different temperatures under refrigerant saturation conditions. Total refrigerant emissions are defined as the summation of hose permeation and coupling leakage.

4.3.11.1 A/C hose and coupling assemblies constructed per 4.1.4.1 (Figure A1), shall be subjected to (80 ± 2) °C ((176 ± 4) °F) test temperature for Normal Temperature hoses or (90 ± 2) °C ((194 ± 4) °F) test temperature for High Temperature hoses. The hose lines shall be preconditioned per 4.1.5. At each test temperature, one sample will remain uncharged and capped at both ends. This sample will be used as the volatility control.

4.3.11.2 Test Setup. The samples designated for testing shall be charged with an amount of Refrigerant and PAG or POE oil shown in Table 22 (see “Note” in 1.4 for compressor oil type), using the charging procedure in 4.1.4.4.1.

Table 22: Refrigerant and Lubricant Charges

Hose ID	Refrigerant Charge	Lubricant Charge	Minimum Refrigerant Charge at End of Test
8 mm (5/16 in)	50 g	5 g	13 g
10 mm (13/32 in)	85 g	9 g	21 g
16 mm (5/8 in)	210 g	20 g	41 g
19 mm (3/4 in)	280 g	30 g	60 g

4.3.11.3 Weighing Procedure. The volatility control sample must be weighed prior to the elevated temperature exposure to establish an initial weight. The hoses shall be weighed within 5 minutes of oven removal.

4.3.11.4 Temperature Exposure. The samples are to be placed horizontally in a circulating air oven at the specified test temperature.

4.3.11.5 Establish Short-term Loss Rate. The samples shall be weighed every 48 h for the first 240 h (Short-term Loss Rate). For the evaluation of the measured results, the value from the first 48 h is not taken into consideration as long as it does not exceed twice the average value of the remaining measurements.

4.3.11.6 Calculation.

$$D = 24/t \times (G - G_0)/(L \times d)$$

Where:

D = Rate of loss, in grams per square meter (g/m^2) per day

t = Test duration, in hours

G = Weight loss of the hose line filled with R134a or R1234yf, in grams

G_0 = Weight loss of the reference line, in grams

L = Exposed hose length of the test line and the reference line, in meters

d = Inside diameter of hose, in meters

4.3.11.7 Establish Long-term Constant Weight Loss Rate. The total test period shall be 26 days to 28 days. A/C hose and coupling assemblies constructed as per 4.1.4.1, shall be subjected to (80 ± 2) °C ((176 ± 4) °F) test temperature for Normal Temperature hoses or (90 ± 2) °C ((194 ± 4) °F) test temperature for High Temperature hoses. Samples are to be weighed after the first 4 h to 24 h of heat exposure to establish the initial weight. After the initial weight, all samples shall be weighed at 48 h to 72 h intervals. The final weighing period, in which the data is recorded, will be used to determine the emission rate; this weighing period shall be the last 6 days or 7 days of the entire test period. The samples during the final period shall be weighed six times, 24 h to 72 h apart. The six weights will allow five weight differences to be established. At the end of the test, there must be a minimum refrigerant charge (35% of the original charge) in the hose assembly to ensure that saturated conditions were present throughout the test.

4.3.11.8 Loss Rate Determination. The emission rate for each sample will be determined using the weight loss data during the final period (summation of last five weight losses). The emissions rate is determined as follows:

w = Total weight loss, in grams, during the final period for a particular sample.

v = Total weight loss, in grams, of the volatility sample during the final period.

E = Emissions, in grams, during the final period for a particular sample.

t = Total time, in hours, during the last five weight loss periods.

d = Inside diameter of hose, in millimeters.

e = (w – v) Emissions, in grams per sample.

In order to standardize the emissions rate, the data should be reported on a kilograms/square meter/year basis. This is calculated by the following procedure:

$$2788 \times e/(t \times d) = E\ (kg/m^2/year)$$

Check $2615 \times e/(t \times d) = E\ (kg/m^2/year)$

All weight loss data after deducting variation should be plotted. The y-axis shall be the net weight loss of the sample. The x-axis is the time of the sample weighing. The graph shall be submitted to the GM DRE and the GM Global Thermal BFO.

4.3.11.9 Long Term Loss Rate for R1234yf Refrigerant Verification Procedure (Alternate Method). The testing procedures described in Appendix B can be used as alternate method to measure the refrigerant loss rate for R1234yf refrigerant.

4.3.11.10 Two of the tested hose lines shall be subjected to Pressure test (4.3.9) and Leakage (4.3.3).

4.3.12 Moisture Vapor Ingression Verification Procedure. The purpose of this test is to determine the moisture ingression rate through the hose material at a high humidity condition. This test will determine if the hose will have acceptable moisture ingression resistance for use on GM vehicles. Throughout this test procedure, there are references to corresponding numbers shown in the Schematic Diagram of Test System identified as Figure A5.

4.3.12.1 Prepare the A/C hose and coupling assemblies per 4.1.4.1 (Figure A1) by sealing one end of the hose assembly and attaching the other end to the vacuum pump. Place the hose assemblies in a humidity chamber. Arrange the test assemblies to maximize surface exposure to test chamber ambient conditions without bending the sample in an arc of radius smaller than 254 mm (10 in).

4.3.12.2 Thoroughly clean all vacuum traps, inside and out. Then place the traps in an oven set at (100 ± 2) °C ((212 ± 4) °F) until thoroughly dry.

4.3.12.3 Remove the traps from the oven and allow them to cool to room temperature. Weigh each trap to the nearest 0.5 mg. Plug (seal) the ends of the traps and record the weights.

4.3.12.4 Install the traps in the test system. (See Figure A5.)

4.3.12.5 After all connections are made, turn on the vacuum pump and open Valve (Item 2) and then open Vacuum Valve (Item 12). Valve (Item 9) and Quick Open Valve (Item 11) should be closed.

4.3.12.5.1 A quick leak check must be done by closing Vacuum Valve (Item 12) for about 15 s and noting any vacuum decay on Vacuum Gauge (Item 6). If there is any vacuum loss, the leak should be located, sealed and the system checked.

4.3.12.5.2 Open Vacuum Valve (Item 12).

4.3.12.5.3 Evacuate the system to a maximum pressure of 50 mm Hg and run the system for 1 h. Then close Vacuum Valve (Item 12) for 30 s. If there is any detectable loss of vacuum, the test must be discontinued. The leak must be sealed and this step must be repeated.

4.3.12.6 Once the system is evacuated and integrity is assured, maintain the liquid bath (Item 4) surrounding the Vacuum Traps (Item 5) at a maximum temperature of -70 °C (94 °F) throughout the test.

4.3.12.7 Seal the humidity cabinet and set the dry bulb temperature to (50 ± 1) °C ((122 ± 2) ° F). Based on the mean dry bulb temperature, adjust the mean wet bulb temperature to maintain (85 ± 5)% RH.

4.3.12.8 After 24 h have elapsed, (representing one conditioning period), or >48 h, (representing one calculation period), proceed to 4.3.12.9.

4.3.12.9 Sequence of Operation.

4.3.12.9.1 Record time, dry and wet bulb temperatures.

4.3.12.9.2 Close Valve (Item 2).

4.3.12.9.3 Close Vacuum Valve (Item 12).

4.3.12.9.4 Open Valve (Item 9).

4.3.12.9.5 Slowly open Quick Open Valve (Item 11). This sequence is necessary to ensure the traps are charged with dry air at atmospheric pressure.

4.3.12.9.6 Close Valve (Item 9) and Quick Open Valve (Item 11).

4.3.12.9.7 Remove traps and immediately plug all tubing connections.

Note: Considerable time can be saved if another set of traps are already prepared for use, as described previously.

4.3.12.9.8 Allow traps to return to room temperature.

4.3.12.9.9 Thoroughly dry the traps' exteriors with a lint-free towel remove seals and weigh immediately.

4.3.12.10 Repeat 4.3.12.5 through 4.3.12.9 at >48 h intervals until steady state conditions are achieved. Steady state is reached when the range of three consecutive rates (change in weight divided by time) is no longer greater than 10% of the smallest rate.

4.3.12.11 Repeat 4.3.12.5 through 4.3.12.9 for a minimum of three calculation periods of not less than 48 h each.

4.3.12.12 Calculate the moisture ingression rate (MIR) of each hose assembly for each calculation period as follows:

$$\text{MIR in kg/m}^2\text{/year} = (1859 \times C/T \times D)$$

Where:

C= Condensate weight in grams

T= Test hour

D= Internal hose diameter in millimeters

Note: Plot and maintain a graph of hose performance (rate vs. time).

4.3.12.13 Calculate the average moisture ingression for each assembly. Test data shall include all conditioning period condensate weights, calculation period weights, individual and average moisture ingression rates and any comments on occurrences that may have affected the results.

4.3.12.14 The condensate that has been collected throughout the test shall be analyzed to determine the chloride concentration and the pH.

4.3.13 Internal Cleanliness Verification Procedure. The purpose of this test is to determine whether any gross amounts of production materials exist within the hose assembly. Any loose particles or abrasives (aluminum oxide, etc.) could cause compressor failure or plugging of heat exchangers and/or TXV in the A/C system.

4.3.13.1 Four complete A/C line assemblies shall be tested. There shall be no internal free water present and visible metal surfaces shall not be corroded.

4.3.13.2 Preheat the A/C line assembly for 2 h to 3 h at 80 °C (176 °F) before initiating cleaning procedure. The hose assembly shall be bent into a “U” shape, equivalent to five times the hose diameter, filled to approximately 75% with distilled water at 80 °C (176 °F).

4.3.13.3 Invert the assembly several times and shake to ensure maximum removal of contaminants.

4.3.13.4 The hose contents shall then be poured into a clean beaker.

4.3.13.5 A clean brush of moderate stiffness shall be pulled through the assembly from end to end. A nylon bristle brush similar to a test tube brush, with a diameter greater than the ID of the hose and a brush length of 76 mm (30 in) is acceptable.

4.3.13.6 Rinse the hose interior and the nylon brush with a fresh supply of distilled water at 80 °C (176 °F).

4.3.13.7 Refill the hose with fresh distilled water at 80 °C (176 °F) and empty back into the beaker.

4.3.13.8 Rinse the hose interior and the nylon brush with a fresh supply of distilled water at 80 °C (176 °F).

4.3.13.9 Combine all distilled water samples and filter through a vacuum filtration system capable of retaining all particles greater than 5 µm.

4.3.13.10 The residual distilled water in the hose assembly should then be removed by using the following procedure:

4.3.13.10.1 Blow the hose assembly out thoroughly with filtered compressed air.

4.3.13.10.2 Place the uncapped hose in an air circulating oven for 2 h at 80 °C (176 °F).

4.3.14 Extractables. The purpose of this section is to determine the presence of A/C hose constituents that are potentially corrosive to the refrigerant system. Hose materials are in constant contact with the refrigerant and lubricant inside the hose. Refrigerant and lubricant solubilize potentially corrosive contaminants such as plasticizers and salts, and carry these materials into the refrigerant system. This test measures the amount of material extracted in a given length of time and temperature, and then tests the extracted material for chemical compatibility in the A/C system.

4.3.14.1 Test Specimen. A/C hose and coupling assemblies per Appendix A2, will be used for this test. One end of each assembly is connected to a canister having an internal volume of (510 ± 25) cc. The free end of each assembly is equipped with a charging fitting.

4.3.14.2 Charging Procedure. Each assembly will be charged (no lubricant is required for this test) following Table 23 for refrigerant charge per 1.4 (based on 20% liquid fill). The charge is approximate to 0.6 g/cm^3.

Table 23: Initial Refrigerant Charge

Hose ID	Refrigerant Charge
8 mm (5/16 in)	122 g
10 mm (13/32 in)	128 g
16 mm (5/8 in)	147 g
19 mm (3/4 in)	160 g

4.3.14.3 Procedure for Extraction. Place the hose and canister assembly in an oven at (80 ± 2) °C ((176 ± 4) °F) for 72 h with liquid refrigerant in the hose throughout the test period. At the end of this aging period, the hose canister is removed, chilled below -40 °C (-40 °F) and its contents poured into a pre-weighed beaker. The extract weight is determined by drying to a constant weight. The extract is then saved for subsequent chemical compatibility testing (4.3.15).

4.3.14.4 Subsequently, heat a copper wire over a Bunsen burner until it glows and then bring the hot end of the wire into contact with the extract.

4.3.14.5 Hold the end of the wire in the flame and observe the reaction.

4.3.15 Chemical Compatibility Verification Procedure.

4.3.15.1 Procedure for Stability Testing. Collect the refrigerant extracted from 4.3.14.3 and add the precalculated amount to the contents of each test tube, following the procedure described in ASHRAE 97. Use only approved refrigerant oil per 1.4. The precalculated amount of extractables is determined from the formula outlined below. A minimum of two replicables and one control (no extracted material added) should be prepared.

This formula is based on the amount of extractables material obtained from 4.3.14.3 and is an estimate of the amount of extractable the hose will contribute to an average GM A/C system.

$$\text{Grams Extract} = (A \times B \times C \times D)/E$$

Where:

A = Extract, in grams per square centimeter (g/cm^2)

B = Average Hose Internal Surface Area (for 60 cm (2 ft) of suction hose and 60 cm (2 ft) of discharge hose − use a value of 502 cm^2)

C = Extraction Factor − Takes into account that the extractables test cannot remove all extractable material during the short time of test. On the assumption that 25%of the available extract is removed during testing. This value is set at 4.

D = Lubricant Mass per Test Tube, gram (g) − Depends on, and is specified, in the test method used, normally = 3.2 g.

E = Average System Lubricant Charge, gram (g) − Use 250 g for a standard GM A/C system.

Example: If 4.3.14.3 determined the extractable for a given hose to be 0.0031 g/cm, then:

$$\text{Grams Extract} = (0.0031 \text{ g/cm}^2 \times 502 \text{ cm}^2 \times 4 \times 3.2 \text{ g})/250 \text{ g} = 0.08 \text{ g}$$

Based on these results, 80 mg of extract would be placed in each test tube for stability testing per ASHRAE 97.

4.3.16 Anion Verification Procedure. This test is only performed if the extractables amount from 4.3.14 exceeds 6.0 mg/cm^2. The purpose of the anion test is to determine the type and concentration of anions present, and their contribution to the acidity of the system. It should be noted that the chloride ion is of particular interest.

4.3.16.1 Proton Induced X-ray Emissions (PIXE). The recommended technique to determine the amount of any anion present in the extract is Proton Induced X-ray Emissions (PIXE). The PIXE technique provides a complete elemental analysis of the extract and can be performed on the next extract. This technique can be conducted by the Element Analysis Corporation, however, other sources for tests can be used prior to approval by GM Global Thermal BFO and GM Global Validation Engineer. The results shall be submitted to GM Global Thermal BFO for review.

4.3.17 Change in Length/Change in Angle Verification Procedure. The purpose of the test is to determine how much the hose length changes under pressure. This information is important for designing vehicle routings. The burst strength value must be determined to ensure adequate safety.

4.3.17.1 Prepare A/C hose and coupling assemblies per Appendix A1 and Table A1.

4.3.17.2 Seal one end of the hose sample with a sealing element with integral air bleed valve for releasing trapped air.

4.3.17.3 Connect the other end of the sample to a hydraulic pump. PAG or POE oil, free of air bubbles, shall be test medium. Reference Figure A3.

4.3.17.4 Place the hose sample in an explosion-proof chamber. The hose shall be permitted to lie according to the hose natural curvature.

4.3.17.5 Completely fill the hose sample with oil – ensure that all air is removed via the air bleed valve.

4.3.17.6 Close the air bleed valve and apply a hydraulic pressure of (69 ± 7) kPag ((10 ± 1) psig). The hose length shall be measured at this pressure (original length). The pressure shall be increased to (2.4 ± 0.1) MPag ((348 ± 15) psig) for Normal Temperature hoses and (3.5 ± 0.1) MPag ((507 ± 15) psig) for High Temperature hoses without releasing the original pressure.

4.3.17.7 Maintain pressure for a duration of at least 1 minute and measure the hose length at this pressure.

4.3.18 Delamination Test Verification Procedure. The purpose of this test is to evaluate the integrity and bonding between the elastomer and thermoplastic layer within a multi-layer hose construction. This test should not be performed on Type A hoses.

4.3.18.1 Prepare A/C hose and coupling assemblies per Figure A1.

4.3.18.2 Hoses are filled with refrigerant (refer to section 1.4 for refrigerant type selection) to 0.6 g/cm^3 of internal volume. Compressor oil must be charged with 10% of the value of the refrigerant charge (Refer to 1.4 for compressor oil type selection).

4.3.18.3 Charged assemblies are placed in an oven and heat aged for 72 h at 125 °C for High Temperature hoses or 72 h at 110 °C for Normal Temperature hoses to allow for refrigerant permeation.

4.3.18.4 After heat aging, the assemblies are removed from the oven and the refrigerant and compressor oil are evacuated immediately using an appropriate refrigerant retriever. Within 10 minutes from the time the hoses were removed from the heat age sequence, place the de-pressurized assemblies back in an oven at 125 °C for Normal Temperature hoses and 135 °C for High Temperature hoses and continue heat soak for 1 h.

4.3.18.5 Remove the assemblies, allow them to cool down, remove couplings and cut the hoses open longitudinally. Inspect inner bore and adjacent layers of the hose for any anomalies, blisters or separation of the layers.

4.3.18.6 Perform an adhesion peel test per ASTM D380 between the inner rubber tube and the plastic layers.

4.3.19 Burst Strength Verification Procedure. One refrigerant line from 4.3.17 shall be tested.

4.3.19.1 Seal one end of the hose sample with a sealing element with integral air bleed valve for releasing trapped air or other fluids.

4.3.19.2 Connect the other end of the sample to a hydraulic pump. PAG or POE oil, free of air bubbles, shall be test medium. Place the hose sample in an explosion-proof chamber. The hose shall be permitted to lie according to the hose natural curvature.

4.3.19.3 Completely fill the hose sample with oil – ensure that all air is removed via the air bleed valve.

4.3.19.4 Close the air bleed valve.

4.3.19.5 With the hose at room temperature ((21 ± 2) °C ((70 ± 3.8) °F)), increase the hydrostatic pressure at a uniform rate of approximately 7 MPa/minute (1000 psi/minute) to reach 20.6 MPa. Hold the hydraulic pressure at 20.6 MPa for duration of 1 minute, then release the pressure. The pressure at which failure occurs shall be considered the burst strength of the hose.

4.3.19.6 Record the pressure at hose burst and the failure mode.

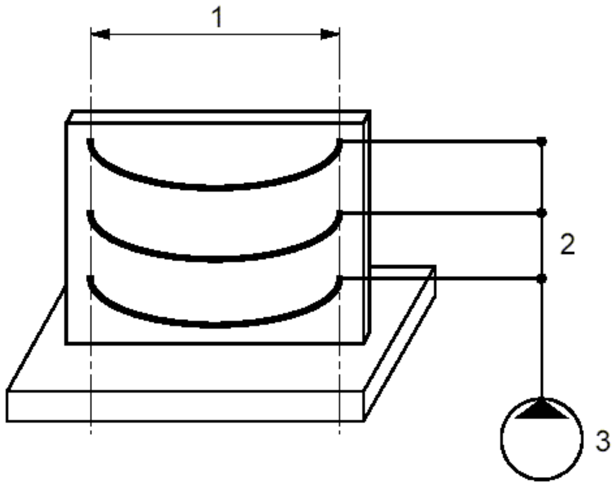
4.3.19.7 Visually inspect the hose sample for oil leakage or degradation of the hose material.

Caution: When conducting the burst pressure test, take necessary precautionary measures to prevent injury to personnel.

4.3.20 Pressure Cycling and Vibration Verification Procedure. The A/C hose and couplings are subjected to vibration during vehicle operation. Additionally, A/C operation subjects the hose and couplings to pressure pulsation; pressure cycling is especially good for determining the quality of the bead lock and for testing the hose yarn.

4.3.20.1 Pressure Cycling Verification Procedure.

4.3.20.1.1 Prepare A/C hose and coupling assemblies (Low and high crimp design) per 4.1.4.1, Appendix A1 and Table A1. The samples shall be preconditioned per 4.1.5 and then connected to a hydraulic pump in the form of “U”shaped bend (distance between axes = 350 mm) with both ends securely clamped to the fixture. See Figure 9. PAG oil, POE oil or other suitable hydraulic fluid, (with moisture content < 500 ppm) shall be used as test medium.



Legend
1 Bend Diameter = 350 mm
2 PAG or POE Oil
3 Pump

Figure 9: Pressure Cycling Test Setup

4.3.20.1.2. Tests shall be conducted from 0 °C to +125 °C for Normal Temperature hose, and from 0 °C to +135 °C for High Temperature hose. Temperature tolerance is ± 2 °C.

4.3.20.1.3 Place the test hose samples in an environmental chamber capable of the temperatures required for this test. Note that the environmental chamber and the test medium must follow the same temperature profile.

4.3.20.1.4 The line shall be subjected to pressure impulses of 0.1 MPa to 3.5 MPa with a trapezoidal pressure characteristic and at a frequency of (15 ± 1.5) Hz. Expose all test samples to 150 000 pressure cycles for 1 life = 10 years or 225 000 pressure cycles for 1 life = 15 years.

One life of 150 000 or 225 000 pressure cycles shall be divided into 28 temperature cycles (for 10 years) or 42 temperature cycles (for 15 years) (temperature cycles are six hours each) as follows:

a. With the chamber and fluid at room temperature, start pressure cycling.
b. Continue pressure cycling throughout the test.

c. From 0 minutes to 60 minutes, raise the chamber and fluid temperatures to the required high temperature (125 °C for NT hose, or 135 °C for HT hose).
d. From 60 minutes to 150 minutes, hold the high temperature.
e. From 150 minutes to 210 minutes, reduce the chamber and fluid temperature to zero degrees (0 °C).
f. From 210 minutes to 348 minutes, hold the temperature at zero degrees (0 °C).
g. From 348 minutes to 360 minutes, raise the chamber and fluid temperatures to room temperature.

Repeat for 28 cycles (for 10 years) or 42 cycles (for 15 years) to complete one test life of 150 000 pressure cycles (for 10 years) or 225 000 (for 15 years).

The expected life will be 2.0 to demonstrate R97C50 with a default slope of 2.0. See 3.2.3.3

4.3.20.1.5 After the pressure cycle test is complete, examine the external portion of all the hose sample lines.

4.3.20.1.6 Remove the 6 samples. Perform the following tests:

a. Tensile test per 4.3.8. (1 sample)
b. Burst test per 4.3.19. (2 samples)
c. Vibration test per 4.3.20.2. (3 full A/C line assemblies)

4.3.20.2 Vibration Verification Procedure. The A/C line assemblies from pressure cycle testing shall have one end plugged and the other connected to a capped charge fitting. An additional sample shall be used as a volatility control.

4.3.20.2.1. Refer to Table 24 for proper charge.

Table 24: AC Lines - Refrigerant Charge

AC Line Type	Refrigerant Charge R134a	Refrigerant Charge R1234yf
High Temperature Hose/Coupling	System Volume (cc) × 0.125 g/cc to reach 3.1 MPag at 135 °C	System Volume (cc) × 0.13 g/cc to reach 3.1 MPag at 135 °C
Normal Temperature Hose	System Volume (cc) × 0.076 g/cc to reach 2.0 MPag at 125 °C	System Volume (cc) × 0.083 g/cc to reach 2.0 MPag at 125 °C

4.3.20.2.2 Complete underhood A/C lines shall follow the three (3) test conditions: 1) Vehicle Accident, 2) Vehicle Pothole and 3) Vibration for Sprung Masses indicated in Appendix C. In case of A/C lines attached only to the body of the vehicle (e.g., liquid lines and underbody lines) the profile of the Vibration test must be discussed with GM Global Thermal BFO and GM Global Validation Engineer.

The expected life will be 2.0 to demonstrate R97C50 with a default slope of 2.0. See section 3.2.3.3.

4.3.20.2.3 After every condition is completed, including the change from vertical to fore-axis in Vibration for sprung masses condition, supplier may be requested by GM Global Thermal BFO to record weekly, the loose weight loose of the A/C complete lines to monitor the leakage performance through the test.

4.3.20.2.4 After the all three (3) sections of vibration were completed, perform leak test per 4.3.3.

4.3.20.2.5 After the leak test is complete, grasp the hose and metal tubing by hand and attempt to rotate the metal tubing in the hose.

4.3.20.2.6 The hoses shall be cut open and examined for signs of degradation.

4.3.21 Coupling Integrity (CI) Verification Procedure. The coupling integrity (CI), test is a comprehensive measure of coupling performance. The test exposes a hose and coupling to severe, but realistic conditions. It checks for integrity of the coupling, material compatibility (see 1.4) and capability for production. The coupler shall run Design Validation with couplings at the minimum (least compression, least material) and maximum (greatest compression, maximum material) production extremes and nominal. The production extremes or equivalent thereof, are to be determined taking into consideration hose, pipe and coupling tolerances.

4.3.21.1 Each production A/C hose and coupling assembly shall be built per 4.1.4.2 and Table A1. The samples shall be constructed as follows:

a. 3 samples crimped to minimum compression.
b. 1 sample crimped to nominal compression.
c. 2 samples crimped to maximum compression.

4.3.21.2 The hose lines shall be preconditioned per 4.1.5 and then connected to each canister.

4.3.21.3 The container unit shall be charged with refrigerant oil (see 1.4 for refrigerant oil type) given in Table 25. This charge ensures that approximately 1/4 of the exposed hose is in contact with the lubricant. These values assume zero volume in the end cap. If a dead-end plug is not used, any additional volume must be filled with lubricant.

Table 25: Lubricant Charge

Hose ID	PAG Lubricant Volume	Mass
8 mm (5/16 in)	6 cm^3	6.2 g
10 mm (13/32 in)	13 cm^3	13.5 g
16 mm (5/8 in)	29 cm^3	30.2 g
19 mm (3/4 in)	46 cm^3	47.8 g

4.3.21.4 The container shall be evacuated and charged of refrigerant that will produce a pressure of approximately 2.07 MPag (30 psig) at 125 °C (257 °F) for Normal Temperature hoses and 3.1 MPag (450 psig) at 135 °C (275 °F) for High Temperature hoses.(See 1.4 for refrigerant type.)

4.3.21.5 The canister unit shall be aligned so that the axis of the container lies (4 ± 2) degrees above the horizontal axis (Figure A2), thus ensuring that the liquid phase always runs to the connector assemblies to be tested.

4.3.21.6 Pre-age the hose samples per 4.1.5.

4.3.21.7 This test comprises the following time:

- For 10 years of expected life: 1152 h (8 exposure cycles) equivalent to 1 life.
- For 15 years of expected life: 1728 h (12 exposure cycles) equivalent to 1 life.

One exposure cycle has a duration of 144 hours, and consists of Interval 1 + Interval 2 as described below:

4.3.21.7.1 Normal Temperature Hose.

- **Interval 1:** 96 hr at +125 °C with canister pressure at 2.07 MPag (300 psig).
- **Interval 2:** 48 hr from +125 °C to -40 °C, following the temperature profile in Figure A6 to understand the sequential order.

4.3.21.7.2 High Temperature Hose.

- **Interval 1:** 96 hr at +135 °C
- **Interval 2:** 48 hr from +135 °C to -40 °C, following the temperature profile in Figure A6 to understand the sequential order.

The expected life will be 2.0 to demonstrate R97C50 with a default slope of 2.0. See 3.2.3.2.3

Note: Samples that reach room temperature may or may not be removed immediately.

4.3.21.8 After each exposure cycle, perform a leakage evaluation per 4.3.3, allowing the test sample to stabilize to room temperature ((+23 ± 2) °C).

After each exposure cycle, record the test sample weight and weight loss in grams.

4.3.21.8.1 Measure crimp per A8.

4.3.21.9 Perform a bending test on the hose sample, (see Figure A4 for fixture design), by flexing the hose ± 15 degrees. **Note:** The hose shall remain connected to the container.

4.3.21.10 Perform 10 bending cycles within approximately10 s at both of the vertical levels of a connector assembly.

4.3.21.11 Perform a leakage check on the hose sample per 4.3.3

4.3.21.11.1 Check for tube rotation.

4.3.21.12 Visually inspect the hose sample for oil leakage and material degradation. Document any visible signs of leakage or hose material degradation.

4.3.21.13 Weigh the test sample again and perform the next exposure interval if the weight is within a 4 g tolerance of the initial weight. If the weight loss is in excess of 4 g, then recharge the test sample to the initial weight before continuing the test. Maintaining the weight within a 4 g tolerance of the initial weight ensures that the initial pressure of the refrigerant in the container unit ≥ 2.07 MPag (300 psig) at +125 °C for Normal Temperature hose and 3.1 MPag (450 psig) at +135 °C for High Temperature hose.

4.3.21.14 At the end of the test, select two (2) of the hose samples. Subject selected hose samples to Pressure Test per 4.3.20.1 and Leakage Test per 4.3.3.

4.3.21.15 Select one assembly and cut the hose off at the coupling and section longitudinally, Check the hose internally for blisters (separation within the elastomer), delamination (separation at the elastomer/nylon interface), cracks or other surface imperfection.

4.3.22 Noise and Vibration Verification Procedure.

4.3.22.1 Vibration Transfer Characteristic: Set a 360 mm length of hose as indicated in A9.

Expose samples to the following exciting conditions:

- Input Acceleration = 3G constant
- Input Frequency = 100 Hz to 1000 Hz (sweep)
- Test Temperature = ambient
- Internal Pressure = 0 MPag (0 psig)

4.3.22.2 Measure the resulting output loading (in G).

4.3.23 Thermal Pressure Resistance of Hose Line with Connected Canister Verification Procedure.

4.3.23.1 Prepare A/C hose and coupling assemblies per 4.1.4.2 and Table A1, Figure A2 with minimum, nominal, and maximum crimping dimensions. Note that one hose sample shall be sealed at both ends and used as a variation control sample.

4.3.23.2 Connect 6 hose samples to a canister (with a pressure rating of 8.6 MPa (1247 psi), minimum) with a charging valve and a volume of (1260 ± 25) cm^3. The opposite end of the hose sample shall be sealed using sealing components tightened to the appropriate tightening torque. (See Table A2.)

4.3.23.3 Charge the container per 4.3.21.3 per the values shown in Table 26. (This corresponds to 3.0 MPa at peak temperature.)

4.3.23.4 The container unit shall be checked for leaks at (+23 ± 2) °C per 4.3.3.

4.3.23.5 The unit shall be shaken so that the oil is distributed and coats all internal surfaces. The initial weight shall be determined with an accuracy of 0.1 g.

4.3.23.6 Weigh the sealed variation control sample with an accuracy of 0.1 g. This hose sample shall be used to determine the weight loss of the hose material.

4.3.23.7 Storage and Peak Temperatures are defined in Table 27 for each type of hose. Expose the test samples to the temperature profile shown in Figures 10a and 10b with details in the area marked Section Z.

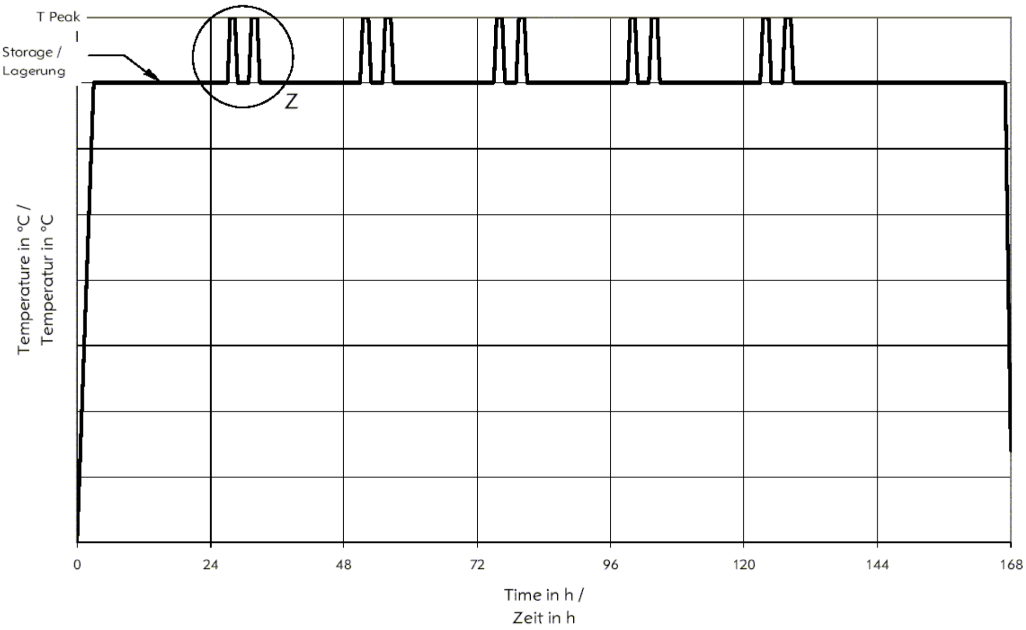


Figure 10a: Temperature Profile

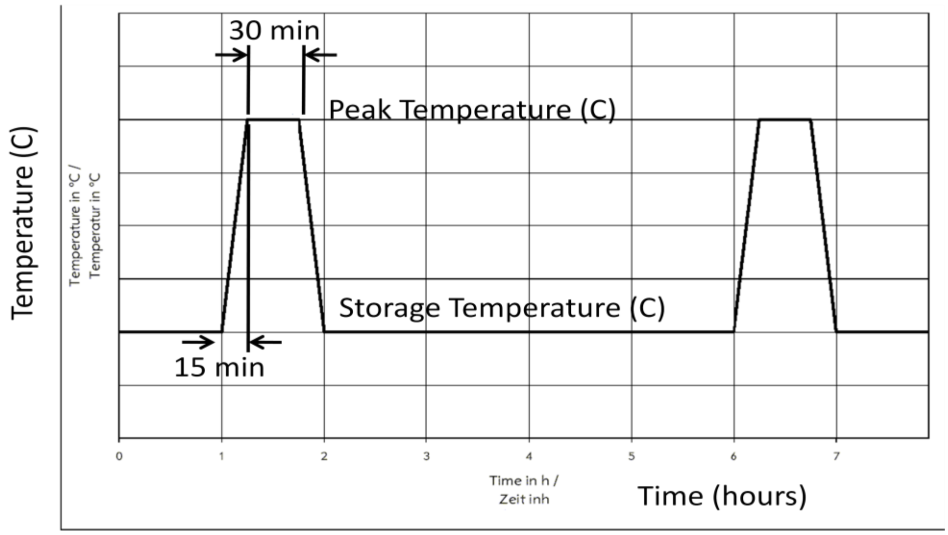


Figure 10b: Section Z: Detail of Temperature Profile

Table 26: Refrigerant Charge for Thermal Pressure Resistance

Hose Type	Charge Quantity
Normal Temperature	0.116 g/cm^3
High Temperature	0.100 g/cm^3

Table 27: Storage Temperature

Hose Type	Storage Temperature	Peak Temperature
Normal Temperature	125 °C	130 °C
High Temperature	135 °C	140 °C

4.3.23.8 Age the test assemblies in the hot chamber for duration:

- For 10 years of expected life: (168 +0/-2) h
- For 15 years of expected life: (252 +0/-2) h

The expected life will be 2.0 to demonstrate R97C50 with a default slope of 2.0. See 3.2.3.3

4.3.23.9 At the end of the test, allow the test samples to cool at room temperature (+23 ± 2) °C for a period of 30 minutes.

4.3.23.10 Weigh the test samples with to an accuracy of 0.01 g.

4.3.23.11 Visually inspect the hose material for signs of degradation and damage.

4.3.23.12 Measure the crimps (per Figure A8).

4.3.23.13 Perform a Leakage Test per 4.3.3

4.3.23.14 Perform a pressure test on two (2) of the hose test samples.

4.3.23.14.1 Evacuate to 3.3 kPa. Follow procedures 4.3.19.1 thru 4.3.19.7.

4.3.24 Corrosion Resistance Verification Procedure. Complete underhood A/C lines shall be tested per GMW15272, Table B4.

4.3.24.1 Cosmetic Corrosion Resistance. GMW14872, UH (Underhood), All, four (4) per cycle, Method 1/2, Exposure B = 9 for 10 years of expected life and B = 14 cycles for 15 year of expected life

4.3.24.2 Functional Corrosion Resistance. GMW14872, UB (Underbody), All, four (4) per cycle, Method 1/2, Exposure D = 68 for 10 years of expected life and B = 102 cycles for 15 years of expected life.

4.3.24.3 Leak test per 4.3.3 after functional corrosion is complete.

4.3.25 Heat Age Verification Procedure.

4.3.25.1 Test fixtures coming from 4.1.4.4.2 shall be placed in a hot chamber with the following parameters:

4.3.25.1.1 Normal Temperature Hose.

Temperature: (125 ± 3) °C ((257 ± 4.5) °F)

Time:

- For 10 years of expected life: (400 +0/-2) h
- For 15 years of expected life: (600 +0/-2) h

4.3.25.1.2 High Temperature Hose.

Temperature: (135 ± 3) °C ((275 ± 4.5) °F)

Time:

- For 10 years of expected life: (400 +0/-2) h
- For 15 years of expected life: (600 +0/-2) h

The expected life will be 2.0 to demonstrate R97C50 with a default slope of 2.0. See 3.2.3.3

4.3.25.2 Record weight loss of the canisters weekly time period to monitor the leakage performance of the A/C sealing washer through the test.

4.3.25.3 Perform Leak test per 4.3.3.

4.3.26 Appearance Verification Procedure. Visually inspect the A/C hose and coupling assemblies. Make cuts to the crimping to look for any abnormalities (e.g., wrinkles) of the hose assembly with the tube end form.

4.3.27 Qualification Tests for A/C Hose Coupling Design Changes. If the A/C hose and couple assembly supplier was approved and some changes need to be made to the A/C hose and coupling design, the following sections will help the Heating Ventilation Air Conditioning (HVAC) DRE to determine the Validation tests to approve the change.

4.3.27.1 Hose Internal Diameter Change. For cases where the hose internal diameter (ID) has changed from the previously validated hose (hose construction and wall thickness remain unchanged), the supplier must perform all tests per Table 14 except for Material (3.2.1.2) and Corrosion (3.2.1.24).

4.3.27.2 Coupling Shell Material Change (Aluminum vs. Steel). If the material for a previously approved coupling shell is to be changed (for example from aluminum to steel, or a change in material thickness), the following tests shall be performed:

a. Refrigerant Emissions – Long Term (3.2.1.11).
b. Internal Cleanliness (3.2.1.13).
c. Burst Strength (3.2.1.19).
d. Pressure Cycling and Vibration (3.2.1.20).
e. Coupling Leakage (3.2.1.21).
f. Crystallization (3.2.1.7).

4.3.27.3 Post-formed Hose versus Non-formed Hose. If non post-formed hose has been validated and post-formed hose must be validated, the following tests shall be performed:

a. Moisture Vapor Ingression (3.2.1.12)
b. Burst Strength (3.2.1.9)
c. Refrigerant Emissions-Long Term (3.2.1.11)
d. Coupling Integrity (3.2.1.21)

4.3.27.4 Non-Formed Hose versus Post-formed Hose. If post-formed hose has been validated and non-formed hose must be validated, the following tests shall be performed:

a. Refrigerant Emissions- Long Term (3.2.1.11)
b. Burst Strength (3.2.1.19).

4.3.27.5 Metal Tube Wall Thickness Change (Under the Coupling). If the metal tube wall thickness is greater than was previously qualified, no requalification is necessary. However, if the metal tube wall thickness is less than was previously qualified, the following tests must be performed:

a. Burst Strength (3.2.1.19)
b. Coupling Integrity (3.2.1.21).

4.3.27.6 Steel Insert versus Retractable Mandrel. If the coupled hose supplier is changing from a steel insert to a retractable mandrel or vice versa, the following tests shall be performed:

a. Burst Strength (3.2.1.19).
b. Coupling Integrity (3.2.1.21).

4.3.27.7 Bands or Finger Changes on the Coupling. If the coupled hose supplier changes the number of bands or fingers change on the coupling shell, the following tests shall be performed:

a. Pressure Cycling and Vibration (3.2.1.20).
b. Burst Strength (3.2.1.19).
c. Coupling Integrity (3.2.1.21).

4.3.27.8 Steel Tube and Aluminum Shell. If an aluminum tube with an aluminum shell has been validated and a steel tube with aluminum shell needs to be validated, and if the crimp diameters have changed, the following tests shall be completed. If the crimp diameter has not changed, no retesting is required for the tube material change.

a. Burst Strength (3.2.1.19).
b. Coupling Integrity (3.2.1.21).

4.3.27.9 New Coupler with Approved Hose. A new coupler requiring validation with a hose that has already been approved per this specification must perform the following abbreviated test schedule:

a. Refrigeration Emissions - Long Term (3.2.1.11).
b. Internal Cleanliness (3.2.1.13).
c. Change in length/angle (3.2.1.17) and Burst Strength (3.2.1.19).
d. Pressure Cycling and Vibration (3.2.1.20).

e. Coupling Integrity (3.2.1.21)

5 Provisions for Shipping

5.1 The A/C hose and coupling assemblies must be compatible with commercial shipping by air, rail, truck and/or boat and include retaining provisions if necessary. Degradation of the A/C hose and coupling assemblies' appearance, performance, and/or durability due to shipping is not acceptable. Upon successful completion of required manufacturing quality levels, the A/C hose and coupling assemblies must be prepared for delivery in accordance with GM1738 (Intercontinental Packaging Requirements for product part).

5.2 All hose assemblies shall have shipping caps, as specified by the detail drawing which maintain a fully installed position, until the hose assembly is installed into a final system assembly. The shipping caps must conform to GMW15786. During removal, there must be no degradation of features as represented by the detail drawings. This would include but not be limited to, dislodging of sealing mechanism (if required), damage to threads or sealing areas.

6 Notes

6.1 Glossary.

R134a: 1,1,1,2 Tetrafluoroethane, a refrigerant commonly used in automotive air conditioning applications.

R1234yf: 2,3,3,3 Tetrafluoropropene, a low GWP refrigerant used in automotive air conditioning applications.

6.2 Acronyms, Abbreviations, and Symbols.

A1	Input Acceleration
A2	Output Acceleration
A/C	Air Conditioning
ADVP&R	Analysis/Development/Validation Plan and Report
Al	Aluminum
APM	Area Parts Manager
BFO	BOM Family Owner
BOM	Bill of Materials
CI	Coupling Integrity
Cu	Copper
DRE	Design Release Engineer
DSC	Differential Scanning Calorimetric
DV	Design Validation
Fe	Iron
FMEA	Failure Mode and Effects Analysis
g	Gauge, when used with units of pressure
GC	Gas Chromatography
GPDS	Global Product Description System
GWP	Global Warming Potential
HF	Hafnium Element
HP	High Pressure
HT	High Temperature
HVAC	Heating Ventilation Air Conditioning
ID	Inner Diameter
IP	In-Process
IR	Infrared
IRHD	International Rubber Hardness Degree
KPC	Key Product Characteristic

LP	Low Pressure
MIR	Moisture Ingression Rate
MS	Mass Spectrometry
MSDS	Material Safety Data Sheet
NT	Normal Temperature
NVH	Noise Vibration Harshness
OD	Outer Diameter
PAG	Polyalkylene Glycol
PC	Personal Computer
PIXE	Proton Induced X-ray Emissions
P/N	Part Number
POE	Polyolester
PPAP	Production Part Approval Process
ppm	parts per million
PTFE	Polytetrafluoroethylene
PV	Product Validation
RCA	Root Cause Analysis
REP	Reliability Evaluation Point
RH	Relative Humidity
SPC	Statistical Process Control
SQE	Supplier Quality Engineer
T_g	Glass Transition Temperature
TGA	Thermogravimetric Analysis
TXV	Thermostatic Expansion Valve
UB	Underbody
UH	Underhood
VTS	Vehicle Technical Specification

7 Additional Paragraphs

7.1 All parts or systems supplied to this standard must comply with the requirements of GMW3059, **Restricted and Reportable Substances for Parts.**

8 Coding System

This standard shall be referenced in other documents, drawings, etc., as follows:

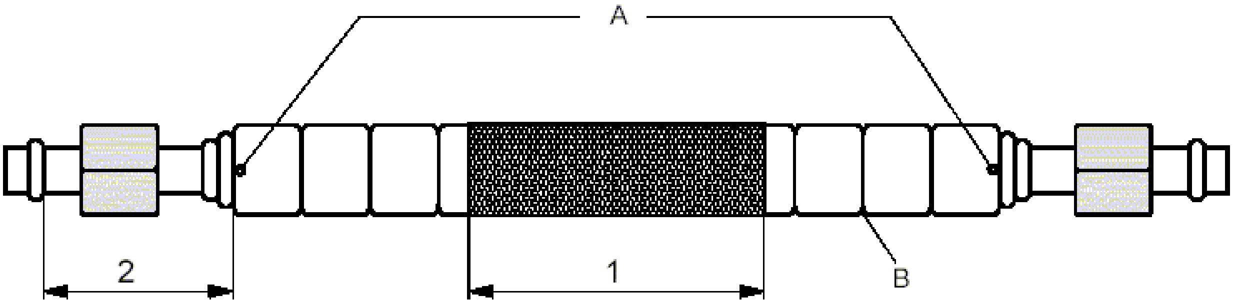
GMW14319

9 Release and Revisions

This standard was originated in September 2005. It was first approved by the A/C Lines and Fittings Subsystem Leadership Team and the Global Plumbing SSLT in January 2006. It was first published in January 2006.

Issue	Publication Date	Description (Organization)
1	JAN 2006	Initial publication.
2	MAR 2012	General revision supporting 5 Year refresh project. (A/C Lines and Fittings GSSLT)

Appendix A



Legend
A Check hole of 2.5 mm for leak detection unit or impulse leakage.
B Determine crimping dimensions.
1 = Length of exposed hose per Table A1
2 = Length of pipe section per Table A1

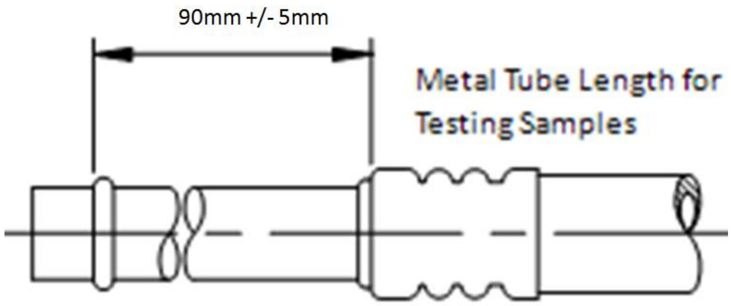


Figure A1: Coupling Construction for Tests

Table A1: Coupled Hose Assembly Required Tests

Paragraph Number	Hose Length Exposed to Refrigerant (Item 1, Figure A1)	Test Name
4.3.7	(76 ± 1.3) cm ((30 ± 0.5) in)	Crystallization, Low Temperature Embrittlement, and Vacuum Flattening
4.3.11	107 ± 1.3) cm ((42 ± 0.5) in)	Refrigerant Emissions (Short Term Loss Rate/Long Term Loss Rate)
4.3.12	(152 ± 1.3) cm ((60 ± 0.5) in)	Moisture Vapor Ingression
4.3.14	(76 ± 1.3) cm ((30 ± 0.5) in)	Extractables
4.3.17	(76 ± 1.3) cm ((30 ± 0.5) in)	Change in Length/Change in Angle Verification Procedure
4.3.20	(76 ± 1.3) cm ((30 ± 0.5) in)	Pressure Cycling and Vibration
4.3.21	(7.6 ± 1.3) cm ((3.0 ± 0.5) in) canister	Coupling Integrity
4.3.18	(76 ± 1.3) cm ((30 ± 0.5) in)	Delamination

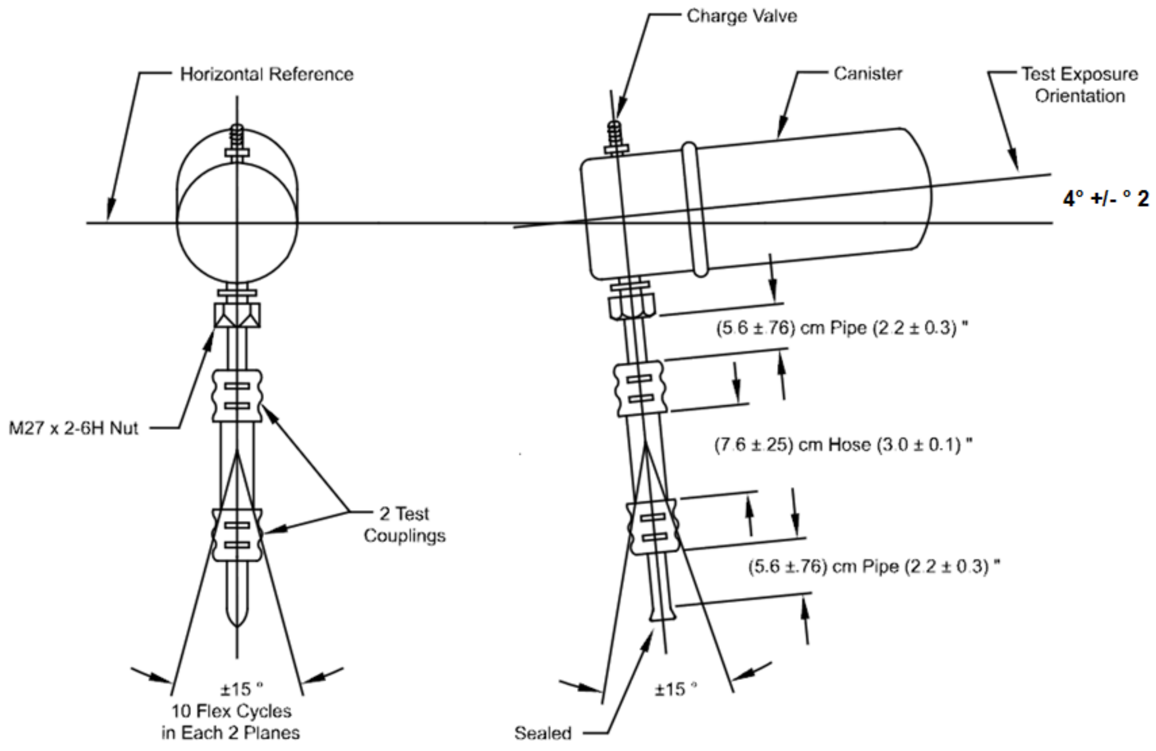
Table A1a: Hose Lengths for Required Tests

Nominal Diameter	Hose Type	Free Length of Hose (Figure A1, Item 1)	Length of Fitting (Figure A1, Item 2)
8 mm (5/16 in) 10 mm (13/32 in) 12.7 mm (1/2 in) 16 mm (5/8 in) 19 mm (3/4 in)	**A** (Rubber)	(200 ± 5) mm	(90 ± 5) mm
	B (Standard Permeation)	(500 ± 5) mm	(90 ± 5) mm
	C (Low Permeation)	(680 ± 5) mm	(90 ± 5) mm

Table A2: Required End Forms and Nuts, Sealing Components and Tightening Torques

Hose ID/ Internal Volume	Tube End Forms	Nuts	Torques Required for Assembling Samples
8 mm (5/16 in)/ 1.0 cm^3 ± 10%	3/8 inch Tube Standard Male Pilot	GM P/N 52458086 M18 × 1.5 - 6H	(15 to 18) Nm ((11 to 13) ft·lb)
10 mm (13/32 in) 2.0 cm^3 ± 10%	1/2 inch Tube Standard Male Pilot	GM P/N 52458087 M20 × 1.5 - 6H	(15 to 18) Nm ((11 to 13) ft·lb)
12.7 mm (1/2 in) 2.0 cm^3 ± 10%	1/2 inch Tube Standard Male Pilot	GM P/N 52458087 M20 × 1.5 - 6H	(27 to 33) Nm ((20 to 24) ft·lb)
16 mm (5/8 in) 7.0 cm^3 ± 10%	3/4 inch Tube Standard Male Pilot	GM P/N 52458090 M27 × 2 - 6H	(45 to 55) Nm ((33 to 40) ft·lb)
19 mm (3/4 in) 10.0 cm^3 ± 10%	3/4 inch Tube Standard Male Pilot	GM P/N 52458090 M27 × 2 - 6H	(45 to 55) Nm ((33 to 40) ft·lb)

P/N = Part Number



* An optional orientation can have the hose assembly out the top of the canister in a 180 degree alignment. The assembly could then be placed vertically. The female fitting on the canister should be flush on the inside, so lubricant can drain into the hose assembly.

Figure A2: Coupling Leakage Test Setup

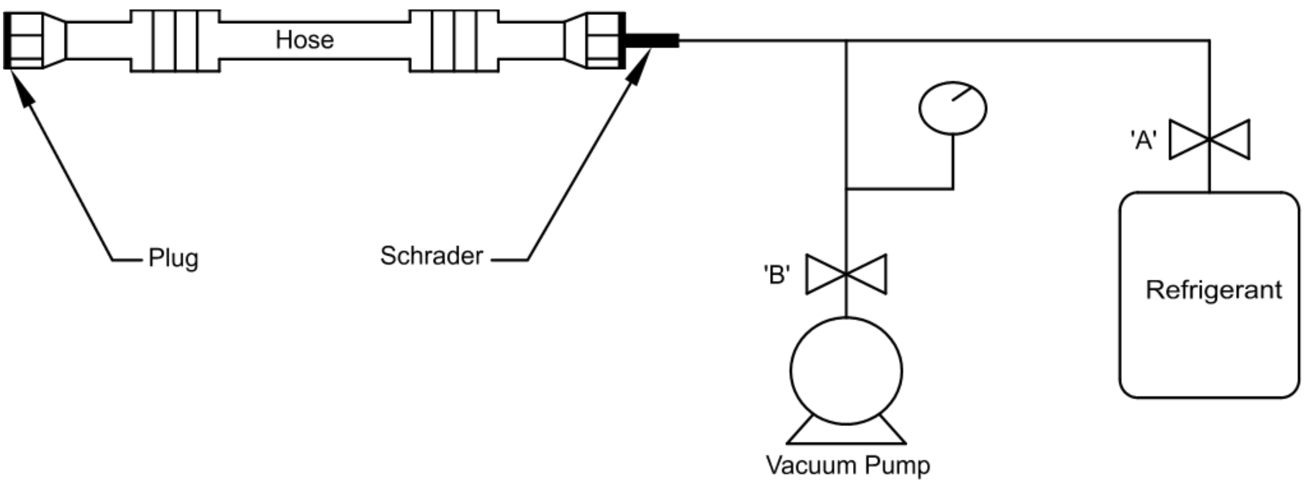


Figure A3: Hose Assembly

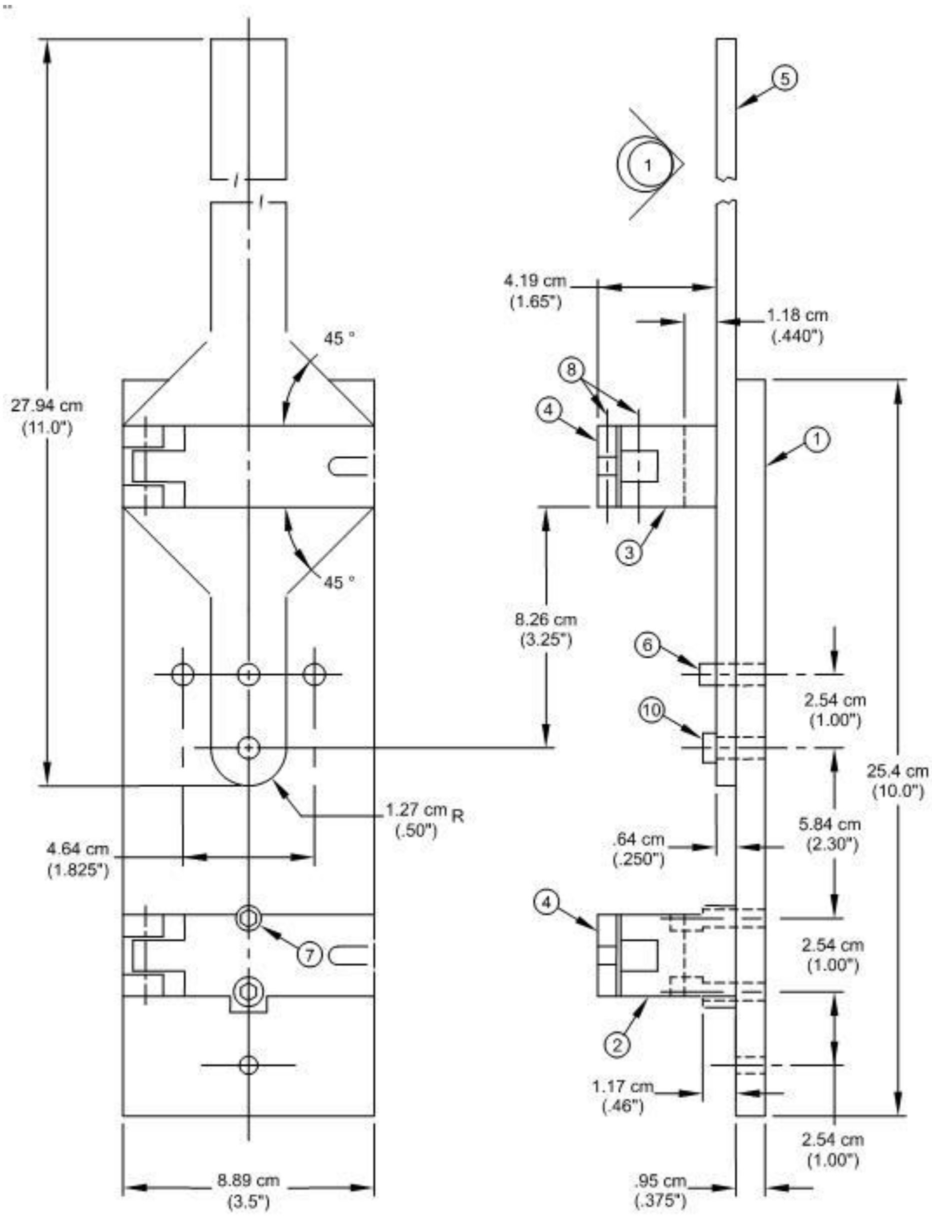
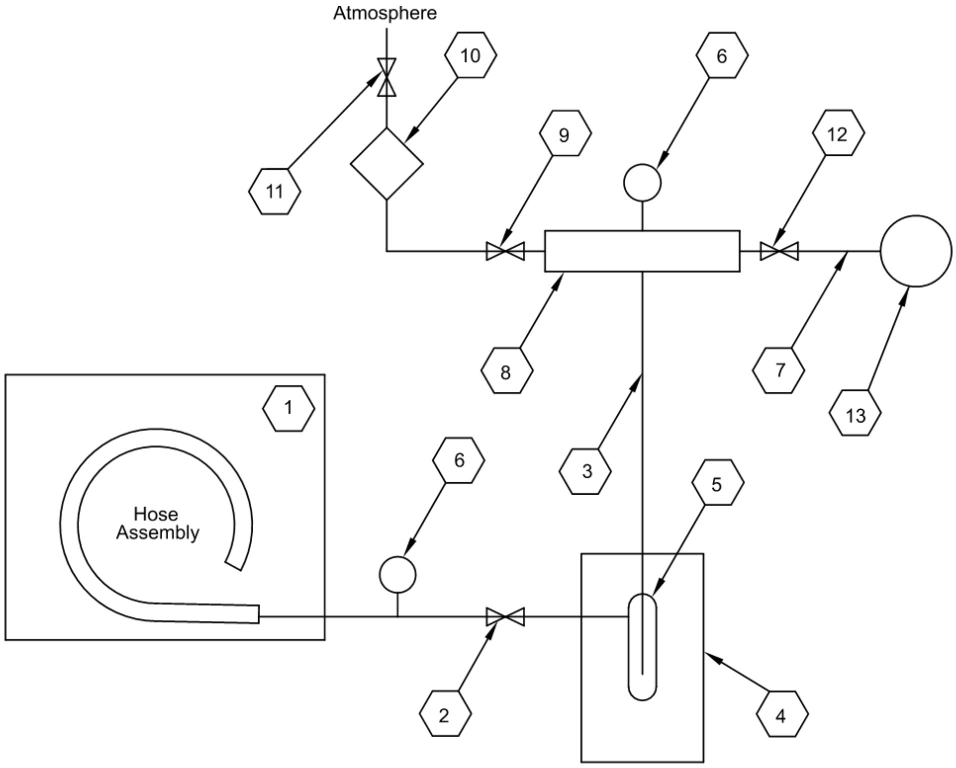


Figure A4: Hose Flexing Fixture



Legend

Item Description

1 Humidity Chamber
2 Stainless Steel Valve
3 Copper or Stainless Steel Tubing
4 Methanol/Dry Ice Bath
5 Glass Vacuum Traps
6 Vacuum Gauges
7 Vacuum Hose
8 Vacuum Manifold
9 Stainless Steel Valve
10 Desiccant Dryer (Indicating Silica Gel)
11 Quick Open Valve
12 Vacuum Valve
13 Vacuum Pump

Figure A5: Moisture Ingression Test Schematic

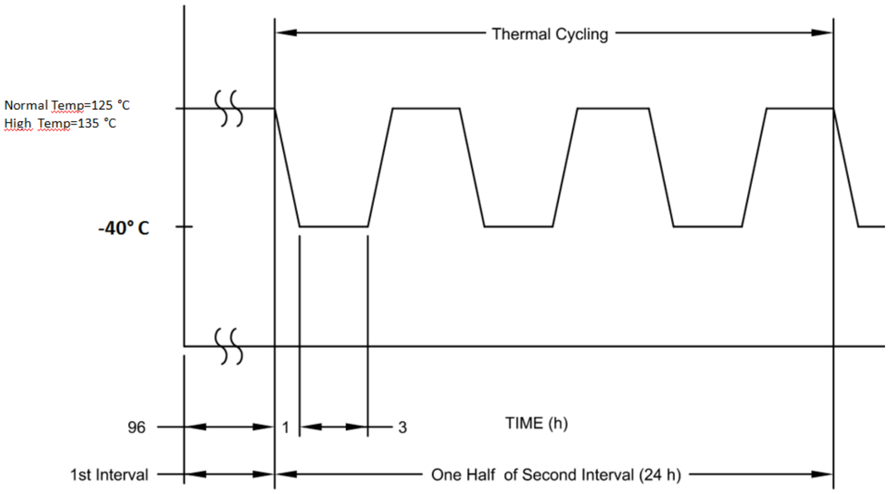


Figure A6: Coupling Integrity - Temperature vs. Time

Data Worksheet

Hose Source and Type ______________________

Hose Size ______________________

Straight or Post Form ______________________

Shell Material ______________________

Tube Material ______________________

Production Crimp Diameter ______________________ ±

		Coupled Hose Supplier Sample Number	Hose Date Code	Crimp Diameter, mm (in)	Percent Compression, %	Total Weight Loss Minus Volatility
	Volatility					
MAXIMUM	**1**					
	2					
NOMINAL	**3**					
MINIMUM	**4**					
	5					
	6					

Specification Acceptance Criteria	Interval	8 mm and 10 mm	12.7 mm	16 mm	19 mm
	4	3	6	6	8
	8	4	6	8	10

Figure A7: Setup for Sealing A/C Hoses

Linear Compression:

Linear Hose Wall Compression = $[(To - Tf) / To] \times 100\%$

Where:

To = Initial hose wall thickness (prior to crimping)

Tf = Final hose wall thickness (after crimping)

Area Hose Wall Compression:

Area Hose Wall Compression = $(1 - ([R^2_{OD\text{-}F} - R^2_{ID\text{-}F}] / [R^2_{OD\text{-}I} - R^2_{ID\text{-}I}])) \times 100\%$

Where:

$R_{ID\text{-}I}$ = Initial ID radius of the hose (prior to crimping)

$R_{OD\text{-}I}$ = Initial OD radius of the hose (prior to crimping)

$R_{ID\text{-}F}$ = Initial ID radius of the hose (after crimping)

$R_{OD\text{-}F}$ = Final OD radius of the hose (after crimping)

Figure A8: A/C Hose Wall Compression

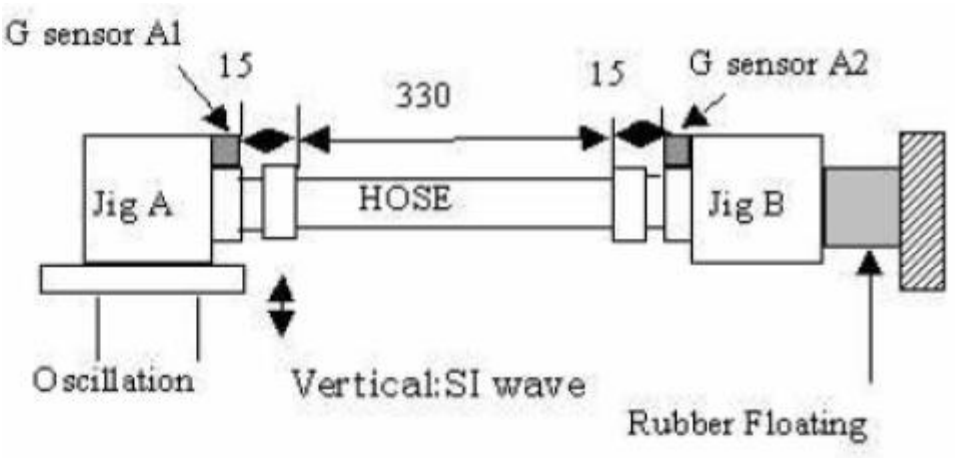


Figure A9: Vibration Transfer Characteristic Test Setup

Appendix B: Determination of the Refrigerant Permeation of Hoses (Alternate Method)

B1 Introduction

The aspired application of new developed Low Global Warming Potential (GWP) refrigerant R1234yf is connected with an extensive investigation program. Appendix B explains the determination of the permeation hoses.

B2 Materials Scheme

The scientific investigation program consists of the tests of hoses for the permeation with the new Low GWP refrigerant "R1234yf" and "R134a" as a reference in combination with the recommended oil applied to the following hoses types:

- High Temperature: (HT) hoses.
- Normal Temperature (NT) hoses.

B2.1 Testing Procedures. The testing procedures are described in the following sections. The description includes the preparation of the hoses, the testing environment, the thermal/refrigerant treatment and the measuring conditions.

The hose handling and the testing procedures are shown in Figure B1.

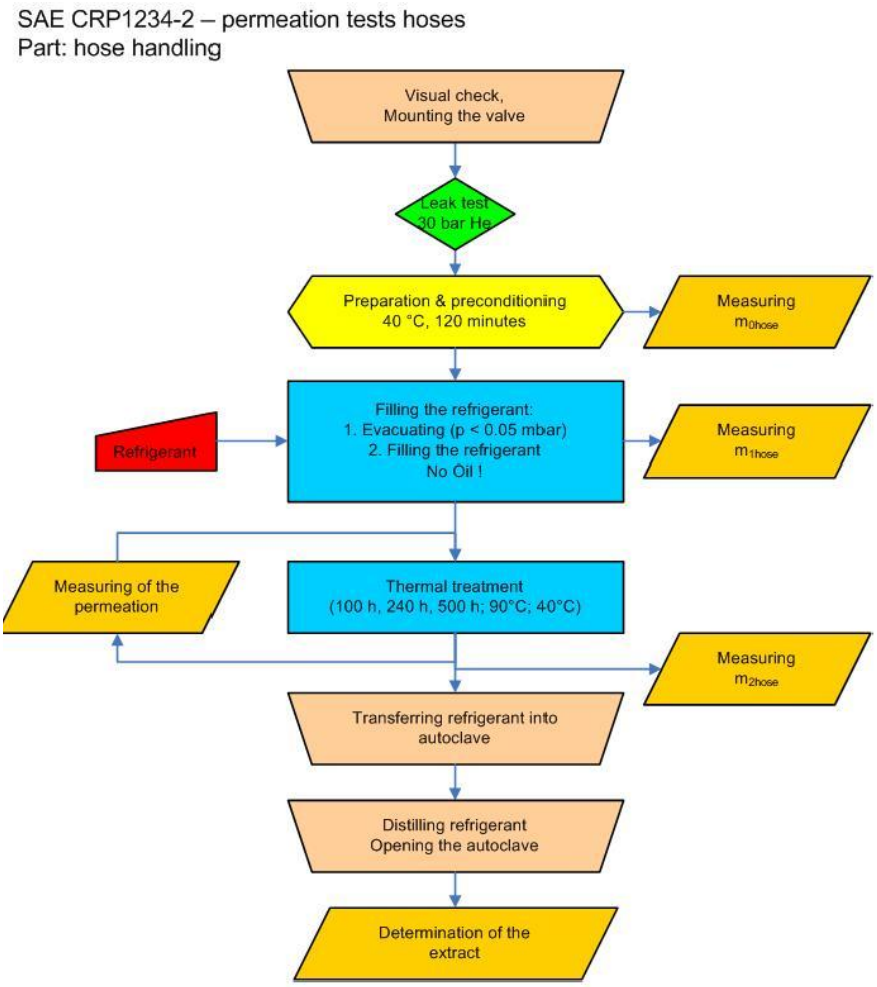


Figure B1: Hose Handling and Testing Procedures

B2.1.1 Preparation and Tightness Check. First, a single test hose is prepared. Some brands of hoses may need to be sealed on one end. The only technology to achieve a nearly refrigerant proof seal is closing by electron-beam welding or adhering.

Any remaining leaks (leaks with more than 1.0 g/h refrigerant loss) must be sealed with a copper cap fastened with a high temperature resistant epoxy adhesive. The leak tests are performed with helium at 3 MPa (435 psi) pressure. Any leaking helium will be detected by mass spectrometry (MS).

Next, a filling valve is mounted using a metallic proofing system by “Serto”. The mounting point, including the filling valve, is located outside of the area used to collect the permeate.

B2.1.2 Filling with Refrigerant. The filling equipment is shown in the Figure B2.

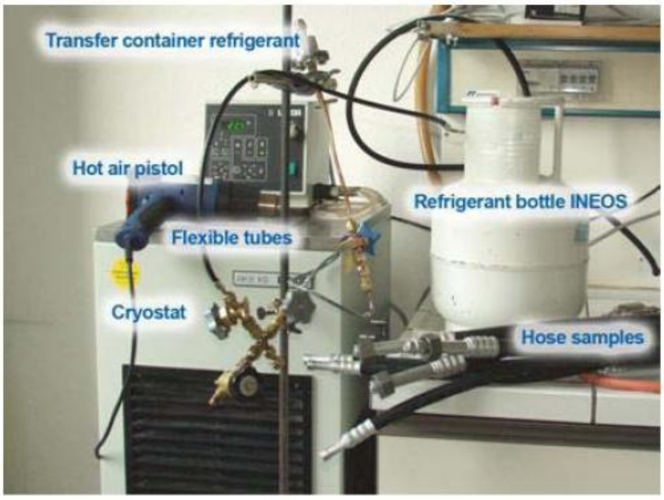


Figure B2: Filling Equipment

Filling is performed using an assisting vessel with a volume suitable for each hose brand.

For filling, the entire system including the hose is evacuated to < 0.01 kPa. Next, the valves for the vacuum pump are closed. The assisting vessel (stored in a cryostat at -35 °C) is filled first. After the assisting vessel is filled, the valve of the refrigerant reservoir is closed and the refrigerant is forced into the hose using hot air. The filling result is controlled gravimetrically.

Table B1: Refrigerant Filling Masses for Test Hoses

Hose Diameter	Refrigerant Mass
10 mm	(25 to 40) g
13 mm	(50 to 70) g
16 mm	(70 to 100) g

B2.1.3 Mounting of the Hoses in the Permeation Housings. The permeation housings shown schematically in Figure B3 are sealed by an O-ring system.

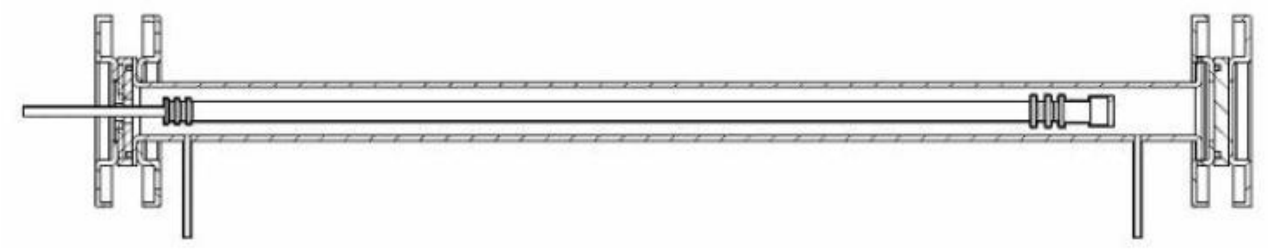


Figure B3: The Permeation Housing

The permeation housing is equipped with two connectors to create a gas loop using a pump and the helium gas carrier. These connectors are open in the following storage process at treatment temperature.

B2.1.4 Thermal Treatment at 90 °C and at 40 °C. A thermo chamber with a volume of 3.0 m^3 is used to store the permeation housings at treatment temperature. About 60 permeation housings can be stored simultaneously as shown in Figure B4.

Figure B4: Thermo Chamber

The permeation housings remain until approximately 1 h before the permeation measuring in the thermo chamber.

B2.1.5 Determination of the Permeation. The permeation housings are taken out from the storage for measuring and are placed in a smaller thermo chamber adapted for the GC-system (see Figure B5) at 90 °C and at 40 °C.

Polytetrafluoroehtylene (PTFE)-hoses (4 mm diameter) are used to connect the permeation housings. A gas loop is created, incorporating a pump. The gas chromatograph is connected directly through a capillary system. The permeation measurement is performed with a P200H Micro Gas Chromatograph by Agilent, using a Micro-TCD detector. Helium is used as the carrier gas. The data acquisition and the control of the GC-system are performed with a personal computer (PC) using the EZChrom Elite/Server software.

First, the loop at the permeation housing is established, then the permeation space is evacuated and the vacuum is replaced with helium. A gas sample is analyzed in defined intervals using the gas chromatograph.

Figure B5: Gas Chromatography Equipment

The measurement signals are integrated over time. A linear increase results in the case of undisturbed permeation. The area values can be derived from the linear increase. The measurement duration is 24 hours (maximum), at 40 °C only.

The calculation of the permeated refrigerant is derived from the calibration data. The result shows the permeated amount of the refrigerant per hour in units of (volume), parts per million (ppm). Using the molecular weight of the refrigerant component, the yearly permeated amount of a component is calculated.

B2.1.6 Comment About the Permeation Testing Conditions. The determination of the permeation is being performed under conditions the maximum permeation is expected. The testing program includes the determination of the permeation after 100 h, 240 h and 500 h, at 90 °C. An additional measurement at 40 °C is performed to show the permeation under normal conditions.

As a result of prior investigations, it can be stated:

- Not all hose and refrigerant combinations reach a static permeation during the 240 h test, therefore, the 500 h test is required.
- For some hose and refrigerant combinations, the 40 °C value measured was below the resolution of the measuring equipment. In this case, permeation could not be measured accurately.
- Measuring the permeation at -30 °C is not expected to deliver reliable values over 24 h. For scheduling reasons, the determination of the permeation at -30 °C will not be performed.

B2.1.7 Determination of the Refrigerant Extract from Hoses. The extract from one HT-hose of each brand is examined after the permeation tests. The refrigerant is transferred to an evacuated and cleaned autoclave. Then, the refrigerant is transferred to an evacuated and cleaned autoclave, and the refrigerant is distilled out. The remaining residue is dissolved in R113 or Dichloromethane and transferred to a glass bulb. After the solvent evaporates, the following parameters are determined:

- The mass of the extract, by gravimetry.
- The character of the extract, by gas chromatography.
- The character of the extract, by infrared (IR) spectroscopy.
- The character of the extract, by GC/MS.

All spectrograms are delivered with final report. The goal is the determination of the material class of the extract and the determination of the mass. Depending on the limits of the measuring equipment, the identification of each extract component may not be possible.

Appendix C: Collision, Shock, and Vibration Input Data Conditions

C1 Vehicle Accident

Test to simulate the effect of a minor vehicle accident that does not result in the vehicle being "totaled" and components are not directly affected by the collision. An example of this might be a vehicle that was hit in the rear or side impact from a collision.

Table C1: Vehicle Accident Simulation Test

Description	Test Parameter Value
Acceleration	100G
Nominal Shock Duration	11 ms
Nominal Shock Shape	Half Sine
Total Number of Shocks: Lateral (Right, Left), Vertical (Up, Down), Horizontal (Fore, Aft)	For 10 years of expected life: 3 × 6 Directions = 18 (per GMW3172) For 15 years of expected life: 5 × 6 Directions = 30 (per GMW3172)
Temperature	T Ambient

C2 Vehicle Pothole

Test to simulate the effect of potholes in the road while traveling at a moderate rate of speed. The pulse that is generated from hitting a pothole results in a large G force with a half sine shape that occurs in all axes.

Table C2: Vehicle Pothole Simulation Test

Description	Test Parameter Value
Acceleration	25G
Nominal Shock Duration	10 ms
Nominal Shock Shape	Half Sine
Total Number of Impacts: Lateral (Right, Left), Vertical (Up, Down), Horizontal (Fore, Aft)	For 10 years of expected life: 400 × 6 Directions = 2400 (per GMW3172) For 15 years of expected life: 600 × 6 Directions = 3600 (per GMW3172)

C3 Vibration for Sprung Masses

Random Vibration for Sprung Masses. This test evaluates the adequate design margin for fatigue resulting from random vibration induced by rough roads.

Trucks:

The following profile with 2.0 G_{rms} of energy is to be run per the following:

For 10 years of expected life: 36 h for each of the vertical, lateral, and fore-aft axes, per GMW3172.

For 15 years of expected life. 54 h for each of the vertical, lateral, and fore aft axes, per GMW3172.

This is representative of the damage accumulated on the Belgian Block Course at the GM Milford Proving Ground, and is representative of the 99.8% severe customer.

Cars:

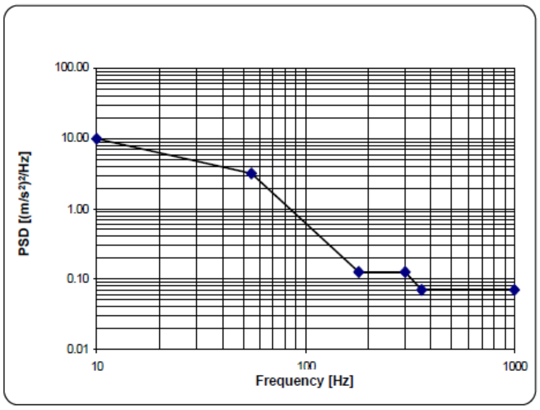
The following profile with 2.0 G_{rms} of energy is to be run per the following:

For 10 years of expected life: 16 h for each of the vertical, lateral, and fore-aft axes, per GMW3172.

For 15 years of expected life. 24 h for each of the vertical, lateral, and fore aft axes, per GMW3172.

This is representative of the damage accumulated on the Belgian Block Course at the GM Milford Proving Ground and is representative of the 99.8% severe customer.

The temperature profile used to run "Vibration for Sprung Masses" section must follow the profile in Appendix D, with a minimum temperature of (-40 ± 3) °C and maximum temperature of (+135 ± 3) °C ((275 ± 4.5) °F) for High Temperature hoses and (+125 ± 3) °C ((257 ± 4.5) °F) for Normal Temperature hoses.

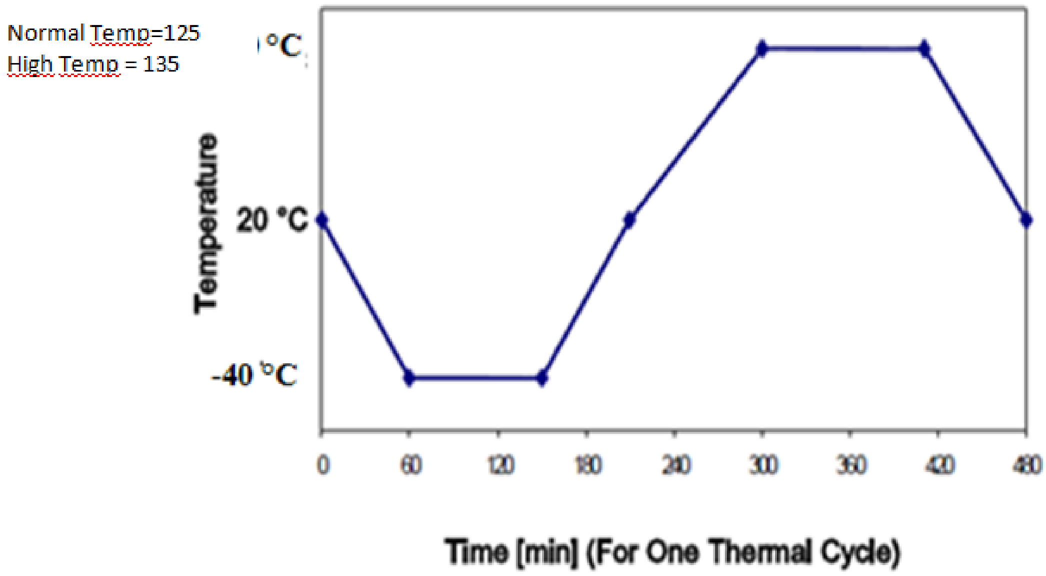


Effective Acceleration = 19.6 m/s^2 = 2.0 G_{RMS}

Fre-quency	Power Spectral Density	
10 Hz	9.9069 $(m/s^2)^2/Hz$	= 0.1032 G^2/Hz
55 Hz	3.2245 $(m/s^2)^2/Hz$	= 0.0336 G^2/Hz
180 Hz	0.1238 $(m/s^2)^2/Hz$	= 0.0013 G^2/Hz
300 Hz	0.1238 $(m/s^2)^2/Hz$	= 0.0013 G^2/Hz
360 Hz	0.0695 $(m/s^2)^2/Hz$	= 0.0007 G^2/Hz
1000 Hz	0.0695 $(m/s^2)^2/Hz$	= 0.0007 G^2/Hz

Figure C1: Cars and Trucks - Random Vibration Profile for Sprung Mass

Appendix D: Temperature Profile Used During All Vibration Tests



Duration	Temperature
0 minutes	20 °C
60 minutes	-40 °C
150 minutes	-40 °C
210 minutes	20 °C
300 minutes	Normal Temp=125° C High Temp = 135° C
410 minutes	Normal Temp=125° C High Temp = 135° C
480 minutes	20 °C

Figure D1: Temperature Profile Used During All Vibration Tests