

**AHRI Standard 700**

**2015 Standard for**

# **Specifications for Refrigerants**



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## **IMPORTANT**

### ***SAFETY DISCLAIMER***

AHRI does not set safety standards and does not certify or guarantee the safety of any products, components or systems designed, tested, rated, installed or operated in accordance with this standard/guideline. It is strongly recommended that products be designed, constructed, assembled, installed and operated in accordance with nationally recognized safety standards and code requirements appropriate for products covered by this standard/guideline.

AHRI uses its best efforts to develop standards/guidelines employing state-of-the-art and accepted industry practices. AHRI does not certify or guarantee that any tests conducted under its standards/guidelines will be non-hazardous or free from risk.

Note:

This standard supersedes AHRI Standard 700-2014 with Addendum 1.

#### **AHRI CERTIFICATION PROGRAM PROVISIONS**

##### **Scope of the Certification Programs**

The Reclaimed Refrigerant and Refrigerant Testing Laboratory Certification Programs are based on this standard. The Reclaimed Refrigerant Certification Program includes purity specifications for reclaimed refrigerants. The Refrigerant Testing Laboratory Certification Program includes verification for refrigerant testing laboratories that perform testing of refrigerants to AHRI Standard 700.

##### **Certified Ratings**

The following ratings are verified by test for the Reclaimed Refrigerant Certification Program:

- a. Water (ppm by weight)
- b. Chloride (pass/fail)
- c. Acidity (ppm by weight)
- d. High boiling residue (% by volume or % by weight)
- e. Particulates/solids (pass/fail)
- f. Air and other non-condensables (% by volume)
- g. All other volatile impurities (% by weight)
- h. Halogenated unsaturated volatile impurities (ppm by weight)

The following contaminants are verified by test for the Refrigerant Testing Laboratory Certification Program:

- a. Water (ppm by weight)
- b. High boiling residue (% by volume or % by weight)
- c. Air and other non-condensables (% by volume)
- d. All other volatile impurities (% by weight)

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# SPECIFICATIONS FOR REFRIGERANTS

## Section 1. Purpose

**1.1 Purpose.** The purpose of this standard is to establish purity specifications, to verify composition, and to specify the associated methods of testing for acceptability of the refrigerants listed in Section 2.1 regardless of source (new, reclaimed and/or repackaged) for use in new and existing refrigeration and air-conditioning products within the scope of AHRI.

**1.1.1 Intent.** This standard is intended for the guidance of the industry including manufacturers, reclaimers, repackagers, distributors, installers, servicemen, contractors and users of fluorocarbon, hydrocarbon and carbon dioxide containing refrigerants.

**1.1.2 Review and Amendment.** This standard is subject to review and amendment as technology advances or as additional data becomes available. This data can be submitted to AHRI for review.

## Section 2. Scope

**2.1 Scope.** This standard specifies acceptable levels of contaminants (purity requirements) for fluorocarbon, hydrocarbon, and carbon dioxide refrigerants regardless of source and lists acceptable test methods. These refrigerants are as referenced in the ANSI/ASHRAE Standard 34 with Addenda:

**2.1.1 Single-Component Fluorocarbon Refrigerants:** R-11; R-12; R-13; R-22; R-23; R-32; R-113; R-114; R-115; R-116; R-123; R-124; R-125; R-134a; R-141b; R-142b; R-143a; R-152a; R-218; R-227ea; R-236fa; R-245fa; R-1233zd(E); R-1234yf; R-1234ze(E)

**2.1.2 Single Component Hydrocarbon Refrigerants:** R-50; R-170; R-E170; R-290; R-600; R-600a; R-601; R-601a; R-610; R-1150; R-1270

**2.1.3 Carbon Dioxide Refrigerant:** R-744

**2.1.4 Zeotropic Blend Refrigerants:** R-401A; R-401B; R-402A; R-402B; R-403A; R-403B; R-404A; R-405A; R-406A; R-407A; R-407B; R-407C; R-407D; R-407E; R-407F; R-408A; R-409A; R-409B; R-410A; R-410B; R-411A; R-411B; R-412A; R-413A; R-414A; R-414B; R-415A; R-415B; R-416A; R-417A; R-417B; R-417C; R-418A; R-419A; R-419B; R-420A; R-421A; R-421B; R-422A; R-422B; R-422C; R-422D; R-422E; R-423A; R-424A; R-425A; R-426A; R-427A; R-428A; R-429A; 430A; R-431A; R-434A; R-435A; R-437A; R-438A; R-439A; R-440A; R-442A; R-444A; R-444B; R-445A; R-446A; R-447A; R-448A; R-449A; R-450A

**2.1.5 Zeotropic Hydrocarbon Blend Refrigerants:** R-432A; R-433A; R-433B; R-433C; R-436A; R-436B; R-441A; R-443A

**2.1.6 Azeotropic Blend Refrigerants:** R-500; R-502; R-503; R-507A; R-508A; R-508B; R-509A; R-510A; R-511A; and R-512A.

## Section 3. Definitions

All terms in this document will follow the standard industry definitions in the *ASHRAE Terminology* website (<https://www.ashrae.org/resources--publications/free-resources/ashrae-terminology>) unless otherwise defined in this section.

**3.1 “Shall” or “Should”.** “Shall” or “should” shall be interpreted as follows:

**3.1.1 Shall.** Where “shall” or “shall not” is used for a provision specified, that provision is mandatory if compliance with the standard is claimed.

**3.1.2 Should.** “Should” is used to indicate provisions which are not mandatory but which are desirable as good practice.

## Section 4. Characterization of Refrigerants and Contaminants

**4.1** *Characterization.* Characterization of single component fluorocarbon (Table 1A) and zeotropic/azeotropic blend (Table 2A/3) refrigerants and contaminants are listed in the following general classifications:

- 4.1.1 Isomer content (see Table 1A)
- 4.1.2 Air and other non-condensables (see Tables 1A, 2A, 3)
- 4.1.3 Water (see Tables 1A, 2A, 3)
- 4.1.4 All other volatile impurities (see Tables 1A, 2A, 3)
- 4.1.5 High boiling residue (see Tables 1A, 2A, 3)
- 4.1.6 Halogenated unsaturated volatile impurities (see Table 1A)
- 4.1.7 Particulates/solids (see Tables 1A, 2A, 3)
- 4.1.8 Acidity (see Tables 1A, 2A, 3)
- 4.1.9 Chloride (see Tables 1A, 2A, 3)

**4.2** *Hydrocarbon Characterization.* Characterization of hydrocarbon refrigerants (Tables 1B and 2B) and contaminants are listed in the following general classifications:

- 4.2.1 Nominal composition
- 4.2.2 Other allowable impurities
- 4.2.3 Air and other non-condensables
- 4.2.4 Sulfur odor
- 4.2.5 High boiling residue
- 4.2.6 Particulates/solids
- 4.2.7 Acidity
- 4.2.8 Water
- 4.2.9 All other volatile impurities
- 4.2.10 Total C<sub>3</sub>, C<sub>4</sub> and C<sub>5</sub> polyolefins

**4.3** *Carbon Dioxide Characterization.* Characterization of carbon dioxide (Table 1C) and its contaminants are listed in the following general classifications:

- 4.3.1 Purity
- 4.3.2 Air and other non-condensables
- 4.3.3 Water
- 4.3.4 High boiling residue
- 4.3.5 Particulates/solids

## Section 5. Sampling and Summary of Test Procedures

**5.1** *Referee Test.* The referee test methods for the various contaminants are summarized in the following paragraphs. Detailed test procedures are included in Appendix C to AHRI Standard 700. If alternative test methods are employed, the user shall be able to demonstrate that they produce results at least equivalent to the specified referee test method.

**5.2** *Refrigerant Sampling.*

**5.2.1** *Sampling Precautions.* Special precautions should be taken to ensure that representative samples are obtained for analysis. Sampling shall be done by qualified personnel following accepted sampling and safety procedures. Refrigerants with critical temperatures near or below ambient temperature cannot be reliably sampled for both liquid and vapor phase without special handling.

Note: Flammable refrigerants which are ASHRAE 34 Class 2L, 2 or 3 present additional safety challenges and require additional measures for sampling safety procedures compared to nonflammable halocarbons documented in this standard.

**5.2.2 Cylinder Preparation.** Place a clean, empty sample cylinder with the valve open in an oven at 110°C for one hour. Remove it from the oven while hot, immediately connect it to an evacuation system and evacuate it to less than 56 kPa. Close the valve and allow it to cool. Weigh the empty cylinder.

**5.2.3 Vapor Phase Sampling.** A vapor phase sample shall be obtained for determining the non-condensables. The source temperature shall be measured and recorded at the time the sample is taken.

**5.2.3.1 Special Handling for Low Critical Temperature Refrigerant.** A vapor phase sample is required to determine non-condensables and volatile impurities, including other refrigerants. The vapor phase sample is obtained by regulating the sample container temperature to 5 K or more above the refrigerant critical temperature.

**5.2.3.2 Handling for Liquid Refrigerants with Boiling Points Near or Above Room Temperature.** Since R-11, R-113, R-123, R-141b, R-245fa, and R-1233zd(E) have normal boiling points near or above room temperature, non-condensable determination is not required for these refrigerants.

Note: Non-condensable gases, if present, will concentrate in the vapor phase of the refrigerant; care must be exercised to eliminate introduction of either air or liquid phase refrigerant during the sample transfer.

**5.2.4 Liquid Phase Sampling.** A liquid phase sample is required for all tests listed in this standard except the test for non-condensables.

**5.2.4.1 Liquid Sampling.** Accurate analysis requires that the sample cylinder, at ambient temperature, be filled to at least 60% by volume; however, under no circumstances should the cylinder be filled to more than 80% by volume. This can be accomplished by weighing the empty cylinder and then the cylinder with refrigerant. When the desired amount of refrigerant has been collected, close the valve(s) and immediately disconnect the sample cylinder.

Note: Care should be taken to ensure that all connections and transfer lines are dry and evacuated to avoid contaminating the sample.

Note: Low critical temperature refrigerants can have extremely high pressure and the sampling vessel, all connections and transfer lines must be designed to handle high pressures.

**5.2.4.2 Special Handling for Low Critical Temperature Refrigerant.** A liquid phase sample is required for all testing except volatile impurities, including other refrigerants. The liquid phase sample is obtained by regulating the sample cylinder temperature to 2°C below the critical temperature of the refrigerant.

Note: If free water is present in the sample, cooling to below 0°C may result in the formation of ice. Clathrates may form at temperatures above 0°C with some fluorocarbon refrigerants.

**5.2.4.3 Record Weight.** Check the sample cylinder for leaks and record the gross weight.

**5.3 Refrigerant Identification.** The required method shall be gas chromatography as described in Appendix C with the corresponding gas chromatogram figures as illustrated in Informative Appendix D to AHRI Standard 700. The chromatogram of the sample shall be compared to known standards.

**5.4 Water Content.**

**5.4.1 Method.** The Coulometric Karl Fischer Titration, as described in Appendix C, shall be used for determining the water content of refrigerants. This method can be used for refrigerants that are either a liquid or a gas at room temperature. For all refrigerants, the sample for water analysis shall be taken from the liquid phase of the container to be tested.

**5.4.2 Limits.** The value for water content shall be expressed in parts per million (ppm) by weight and shall not exceed the maximum specified in Tables 1A, 1B, 1C, 2A, 2B and 3.

**5.5** *Conductivity. (Alternative to chloride and acidity tests).*

**5.5.1 Method.** A refrigerant may be tested for conductivity as an indication of the presence of acids, metal chlorides, and any compound that ionizes in water. This alternative procedure is intended for use with new or reclaimed refrigerants, however, significant amounts of oil can interfere with the test results.

**5.5.2 Limits.** The value for conductivity shall be converted to and expressed in ppm by weight calculated as HCl and shall be compared with the maximum acidity value specified (see in Tables 1A, 1B, 1C, 2A, 2B, and 3). If the conductivity is above this amount, then the chloride and acidity tests shall be conducted. If the conductivity is not greater than this amount, then the chloride and acidity tests may be omitted.

**5.6** *Chloride.*

**5.6.1 Method.** The refrigerant shall be tested for chloride as an indication of the presence of hydrochloric acid and/or metal chlorides. The referee procedure is intended for use with new or reclaimed halogenated refrigerants; however, high boiling residue in excess of the amounts in Tables 1A, 1B, 1C, 2A, 2B and 3 can interfere with the test results.

The test method shall be that described in Appendix C to AHRI Standard 700. The test will show noticeable turbidity at chloride levels of about 3 ppm or greater by weight.

**5.6.2 Limits.** The results of the test shall not exhibit any sign of turbidity. Report the results as “pass” or “fail.”

**5.7** *Acidity.*

**5.7.1 Method.** The acidity test uses the titration principle to detect any compound that is soluble in water and ionizes as an acid. The test method shall be that described in Appendix C to AHRI Standard 700. This test may not be suitable for determination of high molecular weight organic acids; however, these acids will be found in the high boiling residue test outlined in Section 5.8. The test requires a 50 to 60 gram sample and has a detection limit of 0.1 ppm by weight calculated as HCl.

**5.7.2 Limits.** The value for acidity shall be expressed in ppm by weight as HCl and shall not exceed the limits in Tables 1A, 1B, 2A, 2B and 3.

**5.8** *High Boiling Residue.*

**5.8.1 Method.** High boiling residue shall be determined by either volume or weight. The volume method measures the residue from a standard volume of refrigerant after evaporation. The gravimetric method is described in Appendix C to AHRI Standard 700. Oils and/or organic acids will be captured by these methods.

**5.8.2 Limits.** The value for high boiling residue shall be expressed as a percentage by volume or weight and shall not exceed the maximum percent specified in Tables 1A, 1B, 1C, 2A, 2B and 3.

**5.9** *Particulates and Solids.*

**5.9.1 Method.** A measured amount of sample shall be placed in a Goetz bulb under controlled temperature conditions. The particulates/solids shall be determined by visual examination of the Goetz bulb prior to the evaporation of refrigerant. For details of this test method, refer to Part 3 of Appendix C to AHRI Standard 700.

Note: R-744 will partially sublime when measuring a known amount of liquid sample into the Goetz bulb and the solid R-744 will interfere with the visual examination of particulates/solids. Determining the particulates/solids shall be completed by visual examination of the Goetz bulb after the evaporation of the refrigerant.

**5.9.2 Limits.** Visual presence of dirt, rust or other particulate contamination is reported as “fail.”

**5.10** *Non-condensables.*

**5.10.1 Method.** A vapor phase sample shall be used for determination of non-condensables. Non-condensable gases consist primarily of air accumulated in the vapor phase of refrigerants where the solubility of air in the refrigerant liquid

phase is extremely low and air is not significant as a liquid phase contaminant. The presence of non-condensable gases may reflect poor quality control in transferring refrigerants to storage tanks and cylinders.

The test method shall be gas chromatography with a thermal conductivity detector as described in Appendix C to AHRI Standard 700.

**5.10.2 Limits.** The maximum level of non-condensables in the vapor phase of a test sample shall not exceed the maximum at 25.0 °C as shown in Tables 1A, 1B, 1C, 2A, 2B and 3.

**5.11 All Other Volatile Impurities and/or Other Refrigerants.**

**5.11.1 Method.** The amount of volatile impurities including other refrigerants in the subject refrigerant shall be determined by gas chromatography as described in Appendix C to AHRI Standard 700.

**5.11.2 Limits.** The test sample shall not contain more than 0.5% by weight of volatile impurities including other refrigerants as shown in Tables 1A, 1B, 1C, 2A, 2B and 3.

**5.11.2.1 Halogenated Unsaturated Volatile Impurities.** The test sample of a saturated fluorinated refrigerant shall not contain more than 40 ppm by weight of halogenated unsaturated volatile impurities, unless listed individually in Section 5.11.2.2.

The test sample of a blend shall not contain more than 40 ppm by weight of halogenated unsaturated volatile impurities, unless listed individually in Section 5.11.2.2. In the case of a blended saturated fluorinated refrigerant the unsaturates level may be directly measured from the blend to be no more than 40 ppm, unless listed individually in Section 5.11.2.2. Otherwise the unsaturates level in the blend may be calculated from the test data of the individual components and shall contain no more than 40 ppm by weight of halogenated unsaturated volatile impurities, unless listed individually in Section 5.11.2.2.

Refrigerants listed in Tables 2A, 2B and 3 containing an unsaturated fluorinated blend component shall be excluded from this requirement.

**5.11.2.2 Individual Listed Volatile Impurities.** Tables 1A, 1B, 1C, 2A, 2B and 3 list specific volatile impurities and their maximum allowable concentrations in ppm by weight.

**5.12 Total C<sub>3</sub>, C<sub>4</sub> and C<sub>5</sub> Polyolefins in Hydrocarbon Refrigerants.**

**5.12.1 Method.** The amount of polyolefin impurities in the hydrocarbon shall be determined by gas chromatography as described in GPA STD 2177 - *Natural Gas Liquid Mixtures Containing Nitrogen and Carbon Dioxide*.

**5.12.2 Limits.** The test sample shall not contain more than 0.05 % by weight in the hydrocarbon sample as shown in Tables 1B and 2B. Report the results as “pass” or “fail.”

**5.13 Sulfur Odor in Hydrocarbon Refrigerants.**

**5.13.1 Method.** The amount of sulfur containing compounds or other compounds with an odor shall be determined by ASTM method D1296, *Odor of Volatile Solvents and Diluents*.

**5.13.2 Limits.** The test sample paper shall not emit a residual sulfur odor as shown in Tables 1B and 2B.

## Section 6. Reporting Procedure

**6.1 Reporting Procedure.** The source (manufacturer, reclaimer or repackager) of the packaged refrigerant shall be identified. The refrigerant shall be identified by its accepted refrigerant number and/or its chemical name. Maximum allowable levels of contaminants are shown in Tables 1A, 1B, 1C, 2A, 2B and 3. Test results shall be tabulated in a similar manner.



## Section 7. Conformance Conditions

**7.1 Conformance.** While conformance with this standard is voluntary, conformance shall not be claimed or implied for products or equipment within the standard's *Purpose* (Section 1) and *Scope* (Section 2) unless such product claims meet all of the requirements of the standard and all of the testing and rating requirements are measured and reported in complete compliance with the standard. Any product that has not met all the requirements of the standard cannot reference, state, or acknowledge conformance to the standard in any written, oral, or electronic communication.

**Table 1A. Single Component Fluorocarbon Refrigerants and their Allowable Levels of Contaminants**

	Reporting Units	Reference Section	R-11	R-12	R-13	R-22	R-23	R-32	R-113	R-114
<i>CHARACTERISTICS :</i>										
Boiling Point <sup>1</sup>	°C @ 101.3 kPa	N/A	23.7	-29.8	-81.5	-40.8	-82	-51.7	47.6	3.6
Boiling Point Range <sup>1</sup>	K	N/A	± 0.3	± 0.3	± 0.5	± 0.3	± 0.5	± 0.3	± 0.3	± 0.3
Critical Temperature <sup>1</sup>	°C	N/A	198	112	28.9	96.2	26.1	78.1	214.1	145.7
Isomer Content Isomer	% by weight	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0-1 R-133a	0-30 R-144a
<i>VAPOR PHASE CONTAMINANTS :</i>										
Air and Other Non-condensables, Maximum	% by volume @ 25.0°C	5.10	N/A <sup>2</sup>	1.5	1.5	1.5	1.5	1.5	N/A <sup>2</sup>	1.5
<i>LIQUID PHASE CONTAMINANTS:</i>										
Water, Maximum	ppm by weight	5.4	20	10	10	10	10	10	20	10
All Other Volatile Impurities, Maximum	% by weight	5.11	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
High Boiling Residue, Maximum	% by volume or % by weight	5.8	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Halogenated Unsaturated Volatile Impurities, Maximum	ppm by weight	5.11.2.1	40	40	40	40	40	40	40	40
Particulates/Solids	Pass or Fail	5.9	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean
Acidity, Maximum	ppm by weight (as HCl)	5.7	1	1	1	1	1	1	1	1
Chloride <sup>3</sup>	Pass or Fail	5.6	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity

Notes:

1. Boiling points, boiling point ranges and critical temperatures, although not required, are provided for informational purposes. Refrigerant data compiled from Refprop 9.1.
  2. Since R-11, R-113, R-123, R-141b, R-245fa, and R-1233zd(E) have normal boiling points near or above room temperature, non-condensable determinations are not required for these refrigerants.
  3. Recognized chloride level for pass/fail is about 3 ppm.
- N/A Not Applicable

Table 1A. Single Component Fluorocarbon Refrigerants and their Allowable Levels of Contaminants (continued)

	Reporting Units	Reference Section	R-115	R-116	R-123	R-124	R-125	R-134a	R-141b
<i>CHARACTERISTICS :</i>									
Boiling Point <sup>1</sup>	°C @ 101.3 kPa	N/A	-38.9	-78.2	27.8	-12	-48.1	-26.1	32
Boiling Point Range <sup>1</sup>	K	N/A	± 0.3	± 0.3	± 0.3	± 0.3	± 0.3	± 0.3	± 0.3
Critical Temperature <sup>1</sup>	°C	N/A	80	19.9	183.7	122.3	66	101.1	206.8
Isomer Content Isomer	% by weight	N/A	N/A	N/A	0-8 R-123a+ R-123b	0-5 R-124a	N/A	0-0.5 R-134	0-0.1ea R-141, R-141a
<i>VAPOR PHASE CONTAMINANTS :</i>									
Air and Other Non-condensables, Maximum	% by volume @ 25.0°C	5.10	1.5	1.5	N/A <sup>2</sup>	1.5	1.5	1.5	N/A <sup>2</sup>
<i>LIQUID PHASE CONTAMINANTS:</i>									
Water, Maximum	ppm by weight	5.4	10	10	20	10	10	10	100
All Other Volatile Impurities, Maximum	% by weight	5.11	0.5	0.5	0.5	0.5	0.5	0.5	0.9
Halogenated Unsaturated Volatile Impurities, Maximum	ppm by weight	5.11.2 .1	40	40	40	40	40	See footnote <sup>4</sup>	40
High Boiling Residue, Maximum	% by volume or % by weight	5.8	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Particulates/Solids	Pass or Fail	5.9	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean
Acidity, Maximum	ppm by weight (as HCl)	5.7	1	1	1	1	1	1	1
Chloride <sup>3</sup>	Pass or Fail	5.6	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity

## Notes:

- Boiling points, boiling point ranges and critical temperatures, although not required, are provided for informational purposes. Refrigerant data compiled from Refprop 9.1.
  - Since R-11, R-113, R-123, R-141b, R-245fa, and R-1233zd(E) have normal boiling points near or above room temperature, non-condensable determinations are not required for these refrigerants.
  - Recognized chloride level for pass/fail is about 3 ppm.
  - Up to 5000 ppm R-1234yf is acceptable as a halogenated unsaturated volatile impurity in R-134a.
- N/A Not Applicable

**Table 1A. Single Component Fluorocarbon Refrigerants and their Allowable Levels of Contaminants (continued)**

	Reporting Units	Reference Section	R-142b	R-143a	R-152a	R-218	R-227ea	R-236fa	R-245fa	R-1233zd(E)	R-1234yf	R-1234ze(E)	
<i>CHARACTERISTICS :</i>													
Boiling Point <sup>1</sup>	°C @ 101.3 kPa	N/A	-9.2	-47.2	-24	-36.8	-16.5	-1.4	14.9	18.3	-29.4	-19	
Boiling Point Range <sup>1</sup>	K	N/A	--	± 0.3	± 0.3	± 0.3	--	± 0.3	± 0.3	--	N/A	N/A	
Critical Temperature <sup>1</sup>	°C	N/A	137.1	72.7	113.3	72	101.7	124.9	154.1	165.6	94.8	109.4	
Isomer Content Isomer	% by weight	N/A	0-0.1ea R-142, R-142a	0-0.01 R-143	N/A	--	--	--	0-0.1ea R-245ca, R-245cb, R-245ea, R-245eb	--	N/A	0.3 R-1234ze(Z)	
<i>VAPOR PHASE CONTAMINANTS :</i>													
Air and Other Non-condensables, Maximum	% by volume @ 25.0°C	5.10	2	1.5	1.5	1.5	1.5	1.5	1.5	N/A <sup>2</sup>	N/A <sup>2</sup>	1.5	1.5
<i>LIQUID PHASE CONTAMINANTS:</i>													
Water, Maximum	ppm by weight	5.4	15	10	10	10	10	10	20	20	10	10	
All Other Volatile Impurities, Maximum	% by weight	5.11	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	
High Boiling Residue, Maximum	% by volume or % by weight	5.8	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
Halogenated Unsaturated Volatile Impurities, Maximum	ppm by weight	5.11.2.1	40	40	40	40	40	40	40	N/A	N/A	N/A	
Particulates/Solids	Pass or Fail	5.9	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	
Acidity, Maximum	ppm by weight (as HCl)	5.7	3	1	1	1	1	1	1	1	1	1	
Chloride <sup>3</sup>	Pass or Fail	5.6	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	

Notes:  
 1. Boiling points, boiling point ranges and critical temperatures, although not required, are provided for informational purposes. Refrigerant data compiled from Refprop 9.1.  
 2. Since R-11, R-113, R-123, R-141b, R-245fa, and R-1233zd(E) have normal boiling points near or above room temperature, non-condensable determinations are not required for these refrigerants.  
 3. Recognized chloride level for pass/fail is about 3 ppm.  
 N/A Not Applicable  
 -- Data Not Available

Table 1B. Single Component Hydrocarbon Refrigerants and their Allowable Levels of Contaminants

	Reporting Units	R-50	R-170	R-E170	R-290	R-600	R-600a	R-601	R-601a	R-610	R-1150	R-1270
<i>CHARACTERISTICS:</i>												
Boiling Point <sup>1</sup>	°C at 101.3 kPa	-161.5	-88.6	-24.8	-42.1	-0.5	-11.8	36.1	27.8	34.6	-103.8	-47.6
Boiling Point Range <sup>1</sup>	K	± 0.5	± 0.5	± 0.5	± 0.5	± 0.5	± 0.5	± 0.5	± 0.5	± 0.5	± 0.5	± 0.5
Minimum Nominal Composition	% weight	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5	99.5
Other Allowable Impurities	% weight	N/A	N/A	N/A	22	22	22	0-1 R-601a	0-1 R-601	N/A	N/A	0-1 R-290
<i>VAPOR PHASE</i> <sup>3</sup> :												
Air and Other Non-condensables, Maximum	% by volume @ 25.0°C	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
<i>LIQUID PHASE</i> <sup>4</sup> :												
Sulfur Odor	Pass or Fail	No sulfur odor	No sulfur odor	No sulfur odor	No sulfur odor	No sulfur odor	No sulfur odor	No sulfur odor	No sulfur odor	No sulfur odor	No sulfur odor	No sulfur odor
High Boiling Residue, Maximum	% weight	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Particulates/Solids	Pass or Fail	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean
Acidity, Maximum	ppm by weight (as HCl)	1	1	1	1	1	1	1	1	1	1	1
Water, Maximum	mg kg <sup>-1</sup>	10	10	10	10	10	10	10	10	10	10	10
All Other Volatile Impurities, Maximum	% weight	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total C <sub>3</sub> , C <sub>4</sub> and C <sub>5</sub> Polyolefins, Maximum	% weight	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

## Notes:

1. Boiling points, boiling point ranges, although not required, are provided for informational purposes.

2. 2% of other C3 and C4 saturated hydrocarbons are allowed

3. Taken from vapor phase

4. Vaporized from liquid phase

N/A Not Applicable

<b>Table 1C. Carbon Dioxide Refrigerant and its Allowable Levels of Contaminants</b>		
	Reporting Units	R-744
<i>CHARACTERISTICS:</i>		
Sublimation Point <sup>1</sup>	°C at 101.3 kPa	-78.4
Sublimation Point Range <sup>1</sup>	K	± 0.3
<i>VAPOR PHASE</i> <sup>2</sup> :		
Air and other non-condensables, Maximum	% by volume at 10°C below the critical temperature and measure non-condensable directly	1.5
<i>LIQUID PHASE</i> <sup>3</sup> :		
Water, Maximum	ppm by weight	10
High Boiling Residue, Maximum	% by weight	0.0005
Particulates/Solids	Pass or Fail	Visually clean
Minimum Purity	% by weight	99.9
Notes: 1. Sublimation point, sublimation point range, although not required, are provided for informational purposes. Refrigerant data compiled from Refprop 9.1. 2. Sample taken from vapor phase. 3. Sample vaporized from liquid phase.		

Table 2A. Zeotropic Blends (400 Series Refrigerants) and their Allowable Levels of Contaminants

	Reporting Units	Reference Section	R-401A	R-401B	R-402A	R-402B	R-403A	R-403B	R-404A
<i>CHARACTERISTICS :</i>									
Refrigerant Components	N/A	N/A	R-22/ 152a/124	R-22/ 152a/124	R-125/ 290/22	R-125/ 290/22	R-290/ 22/218	R-290/ 22/218	R-125/ 143a/134a
Nominal Composition	% by weight	N/A	53/13/34	61/11/28	60.0/2.0 /38.0	38.0/2.0 /60.0	5/75/20	5/56/39	44/52/4
Allowable Composition	% by weight	N/A	51-55 /11.5-13.5 /33-35	59-63 /9.5-11.5 /27-29	58.0-62.0 /1.0-2.1 /36.0-40.0	36.0-40.0 /1.0-2.1/ 58.0-62.0	3-5.2 /73-77 /18-22	3-5.2 /54-58 /37-41	42-46 /51-53 /2-6
Bubble Point <sup>1</sup>	°C @ 101.3 kPa	N/A	-33.3	-34.9	-49	-47	-47.8	-49.2	-46.2
Dew Point <sup>1</sup>	°C @ 101.3 kPa	N/A	-26.4	-28.8	-46.9	-44.7	-44.3	-46.8	-45.5
Critical Temperature <sup>1</sup>	°C	N/A	105.3	103.5	76	83	87	79.7	72.1
<i>VAPOR PHASE CONTAMINANTS :</i>									
Air and Other Non-condensables, Maximum	% by volume @ 25.0°C	5.10	1.5	1.5	1.5	1.5	1.5	1.5	1.5
<i>LIQUID PHASE CONTAMINANTS:</i>									
Water, Maximum	ppm by weight	5.4	10	10	10	10	10	10	10
All Other Volatile Impurities, Maximum	% by weight	5.11	0.5	0.5	0.5	0.5	0.5	0.5	0.5
High Boiling Residue, Maximum	% by volume or % by weight	5.8	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Particulates/Solids	Pass or Fail	5.9	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean
Acidity, Maximum	ppm by weight (as HCl)	5.7	1	1	1	1	1	1	1
Chloride <sup>2</sup>	Pass or Fail	5.6	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity

## Notes:

1. Bubble points, dew points and critical temperatures, although not required, are provided for informational purposes. Refrigerant data compiled from Refprop 9.1.

2. Recognized chloride level for pass/fail is about 3 ppm.

N/A Not Applicable

**Table 2A. Zeotropic Blends (400 Series Refrigerants) and their Allowable Levels of Contaminants (continued)**

	Reporting Units	Reference Section	R-405A	R-406A	R-407A	R-407B	R-407C	R-407D	R-407E	R-407F
<i>CHARACTERISTICS :</i>										
Refrigerant Components	N/A	N/A	R-22/152a /142b/C318	R-22/600a /142b	R-32 /125/134a	R-32 /125/134a	R-32 /125/134a	R-32 /125/134a	R-32 /125/134a	R-32 /125/134a
Nominal Composition	% by weight	N/A	45/7/5.5 /42.5	55/4/41	20/40/40	10/70/20	23/25/52	15/15/70	25/15/60	30.0/30.0 /40.0
Allowable Composition	% by weight	N/A	43-47 /6-8/4.5-6.5 /40.5-44.5	53-57 /3-5 /40-42	18-22 /38-42 /38-42	8-12 /68-72 /18-22	21-25 /23-27 /50-54	13-17 /13-17 /68-72	23-27 /13-17 /58-62	28.0-32.0 /28.0-32.0 /38.0-42.0
Bubble Point <sup>1</sup>	°C @ 101.3 kPa	N/A	-32.9	-32.7	-45.3	-46.8	-43.6	-39.5	-42.9	-46.1
Dew Point <sup>1</sup>	°C @ 101.3 kPa	N/A	-24.5	-23.5	-38.9	-42.5	-36.6	-32.9	-35.8	-39.7
Critical Temperature <sup>1</sup>	°C	N/A	106	116.5	82.3	75	86	91.4	88.5	83
<i>VAPOR PHASE CONTAMINANTS :</i>										
Air and Other Non-condensables, Maximum	% by volume @ 25.0°C	5.10	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
<i>LIQUID PHASE CONTAMINANTS:</i>										
Water, Maximum	ppm by weight	5.4	10	10	10	10	10	10	10	10
All Other Volatile Impurities, Maximum	% by weight	5.11	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
High Boiling Residue, Maximum	% by volume or % by weight	5.8	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Particulates/Solids	Pass or Fail	5.9	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean
Acidity, Maximum	ppm by weight	5.7	1	1	1	1	1	1	1	1
Chloride <sup>2</sup>	Pass or Fail	5.6	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity
Notes: 1. Bubble points, dew points and critical temperatures, although not required, are provided for informational purposes. Refrigerant data compiled from Refprop 9.1. 2. Recognized chloride level for pass/fail is about 3 ppm. N/A Not Applicable										



Table 2A. Zeotropic Blends (400 Series Refrigerants) and their Allowable Levels of Contaminants (continued)

	Reporting Units	Reference Section	R-408A	R-409A	R-409B	R-410A	R-410B	R-411A	R-411B
<i>CHARACTERISTICS :</i>									
Refrigerant Components	N/A	N/A	R-125/ 143a/22	R-22/ 124/142b	R-22/ 124/142b	R-32/125	R-32/125	R-1270/ 22/152a	R-1270/ 22/152a
Nominal Composition	% by weight	N/A	7/46/47	60/25/15	65/25/10	50/50	45/55	1.5/87.5 /11.0	3/94/3
Allowable Composition	% by weight	N/A	5-9 /45-47 /45-49	58-62 /23-27 /14-16	63-67 /23-27 /9-11	48.5-50.5 /49.5-51.5	44-46 /54-56	0.5-1.5 /87.5-89.5 /10-11	2-3/94-96 /2-3
Bubble Point <sup>1</sup>	°C @ 101.3 kPa	N/A	-44.6	-34.7	-35.6	-51.4	-51.3	-39.5	-41.6
Dew Point <sup>1</sup>	°C @ 101.3 kPa	N/A	-44.1	-26.4	-27.9	-51.4	-51.6	-36.6	-40
Critical Temperature <sup>1</sup>	°C	N/A	83.1	106.9	106.9	71.4	70.8	99.1	96
<i>VAPOR PHASE CONTAMINANTS :</i>									
Air and Other Non-condensables, Maximum	% by volume @ 25.0°C	5.10	1.5	1.5	1.5	1.5	1.5	1.5	1.5
<i>LIQUID PHASE CONTAMINANTS:</i>									
Water, Maximum	ppm by weight	5.4	10	10	10	10	10	10	10
All Other Volatile Impurities, Maximum	% by weight	5.11	0.5	0.5	0.5	0.5	0.5	0.5	0.5
High Boiling Residue, Maximum	% by volume or % by weight	5.8	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Particulates/Solids	Pass or Fail	5.9	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean
Acidity, Maximum	ppm by weight (as HCl)	5.7	1	1	1	1	1	1	1
Chloride <sup>2</sup>	Pass or Fail	5.6	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity

## Notes:

1. Bubble points, dew points and critical temperatures, although not required, are provided for informational purposes. Refrigerant data compiled from Refprop 9.1.

2. Recognized chloride level for pass/fail is about 3 ppm.

N/A Not Applicable

**Table 2A. Zeotropic Blends (400 Series Refrigerants) and their Allowable Levels of Contaminants (continued)**

	Reporting Units	Reference Section	R-412A	R-413A	R-414A	R-414B	R-415A	R-415B	R-416A
<i>CHARACTERISTICS :</i>									
Refrigerant Components	N/A	N/A	R-22/218/ 142b	R-218/ 134a/600a	R-22/124/ 600a/142b	R-22/124/ 600a/142b	R-22/152a	R-22/152a	R-134a/ 124/600
Nominal Composition	% by weight	N/A	70/5/25	9/88/3	51.0/28.5 /4.0/16.5	50.0/39.0 /1.5/9.5	82.0/18.0	25.0/75.0	59.0/39.5 /1.5
Allowable Composition	% by weight	N/A	68-72 /3-7 /24-26	8-10 /86-90 /2-3	49.0-53.0 /26.5-30.5 /3.5-4.5 /15.5-17.0	48.0-52.0 /37.0-41.0 /1.0-2.0 /8.5-10.0	81.0-83.0 /17.0-19.0	24.0-26.0 /74.0-76.0	58.0-59.5 /39.0-40.5 /1.3-1.6
Bubble Point <sup>1</sup>	°C @ 101.3 kPa	N/A	-38	-30.6	-34	-32.9	-37.5	-27.7	-23.4
Dew Point <sup>1</sup>	°C @ 101.3 kPa	N/A	-28.7	-27.9	-25.8	-24.3	-34.7	-26.2	-21.8
Critical Temperature <sup>1</sup>	°C	N/A	107.2	98.5	110.7	111	100	111.3	108.2
<i>VAPOR PHASE CONTAMINANTS :</i>									
Air and Other Non-condensables, Maximum	% by volume @ 25.0°C	5.10	1.5	1.5	1.5	1.5	1.5	1.5	1.5
<i>LIQUID PHASE CONTAMINANTS:</i>									
Water, Maximum	ppm by weight	5.4	10	10	10	10	10	10	10
All Other Volatile Impurities, Maximum	% by weight	5.11	0.5	0.5	0.5	0.5	0.5	0.5	0.5
High Boiling Residue, Maximum	% by volume or % by weight	5.8	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Particulates/Solids	Pass or Fail	5.9	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean
Acidity, Maximum	ppm by weight (as HCl)	5.7	1	1	1	1	1	1	1
Chloride <sup>2</sup>	Pass or Fail	5.6	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity

Notes:  
 1. Bubble points, dew points and critical temperatures, although not required, are provided for informational purposes. Refrigerant data compiled from Refprop 9.1.  
 2. Recognized chloride level for pass/fail is about 3 ppm.  
 N/A Not Applicable

**Table 2A. Zeotropic Blends (400 Series Refrigerants) and their Allowable Levels of Contaminants (continued)**

	Reporting Units	Reference Section	R-417A	R-417B	R-417C	R-418A	R-419A	R-419B	R-420A	R-421A	R-421B
<i>CHARACTERISTICS :</i>											
Refrigerant Components	N/A	N/A	R-125/ 134a/600	R-125/ 134a/600	R-125/ 134a/600	R-290/ 22/152a	R-125/ 134a/E170	R-125/ 134a/E170	R-134a/ 142b	R-125/ 134a	R-125/ 134a
Nominal Composition	% by weight	N/A	46.6/50.0 /3.4	79.0/18.3 /2.7	19.5/78.8 /1.7	1.5/96.0 /2.5	77.0/19.0 /4.0	48.5/48.0 /3.5	88.0/12.0	58.0/42.0	85.0/15.0
Allowable Composition	% by weight	N/A	45.5-47.7 /49.0-51.0 /3.0-3.5	78.0-80.0 /17.3-19.3 /2.2-2.8	18.5-20.5 /77.8-79.8 /1.2-1.8	1.0-2.0 /95.0-97.0 /2.0-3.0	76.0-78.0 /18.0-20.0 /3.0-5.0	47.5-49.5 /47.0-49.0 /3.0-4.0	88.0-89.0 /11.0-12.0	57.0-59.0 /41.0-43.0	84.0-86.0 /14.0-16.0
Bubble Point <sup>1</sup>	°C @ 101.3 kPa	N/A	-38	-44	-32.7	-41.2	-42.6	-37.4	-25	-40.8	-45.7
Dew Point <sup>1</sup>	°C @ 101.3 kPa	N/A	-32.9	-41.5	-29.2	-40.1	-36	-31.5	-24.2	-35.5	-42.6
Critical Temperature	°C	N/A	89.9	75.2	95.4	96.7	79.1	90.4	105.4	78.5	69
<i>VAPOR PHASE CONTAMINANTS :</i>											
Air and Other Non-condensables, Maximum	% by volume @ 25.0°C	5.10	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
<i>LIQUID PHASE CONTAMINANTS:</i>											
Water, Maximum	ppm by weight	5.4	10	10	10	10	20	10	10	10	10
All Other Volatile Impurities, Maximum	% by weight	5.11	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
High Boiling Residue, Maximum	% by volume or % by weight	5.8	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Particulates/Solids	Pass or Fail	5.9	Visually clean	Visually clean	Visually Clean	Visually clean	Visually clean	Visually Clean	Visually clean	Visually clean	Visually clean
Acidity, Maximum	ppm by weight (as HCl)	5.7	1	1	1	1	1	1	1	1	1
Chloride <sup>2</sup>	Pass or Fail	5.6	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity

Notes:  
 1. Bubble points, dew points and critical temperatures, although not required, are provided for informational purposes. Refrigerant data compiled from Refprop 9.1.  
 2. Recognized chloride level for pass/fail is about 3 ppm.  
 N/A Not Applicable

**Table 2A. Zeotropic Blends (400 Series Refrigerants) and their Allowable Levels of Contaminants (continued)**

	Reporting Units	Reference Section	R-422A	R-422B	R-422C	R-422D	R-422E	R-423A	R-424A	R-425A	R-426A
<i>CHARACTERISTICS:</i>											
Refrigerant Components	N/A	N/A	R-125 /134a /600a	R-125 /134a /600a	R-125 /134a /600a	R-125 /134a /600a	R-125 /134a /600a	R-134a /227ea	R-125 /134a/600a /600/ 601a	R-32/134a /227ea	R-125/ 134a /600/601a
Nominal Composition	% by weight	N/A	85.1/11.5 /3.4	55.0/42.0 /3.0	82.0/15.0 /3.0	65.1/30.5 /3.4	58.0/39.3 /2.7	52.5/47.5	50.5/47.0 /0.9/1.0/0.6	18.5/69.5 /12.0	5.1/93.0 /1.3/0.6
Allowable Composition	% by weight	N/A	84.1-86.1 /10.5-12.5 /3.0-3.5	54.0-56.0 /41.0-43.0 /2.5-3.1	81.0-83.0 /14.0-16.0 /2.5-3.1	64.0-66.0 /30.5-32.5 /3.0-3.5	57.0-59.0 /38.0-41.0 /2.5-3.0	51.5-53.5 /46.5-48.5	49.5-51.5 /46.0-48.0 /0.7-1.0 /0.8-1.1 /0.4-0.7	18.0-19.0 /69.0-70.0 /11.5-12.5	4.1-6.1 /92.0-94.0 /1.1-1.4 /0.4-0.7
Bubble Point <sup>1</sup>	°C @ 101.3 kPa	N/A	-46.5	-40.5	-45.3	-43.2	-41.8	-24.2	-39.1	-38.1	-28.5
Dew Point <sup>1</sup>	°C @ 101.3 kPa	N/A	-44.1	-35.6	-42.3	-38.4	-36.4	-23.5	-33.3	-31.3	-26.7
Critical Temperature	°C	N/A	71.7	85.7	76.1	79.6	82.2	99	87.5	93.9	100.2
<i>VAPOR PHASE CONTAMINANTS :</i>											
Air and Other Non-condensables, Maximum	% by volume @ 25.0°C	5.10	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
<i>LIQUID PHASE CONTAMINANTS:</i>											
Water, Maximum	ppm by weight	5.4	10	10	20	10	10	10	10	10	10
All Other Volatile Impurities, Maximum	% by weight	5.11	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
High Boiling Residue, Maximum	% by volume or % by weight	5.8	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Chloride <sup>2</sup>	Pass or Fail	5.6	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity
Notes:											
1. Bubble points, dew points and critical temperatures, although not required, are provided for informational purposes. Refrigerant data compiled from Refprop 9.1.											
2. Recognized chloride level for pass/fail is about 3 ppm.											
N/A Not Applicable											

**Table 2A. Zeotropic Blends (400 Series Refrigerants) and their Allowable Levels of Contaminants (continued)**

	Reporting Units	Reference Section	R-427A	R-428A	R-429A	R-430A	R-431A	R-434A	R-435A	R-437A	R-438A	R-439A
<i>CHARACTERISTICS :</i>												
Refrigerant Components	N/A	N/A	R-32/125/ 143a/134a	R-125 /143a /290/600a	R-E170 /152a/ 600a	R-152a/ 600a	R290 /152a	R-125/ 143a/134a/ 600a	R-E170 /152a	R-125/ 134a/600 /601	R-32/125/ 134a/600 /601a	R-32/ 125/ 600a
Nominal Composition	% by weight	N/A	15.0/25.0 /10.0/50.0	77.5/20.0 /0.6/1.9	60.0/10.0 /30.0	76.0/24.0	71.0/29.0	63.2/18.0 /16.0/2.8	80.0/20.0	19.5/78.5 /1.4/0.6	8.5/45.0/44.2 /1.7/0.6	50/47.0 /3.0
Allowable Composition	% by weight	N/A	13.0-17.0 /23.0-27.0 /8.0-12.0 /48.0-52.0	76.5-78.5 /19.0-21.0 /0.4-0.7 /1.7-2.0	59.0-61.0 /9.0-11.0 /29.031.0	75.0-77.0 /23.025.0	70.0-72.0 /28.0-30.0	62.2-64.2 /17.0-19.0 /15.0-17.0 /2.6-2.9	79.0-81.0 /19.0-21.0	17.7-20.0 /77.8-80.0 /1.2-1.5 /0.4-0.7	7.0-9.0 /43.5-46.5 /42.7-45.7 /1.5-1.8 /0.4-0.7	49.0-51.0 /46.0-48.0 /2.5-3.5
Bubble Point <sup>1</sup>	°C @ 101.3 kPa	N/A	-43	-48.3	-25.5	-27.6	-43.2	-45.1	-26	-32.9	-43	-52
Dew Point <sup>1</sup>	°C @ 101.3 kPa	N/A	-36.3	-47.5	-24.9	-27.4	-43.2	-42.4	-25.8	-29.2	-36.4	-51.7
Critical Temperature	°C	N/A	85.3	69	123.5	107	100.3	75.6	125.2	95.3	84.2	72
<i>VAPOR PHASE CONTAMINANTS:</i>												
Air and Other Non-condensables, Maximum	% by volume @ 25.0°C	5.10	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
<i>LIQUID PHASE CONTAMINANTS:</i>												
Water, Maximum	ppm by weight	5.4	10	10	20	20	10	10	20	10	10	10
All Other Volatile Impurities, Maximum	% by weight	5.11	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
High Boiling Residue, Maximum	% by volume or % by weight	5.8	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Particulates/Solids	Pass or Fail	5.9	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean
Acidity, Maximum	ppm by weight (as HCl)	5.7	1	1	1	1	1	1	1	1	1	1
Chloride <sup>2</sup>	Pass or Fail	5.6	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity

Notes:  
 1. Bubble points, dew points and critical temperatures, although not required, are provided for informational purposes. Refrigerant data compiled from Refprop 9.1.  
 2. Recognized chloride level for pass/fail is about 3 ppm.  
 N/A Not Applicable

**Table 2A. Zeotropic Blends (400 Series Refrigerants) and their Allowable Levels of Contaminants (continued)**

	Reporting Units	Reference Section	R-440A	R-442A	R-444A	R-444B	R-445A	R-446A	R-447A	R-448A	R-449A	R-450A
<i>CHARACTERISTICS :</i>												
Refrigerant Components	N/A	N/A	R-290/ 134a/152a	R-32/125/ 134a/152a/ 227ea	R-32/152a/ 1234ze(E)	R-32 / 152a / 1234ze(E)	R-744/ 134a/1234ze( E)	R-32 /1234ze(E) /600	R-32/ 125/1234ze (E)	R-32 / 125 / 1234yf / 134a / 1234ze(E)	R-32 / 125 / 1234yf / 134a	R-134a / 1234ze(E)
Nominal Composition	% by weight	N/A	0.6/1.6/97.8	31.0/31.0 /30.0/3.0 /5.0	12.0/5.0/83.0	41.5/10.0 /48.5	6.0/9.0/85.0	68.0/29.0 /3.0	68.0/3.5 /28.5	26.0/26.0 /20.0/21.0 / 7.0	24.3/24.7 /25.3/25.7	42.0/58.0
Allowable Composition	% by weight	N/A	0.5-0.7 /1.0-2.2 /97.3-98.3	30.0-32.0 /30.0-32.0 /29.0-31.0 /2.5-3.5/4.0- 6.0	11.0-13.0 /4.0-6.0 /81.0-85.0	40.5-42.5 / 9.0-11.0 / 47.5-49.5	5.0-7.0 /8.0-10.0 /83.0-87.0	67.0-68.5 /28.4-31.0 /2.0-3.1	67.5-69.5 /3.0-5.0 /27.5-29.5	24.0-26.5 / 25.5-28.0 / 18.0-20.5 / 20.0-23.0 / 5.0-7.5	23.3-24.5 / 24.5-25.7 / 24.3-25.5 / 25.5-26.7	40.0-44.0 / 56.0-60.0
Bubble Point <sup>1</sup>	°C @ 101.3 kPa	N/A	-25.5	-46.5	-34.3	-44.6	-50.3	-49.4	-49.3	-45.9	-46	-23.4
Dew Point <sup>1</sup>	°C @ 101.3 kPa	N/A	-24.3	-39.9	-24.3	-34.9	-23.5	-42.1	-44.2	-39.8	-39.9	-22.8
Critical Temperature	°C	N/A	112.9	82.4	103.2	91.5	98	84.2	82.6	81.6	81.5	104.4
<i>VAPOR PHASE CONTAMINANTS :</i>												
Air and Other Non-condensables, Maximum	% by volume @ 25.0°C	5.10	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
<i>LIQUID PHASE CONTAMINANTS:</i>												
Water, Maximum	ppm by weight	5.4	10	10	10	10	10	10	10	10	10	10
All Other Volatile Impurities, Maximum	% by weight	5.11	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
High Boiling Residue, Maximum	% by volume or % by weight	5.8	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Particulates/Solids	Pass or Fail	5.9	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean
Acidity, Maximum	ppm by weight (as HCl)	5.7	1	1	1	1	N/A	1	1	1	1	1
Chloride <sup>2</sup>	Pass or Fail	5.6	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity

Notes:

1. Bubble points, dew points and critical temperatures, although not required, are provided for informational purposes. Refrigerant data compiled from Refprop 9.1.

2. Recognized chloride level for pass/fail is about 3 ppm.

N/A Not Applicable

**Table 2B. Hydrocarbon Blends (400 & 500 Series Refrigerants) and their Allowable Levels of Contaminants**

	Reporting Units	Reference Section	R-432A	R-433A	R-433B	R-433C	R-436A	R-436B	R-441A	R-443A
<i>CHARACTERISTICS :</i>										
Refrigerant Components	N/A	N/A	R-1279 /E170	R-1270 /290	R-1270 /290	R-1270 /290	R-290 /600a	R-290 /600a	R-170 /290/600a /600	R-1270 /290 /600a
Nominal Composition	% by weight	N/A	80.0/20.0	30.0 /70.0	5.0/95.0	25.0/75.0	56.0/44.0	52.0/48.0	3.1/54.8 /6.0/36.1	55.0/40.0 /5.0
Allowable Composition	% by weight	N/A	79.0-81.0 /19.0-21.0	29.0-31.0 /69.0-71.0	4.0-6.0 /94.0-96.0	24.0-26.0 /74.0-76.0	55.0-57.0 /43.0-45.0	51.0-53.0 /47.0-49.0	2.8-2.4 /52.8-56.8 /5.4-6.6 /34.1-38.1	53.0-57.0 /38.0-42.0 /3.8-6.2
Bubble Point <sup>1</sup>	°C @ 101.3 kPa	N/A	-45.2	-44.4	-42.5	-44.1	-34.3	-33.3	-41.5	-45.2
Dew Point <sup>1</sup>	°C @ 101.3 kPa	N/A	-42.4	-44	-42.4	-43.7	-26.1	-25	-20.3	-42.1
Critical Temperature <sup>1</sup>	°C	N/A	97.3	94.4	96.3	94.8	115.9	117.4	117.3	95.1
<i>VAPOR PHASE CONTAMINANTS</i> <sup>2</sup> :										
Air and Other Non-condensables, Maximum	% by volume @ 25.0°C	5.10	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
<i>LIQUID PHASE CONTAMINANTS</i> <sup>3</sup> :										
Sulfur Odor <sup>4</sup>	No odor to pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass
High Boiling Residue, Maximum	% by volume or % by weight	5.8	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Particulates/Solids	Pass or Fail	5.9	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean
Acidity, Maximum	ppm by weight	5.7	1	1	1	1	1	1	1	N/A
Water, Maximum	ppm by weight	5.4	20	10	10	10	10	10	10	10
All Other Volatile Impurities, Maximum	% by weight	5.11	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Total C <sub>3</sub> , C <sub>4</sub> and C <sub>5</sub> Polyolefins, Maximum	% by weight	5.12	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Chloride <sup>2</sup>	Pass or Fail	5.6	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	N/A	N/A

**Notes:**

1. Bubble points, dew points and critical temperatures, although not required, are provided for informational purposes. Refrigerant data compiled from Refprop 9.1.

2. Taken from vapor phase

3. Vaporized from liquid phase

4. Including hydrogen sulphide and mercaptans

N/A Not Applicable

**Table 3. Azeotropic Blends (500 Series Refrigerants) and their Allowable Levels of Contaminants**

	Reporting Units	Reference Section	R-500	R-502	R-503	R-507A	R-508A	R-508B	R-509A	R-510A	R-511A	R-512A
<i>CHARACTERISTICS :</i>												
Refrigerant Components	N/A	N/A	R-12/152a	R-22/115	R-23/13	R-125/ 143a	R-23/116	R-23/116	R-22/218	R-E170/ 600a	R-290/ E170	R-134a/ 152a
Nominal Composition	% by weight	N/A	73.8/26.2	48.8/51.2	40.1/59.9	50/50	39/61	46/54	44/56	88.0/12.0	95.0/5.0	5.0/95.0
Allowable Composition	% by weight	N/A	72.8-74.8 /25.2-27.2	44.8-52.8 /47.2-55.2	39-41 /59-61	49.5-51.5 /48.5-50.5	37-41 /59-63	44-48 /52-56	42-46 /56-60	87.5-88.5 /11.5- 12.5	94.0-96.0 /4.0-6.0	4.0-6.0 /94.0-96.0
Bubble Point <sup>1</sup>	°C @ 101.3 kPa	N/A	-33.6	-45.2	-87.8	-46.7	-87.4	-87	-49.8	-24.9	-42	-24
Dew Point <sup>1</sup>	°C @ 101.3 kPa	N/A	-33.6	-45	-87.8	-46.7	-87.4	-87	-48.1	-24.9	-42	-24
Critical Temperature <sup>1</sup>	°C	N/A	102.1	80.2	18.4	70.6	10.8	11.8	68.6	125.7	97	112.9
<i>VAPOR PHASE CONTAMINANTS :</i>												
Air and Other Non-condensables, Maximum	% by volume @ 25°C	5.10	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
<i>LIQUID PHASE CONTAMINANTS:</i>												
Water, Maximum	ppm by weight	5.4	10	10	10	10	10	10	10	20	20	10
All Other Volatile Impurities, Maximum	% by weight	5.11	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
High Boiling Residue, Maximum	% by volume or % by weight	5.8	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Particulates/Solids	Pass or Fail	5.9	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean	Visually clean
Acidity, Maximum	ppm by weight	5.7	1	1	1	1	1	1	1	1	1	1
Chloride <sup>2</sup>	Pass or Fail	5.6	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity	No visible turbidity
Notes: 1. Bubble points, dew points and critical temperatures, although not required, are provided for informational purposes. Refrigerant data compiled from Refprop 9.1. 2. Recognized chloride level for pass/fail is about 3 ppm. N/A Not Applicable												



## APPENDIX A. REFERENCES – NORMATIVE

**A1** Listed here are all standards, handbooks, and other publications essential to the formation and implementation of the standard. All references in this appendix are considered as part of this standard.

**A1.1** 2008 *Appendix C Analytical Procedures for AHRI Standard 700-2015 - Normative, Specification for Fluorocarbon Refrigerants*, 2008, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Blvd., Suite 500, Arlington, VA 22201, U.S.A.

**A1.2** ANSI/ASHRAE Standard 34-2013, *Designation and Safety Classification of Refrigerants*, 2013, with Addenda, American National Standards Institute/American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 25 West 43rd Street, 4th Floor, New York, New York 10036 U.S.A., 1791 Tullie Circle N.E., Atlanta, GA 30329, U.S.A.

**A1.3** *ASHRAE Terminology*, <https://www.ashrae.org/resources--publications/free-resources/ashrae-terminology>, 2014, American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Atlanta, GA 30329, U.S.A.

**A1.4** ASTM Standard D1296-01-2012, *Standard Test Method for Odor of Volatile Solvents and Diluents*, 2012, ASTM International, 100 Barr Harbor Drive, West Conshohocken, Pennsylvania 19428, USA.

**A1.5** GPA STD-2177, *Analysis of Natural Gas Liquid Mixtures Containing Nitrogen and Carbon Dioxide by Gas Chromatography*, 2013, Gas Processors Association, 6526 East 60<sup>th</sup> Street, Tulsa, Oklahoma 74145, U.S.A.

**A1.6** REFPROP Reference Fluid Thermodynamic and Transport Properties *NIST Standard Reference Database 23 Version 9.1*, 2013, U.S. Department of Commerce, Technology Administration, National Institute of Standards and Technology, Standard Reference Data Program, Gaithersburg, Maryland 20899, U.S.A.

## APPENDIX B. REFERENCES – INFORMATIVE

**B1** Listed here are standards, handbooks and other publications which may provide useful information and background but are not considered essential. References in this appendix are not considered part of the standard.

**B1.1** 2012 *Appendix D Gas Chromatograms for AHRI Standard 700-2015 - Informative, Specification for Fluorocarbon Refrigerants*, 2012, Air-Conditioning, Heating, and Refrigeration Institute, 2111 Wilson Blvd., Suite 500, Arlington, VA 22201; U.S.A.

**B1.2** U.S. Code of Federal Regulations, Title 40, Part 82, *Protection of Stratospheric Ozone*, 2013, Office of the Federal Register, National Archives and Records Administration, 800 North Capitol Street, NW, Washington, DC 20402, U.S.A.