AHRI Standard 580

2014 Standard for

Performance Rating of Non-condensable Gas Purge Equipment For Use with Low Pressure Centrifugal Liquid Chillers

AHRI
AIR-CONDITIONING, HEATING, & REFRIGERATION INSTITUTE
we make life better™

2111 Wilson Boulevard, Suite 500
Arlington, VA 22201, USA
www.ahrinet.org
PH 703.524.8800
FX 703.562.1942

IMPORTANT

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Note:

This standard supersedes AHRI Standard 580-2009.

AHRI CERTIFICATION PROGRAM PROVISIONS

Scope of the Certification Program

The Certification Program includes testing purge systems used in conjunction with Low Pressure Centrifugal Liquid Chillers.

Certified Ratings

The following Certification Program ratings are verified by test:

1. Concentration, ratio of mass of refrigerant to mass of air, g of refrigerant / g of air.

Price $10.00 (M) $20.00 (NM)
Printed in U.S.A.

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NON-CONDENSABLE GAS PURGE EQUIPMENT FOR USE WITH LOW PRESSURE CENTRIFUGAL LIQUID CHILLERS

Section 1. Purpose

1.1 *Purpose.* The purpose of this standard is to establish for Non-condensable Gas Purge Equipment for use with Low Pressure Centrifugal Liquid Chillers: definitions; test requirements; rating requirements; minimum data requirements for Published Ratings; marking and nameplate data; and conformance conditions.

1.1.1 *Intent.* This standard is intended for the guidance of the industry, including manufacturers, engineers, installers, contractors and users.

1.1.2 *Review and Amendment.* This standard is subject to review and amendment as technology advances.

Section 2. Scope

2.1 *Scope.* This standard applies to Non-condensable Gas Purge Equipment for use with Low Pressure Centrifugal Liquid Chillers as defined in Section 3. This standard defines general equipment requirements, test methods and analysis techniques used to determine the performance rating for Purge Equipment that removes Non-condensable gases from Low Pressure Centrifugal Liquid Chillers. This purge equipment is typically used in conjunction with chillers which operate with at least a portion of the system below atmospheric pressure.

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 *Bubble Point.* Refrigerant liquid saturation temperature at a specified pressure.

3.2 *Concentration.* Ratio of the mass of refrigerant to the mass of air at the Refrigerant Holding Capacity.

3.3 *Dew Point.* Refrigerant vapor saturation temperature at a specified pressure.

3.4 *Low Pressure Centrifugal Liquid Chiller*. A centrifugal liquid chiller that typically has a portion of the refrigerating system below atmospheric pressure (100 kPa) when operated at typical conditions for comfort cooling applications.

3.5 *Non-condensable Gases.* Gases, such as nitrogen and oxygen. which do not condense at normal operating temperatures and pressures in centrifugal water-chiller condensers.

3.6 *Published Rating.* A statement of the assigned values of those performance characteristics, under stated Rating Conditions, by which a unit may be chosen to fit its application. These values apply to all units of like nominal size and type (identification) produced by the same manufacturer. As used herein, the term Published Rating includes the rating of all performance characteristics shown on the unit or published in specifications, advertising or other literature controlled by the manufacturer, at stated Rating Conditions.

3.6.1 *Application Rating.* A rating based on tests performed at Application Rating Conditions (other than Standard Rating Conditions).

3.6.2 *Standard Rating.* A rating based on tests performed at Standard Rating Conditions.

3.7 *Purge Equipment.* A device which will separate Non-condensable Gases from refrigerant and remove them from the refrigeration system.

3.7.1 *Automatically Regenerated Media*. Media that is recycled at the purge system to remove entrained refrigerant and return this refrigerant to the chiller. The regeneration process is initiated automatically by the purge control system**.**

3.7.2 *Manually Regenerated Media*. Media that is recycled at the purge system to remove entrained refrigerant and return this refrigerant to the chiller. The regeneration process is set up and initiated by an operator.

3.7.3 *Refrigerant Holding Capacity*. The amount of refrigerant, designated by the manufacturer, which the media can hold prior to being replaced or regenerated, g.

3.7.4 *Replaceable Media.* Media that is removed from the system and replaced with new or recycled media. The media from the system is processed to ensure refrigerant is not released to the atmosphere.

3.8 *Rating Conditions.* Any set of operating conditions under which a single level of performance results and which causes only that level of performance to occur.

3.8.1 *Standard Rating Conditions.* Rating Conditions used as the basis for comparison of performance characteristics.

3.9 *"Shall"* or *"Should."* "Shall" or "should" shall be interpreted as follows:

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

3.9.2 *Should.* "Should" is used to indicate provisions which are not mandatory but which are desirable as good practice.

Section 4. Test Requirements

4.1 *Test Requirements*. Non-condensable Gas Purge Equipment shall be tested in accordance with the procedures set forth in Appendices C and D. Calculation of purge equipment concentration rating for the activated carbon method is described in Appendix E. Determination of discharge gas concentration using the gas chromatograph method is described in Appendix F. If alternative test methods are employed for the gas chromatograph method, the user must be able to demonstrate that they produce results at least equivalent to the specified testing method.

Section 5. Rating Requirements

5.1 *Purge Equipment Concentration Rating.* Purge Equipment exhaust gas concentration shall be expressed in g refrigerant / g air.

5.2 *Operating Conditions for Purge Equipment Rating.* The Purge Equipment efficiency rating point shall be established with a chiller operating at the following conditions:

5.2.1 Condenser refrigerant pressure at a nominal dew point temperature of 29°C ± 0.5°C. Allowable pressure limits during the test are equivalent to a dew point temperature range of 28 to 31°C.
5.2.2 Ambient temperature at 25°C ± 1.0°C
5.2.3 Evaporator refrigerant pressure at a Bubble Point temperature of 4.0°C or greater
5.2.4 For Purge Equipment designs that use adsorption or absorption devices to selectively separate refrigerant and air, these devices shall be brought to a normal operating condition prior to test. See Appendix D for specific rating and testing instructions. This may include saturating and then regenerating a device or bringing oil supplies to a typical refrigerant concentration.

5.3 All tests shall be performed at the nameplate rated voltage and frequency or as otherwise specified in this standard. For units with dual nameplate voltage ratings, standard rating tests shall be performed at both voltages or at the lower of the two voltages if only a single Standard Rating is to be published.

5.4 *Tolerances.* If conformance with this standard is claimed for a Published Rating, then any Purge Equipment tested, following the procedures of Appendices C, D, E and F, shall not have an exhaust gas concentration greater than the Published Rating. If a Manually Regenerated or Replaceable Media is used, then the refrigerant exhaust gas concentration should not be greater than the Published Rating when the absorptive medium has been filled with the amount of refrigerant specified by the manufacturer as the Refrigerant Holding Capacity.

Section 6. Minimum Data Requirements for Published Ratings

6.1 *Minimum Data Requirements for Published Ratings*. As a minimum, Published Ratings shall include Standard Ratings. All claims to ratings within the scope of this standard shall include the statement "Rated in accordance with AHRI Standard 580". All claims to ratings outside the scope of this standard shall include the statement "Outside the scope of AHRI Standard 580". Wherever Application Ratings are published or printed, they shall include a statement of the conditions at which the ratings apply.

6.1.1 Published Ratings shall consist of the following information.

6.1.1 Concentration, g of refrigerant / g of air
6.1.2 Refrigerant Holding Capacity where applicable, g

Section 7. Marking and Nameplate Data

7.1 *Marking and Nameplate Data.* As a minimum, the nameplate shall display the manufacturer's name, model number, electrical characteristics and refrigerant designation(s).

Nameplate voltages for 60 Hertz systems shall include one or more of the equipment nameplate voltage ratings shown in Table 1 of ANSI/AHRI Standard 110. Nameplate voltages for 50 Hertz systems shall include one or more of the utilization voltages shown in Table 1 of IEC Standard Publication 60038.

Section 8. Conformance Conditions

8.1 *Conformance*. While conformance with this standard is voluntary, conformance shall not be claimed or implied for products or equipment within its *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 shall not reference, state, or acknowledge the standard in any written, oral, or electronic communication.

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 the standard.

A1.1 AHRI Standard 700-2014, *Specifications for Refrigerants,* 2014, Air-Conditioning, Heating and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.2 ANSI/AHRI Standard 110-2012, *Air-Conditioning and Refrigerating Equipment Nameplate Voltages,* 2012, Air-Conditioning, Heating and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.3 Appendix C to AHRI Standard 700, *Analytical Procedures for AHRI Standard 700-2012,* 2008, Air-Conditioning, Heating and Refrigeration Institute, 2111 Wilson Boulevard, Suite 500, Arlington, VA 22201, U.S.A.

A1.4 ASHRAE Standard 41.1-2013 (RA 2006), *Measurements Guide - Section on Temperature Measurements*, 2013, American Society of Heating, Refrigeration, and Air-Conditioning Engineers, Inc. ASHRAE, 1791 Tullie Circle, N.E., Atlanta, Georgia, 30329, U.S.A.

A1.5 *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.

A1.6 ASME Standard PTC 19.2-2010, *Instruments and Apparatus, Part 2, Pressure Measurement,* 2010, American Society of Mechanical Engineers. ASME, 345 East 47th Street, New York, NY 10017, U.S.A.

A1.7 IEC Standard 60038, *IEC Standard Voltages*, 2009, International Electrotechnical Commission, 3 rue de Varembe, P.O. Box 131, 1211 Geneva 20, Switzerland

APPENDIX B. REFERENCES – INFORMATIVE

None.

APPENDIX C. METHODS OF TESTING FOR RATING PERFORMANCE OF NON-CONDENSABLE GAS PURGE EQUIPMENT – NORMATIVE

C1 *Installation and Operation.*

C1.1 *Installation.* The Purge Equipment shall be installed and operated per the manufacturer's instruction manual. A thorough inspection shall be made of the purge tank and exhaust system to insure that all devices and connecting lines are leak tight. A leak detector shall be used to ensure that any leak point does not exceed 14 g/year at 25°C.

C1.2 *Test Procedure.* The chiller test equipment shall be brought to steady state operation within specified tolerances for the refrigerant bubble point temperature (evaporator side) and refrigerant dew point temperature (condenser side). Operate the Purge Equipment and allow it to operate until the approach of the water temperature leaving the condenser to the refrigerant saturation temperature does not decrease by more than 0.20°C in 30 minutes.

Introduce air at a rate of 4.0×10^{-6} m^3/s into the evaporator. During the test, the pressure in the chiller condenser shall not exceed the limits stated in Section 5.2.1.

The Purge Equipment exhaust gas shall then be collected and analyzed as indicated by either the activated carbon or gas chromatograph method.

C2 *Instruments.*

C2.1 *Activated Carbon Canisters.* Canisters shall be filled with unused vapor phase activated carbon.

C2.2 *Temperature Measurement Device.* The temperature measurement device shall be in accordance with ASHRAE Standard 41.1.

C2.3 *Gas Collection Bag.* This will be a minimum capacity of 50 L for purge devices without Replaceable Media. The collection bag capacity will be a nominal 20 L ± 4 L for purge devices with Manually Regenerated or Replaceable Media. Volume will be calibrated to 2.5 kPa gauge pressure. The calibration for volume shall be made to assure accuracy better than ±5% for the nominal bag volume.

C2.4 *Non-condensable Flow Meter.* A device for metering air flow into the test equipment shall be calibrated to an accuracy of 8.0×10^{-7} m^3/s at an indicated flow of 4.0×10^{-6} m^3/s.

C2.5 *Pressure Measurement Devices.*

C.2.5.1 Pressure measurement devices used in the exhaust gas concentration determination for the activated carbon method shall be calibrated to an accuracy of 0.02 kPa.

C.2.5.2 Pressure measurement devices used to measure evaporator and condenser pressure shall be made in accordance with ASME Standard PTC 19.2.

C2.6 *Weight Scale.* This device shall be calibrated to an accuracy of 0.1 g over the range at which the carbon canister weight measurements are made.

C3 *Activated Carbon Method.*

C3.1 *Activated Carbon Method Setup.* Two activated carbon canisters shall be weighed at atmospheric pressure, connected in series and placed in the purge equipment exhaust stream as shown in Figure C1. The connecting tubing from the purge equipment exhaust to the primary canister shall be heated to a temperature above 30°C . The exhaust from the secondary canister shall be connected to a gas collection bag (as defined in Section C4.3) to capture the Non-condensable Gases. A means shall be provided to measure the gas sample pressure.

C3.2 *Sample Procedure.*

C3.2.1 Purge Equipment is to be operated for a period of time to fill the collection bag to a pressure of 0.75 to 1.25 kPa above atmospheric pressure

C3.2.2 Close valve at the inlet to the primary canister and check for pressure loss. Allow the pressure to stabilize for 5 minutes. The pressure decay rate after 5 minutes may not exceed 0.1 kPa in 15 minutes.

C3.3 *Purge Equipment Exhaust Gas Analysis.* Disconnect gas collection bag and allow the carbon canisters to bleed to atmospheric pressure. The carbon canisters shall then be sealed and weighed. If the increase in the secondary canister is greater than 5% of the increase in the primary canister weight, the test is invalid.

If the test is valid, the weight increase of the primary and the secondary canisters will be added to determine the refrigerant mass adsorbed and the concentration of the purge equipment exhaust gas.

C4 *Gas Chromatograph (GC) Method.*

C4.1 *Purge Equipment Exhaust Collection Setup.* Connect a collection bag (as defined in Section C4.3) by means of leak-tight tubing (able to sustain a 2 kPa vacuum for a period of 30 seconds from the collection bag to valve 1, as shown in Figure C2) and three valves as shown in Figure C2 to the point at which the Purge Equipment discharges. The internal volume of the interconnecting tubing will be kept to a minimum. Interconnecting tubing between the purge equipment exhaust and the collection bag shall be heated to a temperature above 30°C. A vacuum pump, as shown in Figure C2, will be provided to remove residual air from the collection bag.

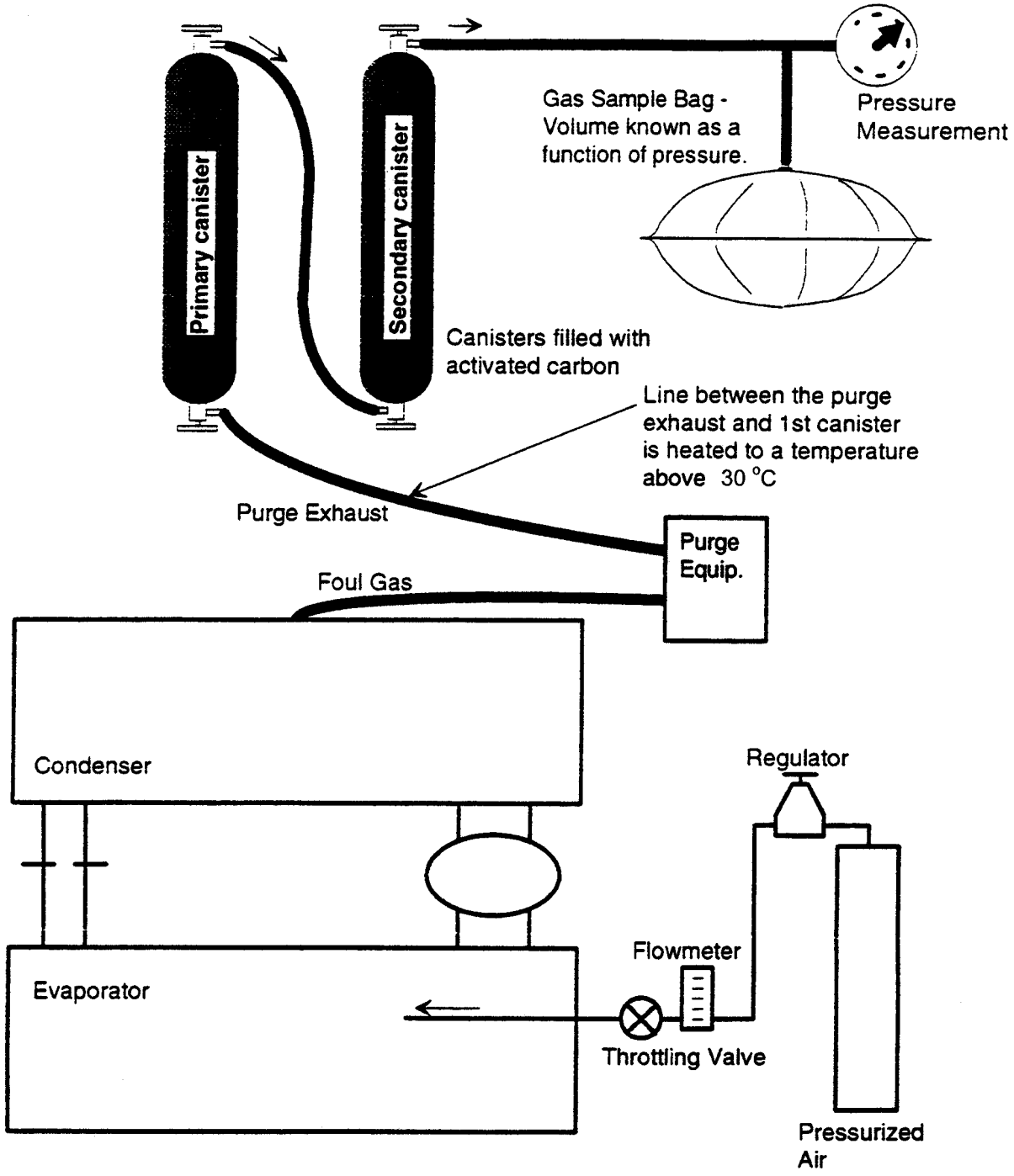

Figure C1. Activated Carbon Sampling Method

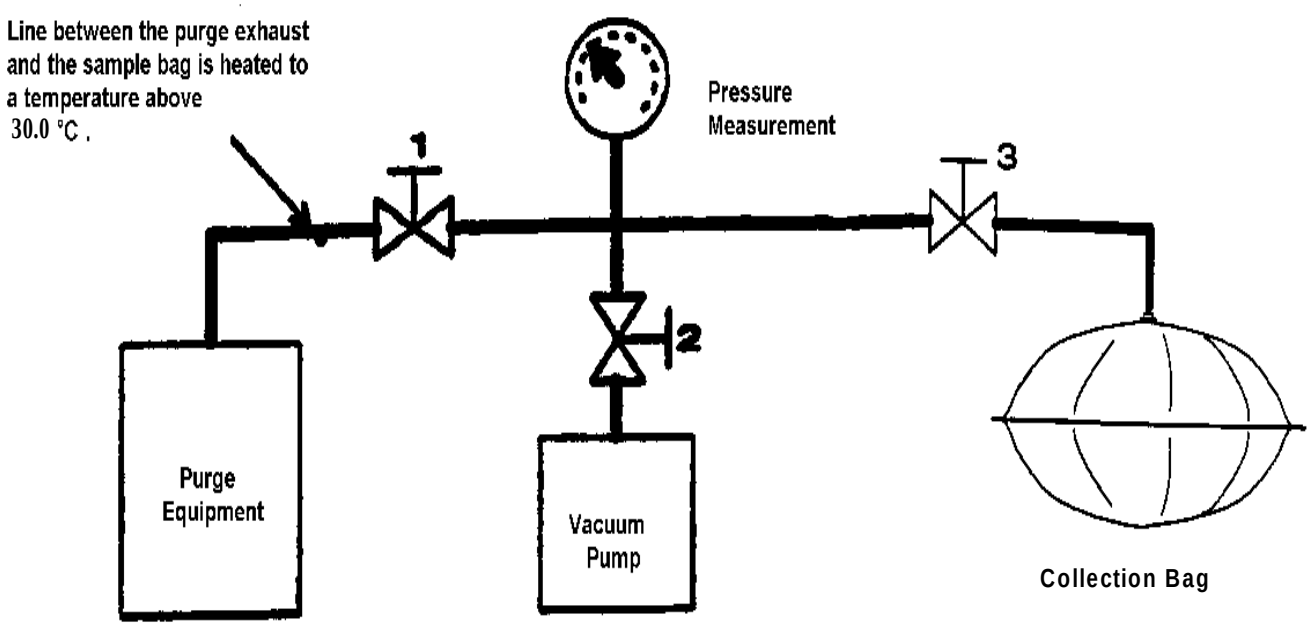

Figure C2. Gas Chromatograph Sampling Method

C4.2 *Sample Procedure.*

C4.2.1 With valve 1 closed and valves 2 and 3 open, residual air from the collection bag shall be removed with the vacuum pump. Valve 2 shall then be closed.

C4.2.2 Valve 1 shall then be opened to collect purge equipment exhaust gas. Purge equipment exhaust is collected until the collection bag reaches a pressure of 0 to 1.25 kPa above atmospheric pressure.

C4.2.3 Valve 3 shall then be closed to contain the purge equipment exhaust gases in the collection bag.

C4.3 *Purge Equipment Exhaust Gas Chemical Analysis.* The contents of the collection bag shall be analyzed by means of gas chromatography. A standard of known concentration of the refrigerant of interest shall be used to calibrate the GC. The standard's concentration shall be within 25% of the measured test sample concentration. Minimum requirements for the chromatography method employed, taken at a 95% confidence interval, shall be as follows:

C4.3.1 Sensitivity, 0.015% refrigerant by weight in air

C4.3.2 Precision, ±1.75% of the result

C4.3.3 Accuracy, including the effect of all calibration processes, ±3.5% of the result

Refer to Appendix F for detailed instructions.

C5 *Measurements.*

C5.1 *Recording Data.* Data to be recorded during the test:

C5.1.1 Condenser and evaporator pressure every 15 minutes during period of purge operation used for certification

C5.1.2 Non-condensable gas flow rate into chiller in m^3/s every 15 minutes during the purge equipment certification period

C5.1.3 Gas collection pressure and volume when filled

C5.1.4 Ambient temperature and barometric pressure at end of test

C5.1.5 For activated carbon method, weights for primary and secondary carbon canisters before and after completion of test. Weight to be taken with internal pressure at 1 atmosphere.

C5.1.6 Water temperature supplied to purge equipment condenser if present

C5.2 *Auxiliary Data.*

C5.2.1 Nameplate data including make, model and refrigerant, sufficient to completely identify the Purge Equipment

C5.2.2 Date, place and time of test

C5.2.3 Names of test supervisor and witnessing personnel

C5.2.4 For GC method, chemistry laboratory analysis of purge equipment exhaust gas concentration listing of concentration standards used to calibrate the gas chromatograph and Refrigerant Holding Capacity.

APPENDIX D. SPECIFIC RATING AND TESTING INSTRUCTIONS FOR PURGES CONTAINING ADSORPTIVE/ABSORPTIVE MEDIA – NORMATIVE

D1 *Specific Rating and Testing Instructions.*

D1.1 Purges that contain adsorptive/absorptive media (referred to later as media) have special rating and listing requirements. If the purge contains media that is a replaceable component or the regeneration of the media is manually controlled, the purge shall be tested and rated both with and without the media in the system. In addition, the purge instructions supplied by the manufacturer with the purge shall contain the Refrigerant Holding Capacity of the media, and will indicate to the purge operator a measurement that shall be used to determine when the media must either be changed (for a replaceable component) or regenerated (for a manually regenerated component). For media that is manually regenerated, the Refrigerant Holding Capacity will represent the amount of refrigerant added to the media between regeneration cycles. Purges that contain media that is automatically regenerated (no operator interaction required) do not have to be rated without the media.

When the purge is tested with the media installed, regardless of whether the media is replaceable or regenerated manually or automatically, the media shall be brought to a normal operating state prior to a rating test. Specific requirements for each of the media regeneration types are detailed below.

D1.1.1 Purges that contain replaceable media - The manufacturer's operating instructions shall specify the Refrigerant Holding Capacity of the media. The purge is tested and rated both with and without the media. Prior to testing the purge with media installed, the media is loaded with the amount of refrigerant specified by the manufacturer as the Refrigerant Holding Capacity of the media in the operating instructions supplied with the purge system. The refrigerant is loaded to the media as specified below.

D1.1.2 Purges that contain manually regenerated media - The manufacturer's operating instructions shall specify the Refrigerant Holding Capacity of the media between regenerations. The purge is tested and rated both with and without the media.
Prior to testing the purge with media installed, the media is first saturated with refrigerant, regenerated on the purge per the manufacturer's instructions and then loaded with refrigerant equal to the Refrigerant Holding Capacity specified in the manufacturer's instructions. The media is saturated by adding refrigerant to the media, where the weight of refrigerant added is equal to the weight of the media. Refrigerant is added according to the procedure detailed below. After regeneration of the media, refrigerant is again added to the media. The weight of refrigerant added (per the procedure detailed below) is equal to the Refrigerant Holding Capacity specified by the manufacturer in the operating manual.

D1.1.3 Purges that contain media that is automatically regenerated (no operator intervention required) - Prior to testing the purge with media installed, the media used during the rating procedure is first saturated with refrigerant, regenerated on the purge, and made to process 0.03 m^3 of air. The weight of the refrigerant added in the saturation procedure (detailed below) is equal to the weight of the media. The chiller is brought to the normal operating conditions at the purge rating point and media regeneration is initiated. The media regeneration cycle is allowed to run and terminate per the automatic controls on the purge system. If air introduction is required during regeneration, air may be introduced into the chiller at a rate of 4×10^{-6} m^3/s. After media regeneration, if not already started, air is introduced into the chiller at the above rate (4×10^{-6} m^3/s). The purge is allowed to process 0.03 m^3 of air through the media at the normal operating conditions. The purge and test system is then allowed to stabilize and the purge rating test is run. If subsequent regenerations occur during the test procedure, air introduction into the chiller may be suspended in order to maintain the condenser pressure within the test limits.

D2 *Procedure to Add Refrigerant to Media.*

D2.1 For convenience, the media container may be removed from the purge platform

D2.2 The media will be heated to a minimum of 35ºC

D2.3 A container of refrigerant will be connected to the inlet to the media

D2.4 The refrigerant container may be heated to elevate the pressure to drive off refrigerant vapor into the media inlet

D2.5 Refrigerant vapor will be allowed to flow into the media at a rate not to exceed 250 g/min until the amount of refrigerant specified has been driven into the media

D2.6 The media is then reconnected to the purge

APPENDIX E. CALCULATION OF PURGE EQUIPMENT CONCENTRATION RATING FOR THE ACTIVATED CARBON METHOD – NORMATIVE

E1 *Calculation of Purge Equipment Concentration Rating.*

E1.1 Purge Equipment exhaust gas concentration, g of refrigerant / g of air, shall be calculated as follows for the activated carbon technique:

$$W_{ref} = W_{c1} + W_{c2} \quad \text{E1}$$

$$W_{ncg} = \frac{P_{bag} \times V_{bag}}{R_{da}(T_{amb} + 273.15)} \quad \text{E2}$$

$$C = \frac{W_{ref}}{W_{ncg}} \quad \text{E3}$$

Where:

C = Purge Equipment exhaust gas concentration
P_{bag} = Pressure of gas collection bag at termination of test, kPa
R_{da} = Gas constant for dry air (0.000287), $m^3 \cdot kPa/g \cdot K$
T_{amb} = Ambient temperature, °C
V_{bag} = Gas collection bag volume at a pressure equal to P_{bag}, m^3
W_{c1} = Weight increase of primary canister, g
W_{c2} = Weight increase of secondary canister, g
W_{ncg} = Weight of Non-condensable Gas in purge discharge, g
W_{ref} = Weight of refrigerant in Purge Equipment discharge, g

Note: If Purge Equipment exhaust gas concentration is expressed as efficiency (E), %, it shall be expressed as follows:

$$E = 100 \frac{W_{ncg}}{W_{ref} + W_{ncg}} \quad \text{E4}$$

APPENDIX F. DETERMINATION OF DISCHARGE GAS CONCENTRATION FOR NON-CONDENSABLE GAS PURGE EQUIPMENT TESTING – NORMATIVE

F1 *Purpose.*

F1.1 The purpose of this test method is to determine the ratio of refrigerant mass to air mass discharged by a Non-condensable Gas purge device.

F2 *Scope.*

F2.1 This test method is for use with low pressure chillers.

F3 *Definitions.*

F3.1 Definitions for this method are identical to those of this standard and ARI Standard 700.

F4 *Principle.*

F4.1 Purge Equipment exhaust gas is measured for refrigerant and Non-condensable Gas (NCG) content by isothermal gas chromatography using a thermal conductivity detector (TCD) and external calibration. Although NCG is defined as including trace gases such as carbon dioxide and carbon monoxide, air is the only non-condensable which will be present in significant amounts.

F5 *Applicability.*

F5.1 This method, which was developed to determine the ratio of refrigerant mass to air mass discharged by a Non-condensable Gas purge device, is suitable for use in conjunction with this standard.

F6 *Limitations and Interferences.*

F6.1 Refrigerants used in low pressure chillers do not interfere with and are not interfered by the measurement of air, as they elute chromatographically after the air peak.

F6.2 The temperature of the laboratory and all materials used should be 20°C or higher to avoid refrigerant condensation.

F7 *Sensitivity, Precision, and Accuracy.*

F7.1 The sensitivity, precision, and accuracy of this method, taken at a 95% confidence interval, are as follows:

F7.1.1 Sensitivity, 0.015% refrigerant by weight in air

F7.1.2 Precision, ±1.75% of the result

F7.1.3 Accuracy, including the effect of all calibration processes, ±3.5% of the result

F7.2 The accuracy of the entire test, as it applies to testing equipment for rating, depends heavily on the purge unit being tested. The cyclic nature of the unit under test results in steady-state operation not being reached. This is generally a consideration only for units without absorptive or adsorptive media. The measured concentration of air will vary across a wide range from one evaluation to the next. The concentration of air also changes dramatically over the duration of a single purge cycle, with the greatest concentration of air being at the beginning of the cycle and the greatest concentration of refrigerant typically at the conclusion of the cycle.

F8 *Special Apparatus and Reagents.*

F8.1 Note: Equivalents may be substituted.

F8.1.1 Gas chromatograph equipped with a thermal conductivity detector, helium carrier gas, gas sample valve with 1 ml sample loop, and vacuum pump for evacuating loop
F8.1.2 GC column: 20 ft. by 1/8 in. Porapak Q™, 100-120 mesh (no metric equivalent)
F8.1.3 85 L Tedlar™ gas sampling bag with some small tubing and adapter
F8.1.4 50 mL gas-tight syringe
F8.1.5 Analytical balance, 2000 x 0.01 g
F8.1.6 Steel cylinder, 1 L, with valve.
F8.1.7 Refrigeration hose
F8.1.8 Vacuum pump
F8.1.9 Silicon septum and cap to retain septum over refrigeration fitting
F8.1.10 Air, zero grade, with a suitable regulator and a refrigeration fitting for the outlet
F8.1.11 Small quantities of refrigerants for making calibration standards

F9 *Procedure.*

F9.1 *Preparing or Cleaning the Bag.*

F9.1.1 Attach bag to vacuum pump and evacuate the bag
F9.1.2 Attach bag to air tank and regulator; fill bag with air
F9.1.3 Repeat steps a. and b. three times
F9.1.4 Analyze the bag in accordance with F9.3, disregarding any calculations
F9.1.5 The chromatogram produced should show no trace of refrigerant. If refrigerant is present, the bag has not been sufficiently cleared

F9.2 *Standard Preparation.* The calibration standards concentration, expressed as the ratio of refrigerant to air by mass, will need to be within 25% of the actual sample concentration. For this reason, it is necessary to estimate the sample concentration using the purge equipment's rating or other data, prepare a calibration standard, analyze the sample, and then prepare additional calibration standards as necessary to have a standard concentration within 25% of the sample's concentration.

F9.2.1 Evacuate a clean bag

F9.2.2 Calculate

$$R = m \times C \qquad \text{F1}$$

Where:

C = Concentration of calibration standard, g of refrigerant / g of air
m = 78 g of air
R = Amount of refrigerant to add, g

F9.2.3 Using the gas-tight syringe, septum, cap, and balance, add R to the evacuated bag. Note that the bag is not weighed; instead, the syringe contents must be weighed.

F9.2.4 Evacuate the steel cylinder, fill it with compressed air, and weigh the full cylinder

F9.2.5 Empty the contents of the cylinder into the bag, and reweigh the cylinder to determine the mass of air added

F9.2.6 Repeat steps e. and f. until 78 g of air has been added to the bag. Record the amount added.

F9.2.7 The actual concentration of the standard, C, is calculated as mass of refrigerant, g, divided by the mass of air, g, added to the bag.

F9.3 *Sample Analysis.*

F9.3.1 Set GC conditions as follows:
Oven temperature 160ºC
Injector temperature 150ºC
Detector temperature 200ºC
Carrier gas 30 ml/ min
Run time 20 min

F9.3.2 Attach bag to sample valve on GC

F9.3.3 Turn on vacuum pump and open valve on bag. Allow the pump to draw sample through the sample loop for approximately one minute, then valve off the pump and allow the sample loop to reach atmospheric pressure.

F9.3.4 Inject the sample loop contents

F9.3.5 Run both the calibration standard and the sample loop in triplicate. The peak areas for each set of three runs should not vary by more than 2%. The following calculations should employ average values from the triplicate runs.

F9.3.6 Concentration of the unknown sample is determined as follows:

$$U = \frac{S \times R_u \times A_s}{A_u \times R_s}, \text{ g of refrigerant/g of air} \qquad \text{F2}$$

Where:

A_s = Area of air peak in the standard
A_u = Area of air peak in the sample
R_s = Area of refrigerant peak in the standard
R_u = Area of refrigerant peak in the sample
S = Concentration of the standard
U = Measured concentration of sample

F9.3.7 If the concentration of the sample differs by more than 25% from the concentration of the calibration standard, a new standard must be made and used.