BSR/ASHRAE Standard 139-2022R

Public Review Draft

Method of Testing for Rating Desiccant Dehumidifiers Utilizing Heat for the Regeneration Process

First Public Review (May 2025)

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NOTE

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FOREWORD

First published in 1998, ASHRAE Standard 139 was developed under guidance from TC 8.12, Desiccant Dehumidification Equipment and Components (previously TC 3.5). The intent of this standard is to provide uniform test methods for rating desiccant dehumidifiers that use heat for the regeneration process. It addresses the test methods, apparatus and instruments to be used, data to be obtained, and calculations needed to confirm valid test results.

This 2022 revision of Standard 139 updates references. The standard was prepared under the auspices of ASHRAE. It may be used, in whole or in part, by an association or government agency with due credit to ASHRAE. Adherence is strictly on a voluntary basis and merely in the interests of obtaining uniform guidelines throughout the industry.

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1. PURPOSE

The purpose of this standard is to provide test methods for determining the moisture removal capacity of heat-regenerated desiccant dehumidifiers, as well as the coincident thermal energy performance, so that comparative evaluations of capacity and performance can be made irrespective of the type or make of the device.

2. SCOPE

2.1 This standard applies to desiccant-based dehumidifiers operating at atmospheric pressure. The dehumidifier shall use solid or liquid desiccants that are regenerated using heat energy.

2.2 Normally, equipment within this standard would consist of one or more desiccant contact stations through which the air to be dehumidified is moved, a means to expose the moisture-laden desiccant to a source of heat energy for regeneration, and a heating device.

2.3 Ancillary devices are normally used to move air to be dehumidified through the device and to provide ventilation for regeneration, but they are not a part of this standard.

2.4 This standard is intended to

a. describe a uniform method of testing for obtaining performance data,
b. reference and specify test instruments and apparatus,
c. describe and specify test data to be recorded, and
d. describe and specify calculations to be made from the test data.

2.5 This standard does not apply to

a. dehumidifiers operating at other than atmospheric pressure,
b. dehumidifiers not using a desiccant for dehumidification,
c. dehumidifiers not using heat for regeneration of the desiccant,
d. ancillary equipment that may be used in any dehumidification process, such as fans or pre- or post-conditioning equipment, or
e. dehumidifiers using a sealing arrangement that results in leakage rates in excess of 1% of process flow.

3. DEFINITIONS

airflow: the rate of flow of air through any part of a dehumidifier expressed in standard cubic meters per hour (scmh) or standard cubic feet per minute (scfm).

conditioner: a device in which the process air is dehumidified in a liquid desiccant system.

desiccant contactor: the structure or section containing the desiccant contacting the air to be dehumidified.

heat input: the gross heating value of the fuel supplied to the regeneration heater, expressed in watts (British thermal units per hour).

FOREWORD

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humidity ratio (G): the ratio of the mass of water vapor in the air to the mass of dry air; the ratio is defined as grams of moisture per kilogram of dry air (grains of moisture per pound of dry air).

liquid desiccant concentration: the concentration of liquid desiccant expressed as kilograms (pounds) of anhydrous desiccant per kilogram (pound) of desiccant solution.

liquid desiccant transfer to conditioner: the amount of kilograms (pounds) per hour of concentrated desiccant solution transferred from the regenerator to the conditioner.

moisture removal capacity (MRC): the mass of water vapor removed from the process air per unit of time and expressed in kilograms per hour (pounds per hour).

moisture removal rate (MRR): the mass of water vapor removed from the desiccant per unit of time via the regeneration process (desorption) and expressed in kilograms per hour (pounds per hour).

process air: the airstream to be dehumidified.

regeneration air: the airstream used as a carrier for the desorbed moisture and/or a mechanism to transfer heat for the regeneration of the desiccant in a dry desiccant system.

regeneration heater: a device used to heat the regeneration air or the liquid desiccant.

regeneration specific heat input (RSHI): the energy per unit moisture removed expressed in kilojoules per kilogram (British thermal units per pound).

regenerator: the structure or section containing the desiccant to be regenerated.

standard air: for the purpose of this standard, *standard air* is air with a density of 1.20 kg/m^3 (0.075 lb/ft^3). This is substantially equivalent to dry air at 21°C (70°F) and at a barometric pressure of 101.325 kPa (29.92 in. Hg).

temperature

> ***dry-bulb temperature:*** the temperature of air indicated by an ordinary thermometer.
>
> ***wet-bulb temperature:*** the temperature indicated when a thermometer bulb is covered with a water-saturated wick over which air is caused to flow at approximately 4.5 m/s (900 ft/min) to reach the equilibrium temperature of water evaporating into the air when the heat of vaporization is supplied by the sensible heat of the air.
>
> ***dew-point temperature:*** the temperature at which water vapor is saturated (100% rh) with water vapor. (***Informative Note:*** It is improper to refer to dew point as the temperature at which condensation begins to occur, because condensation at the dew point requires removal of latent heat from the vapor to induce condensation and this can occur only if the vapor is cooled below the dew point.)

4. CLASSIFICATION OF UNITS

4.1 Desiccant dehumidifiers for the purpose of this standard are classified as to desiccant type and heating source.

4.2 Desiccant Types

a. Dry (solid)
b. Liquid

4.3 Heat Sources

a. Electric
b. Gas
c. Steam
d. Hot water
e. Other appropriate sources of heat

5. REQUIREMENTS

5.1 Testing Requirements. Desiccant dehumidifiers shall be tested for rating in accordance with the requirements set forth in this section.

5.2 Equipment. Equipment to be tested shall contain the desiccant contactor, regenerator, and regeneration heater regularly furnished with the equipment. Other accessories used shall be consistent with the test procedure.

5.3 Performance Determinations. Performance determinations of desiccant dehumidifiers shall consist of the

a. determination of the water vapor removal capacity at airflow rates, velocities, and operational parameters defined in Tables 1 and 2 taken at specific inlet conditions; and
b. determination of the coincident thermal energy requirements at the water vapor removal capacity determined in Section 5.3(a).

5.4 Measuring Instruments. All instruments used for measurement shall be calibrated by comparison with an instrument that has a NIST (or equivalent national laboratory) certification in the range of use, or an instrument with a NIST (or equivalent national laboratory) certification shall be used.

6. INSTRUMENTS

6.1 Temperature Measuring Instruments. Temperature measuring instruments, unless noted below, shall be in accordance with ASHRAE Standard 41.1 [1].

6.1.1 Temperature measurement shall be made with one or more of the following instruments:

a. Mercury-in-glass thermometer
b. Thermocouple
c. Electric resistance thermometer

6.1.2 Accuracy shall be within the following limits:

a. Air dry-bulb temperatures: ±0.3°C (0.5°F)
b. Air dew-point temperatures: ±0.3°C (0.5°F)
c. Water and nonvolatile refrigerants: ±0.05°C (0.1°F)
d. Other dry-bulb temperatures: ±0.3°C (0.5°F)

6.1.3 In no case shall the smallest scale division of the temperature measuring instrument exceed twice the specified accuracy. For example, for the specified accuracy of ±0.05°C (0.1°F), the smallest scale division shall not exceed 0.1°C (0.2°F).

6.1.4 Dew-point temperatures shall be used to determine humidity levels through direct measurement of dew point using NIST traceable instruments providing an accuracy of 0.3°C (0.05°F).

6.1.5 Whenever possible, temperature measuring instruments used to measure the change in temperature shall be arranged so that they are readily interchanged between the supply and exhaust position to improve accuracy by using an average value.

6.1.6 Psychometric measuring stations will be uniformly located downstream of the diffusers at each flow measuring station.

6.1.7 The pressures existing in the psychrometric chambers shall be used in the humidity calculations.

6.1.8 The temperature of fluids within conduits shall be measured by inserting the temperature measuring instrument directly within the fluid or within a well inserted into the circuit. Glass thermometers shall not be inserted directly into the fluid when pressure within the conduit is great enough to affect the thermometer reading.

6.2 Pressure Measuring Instruments. All pressure measuring instruments shall be in accordance with ASHRAE Standard 41.3 [2].

6.2.1 Pressure measurements shall be made with one of the following:

a. Water column
b. Oil column (0.826 density)
c. Mercury column
d. Bourdon gage
e. Electronic pressure transducers

6.2.2 Accuracy of pressure measuring instruments shall be within ±1% of the reading.

6.2.3 In no case shall the smallest scale division of the pressure measuring instrument exceed two times the specified accuracy.

6.3 Dew-Point Measuring Instruments. All dew-point measurements shall be in accordance with Section 6.4 of ASHRAE Standard 41.6 [3].

Table 1 Test Data to be Recorded for Dry Desiccant Systems (SI)

			Date:
Dry Desiccant Equipment			
Description		**Units**	**Value**
1.	Model number		
2.	Serial number		
3.	Process inlet airflow	acmh	
3a.	Process air inlet temperature	°C	
3b.	Process air inlet dew-point temperature	°C	
3c.	Process air inlet absolute humidity	g/kg	
3d.	Process air inlet relative humidity	%	
4.	Process outlet airflow	acmh	
4a.	Process air outlet temperature	°C	
4b.	Process air outlet dew-point temperature	°C	
4c.	Process air outlet absolute humidity	g/kg	
4d.	Process air outlet relative humidity	%	
5.	Process air pressure drop	Pa	
6.	Regeneration inlet airflow	acmh	
6a.	Regeneration air inlet temperature	°C	
6b.	Regeneration air inlet dew-point temperature	°C	
6c.	Regeneration air inlet absolute humidity	g/kg	
6d.	Regeneration air inlet relative humidity	%	
6e.	Regeneration air inlet heated to temperature	°C	
7.	Regeneration outlet airflow	acmh	
7a.	Regeneration air outlet temperature	°C	
7b.	Regeneration air outlet dew-point temperature	°C	
7c.	Regeneration air outlet absolute humidity	g/kg	
7d.	Regeneration air outlet relative humidity	%	
8.	Regeneration heat source (stem, gas, electric, hot water, etc.)		
8a.	Regeneration heat input (electric)	kW	______ Amps ______ Volts ______ Phase ______ Hz
8b.	Regeneration heat input (gas)	kJ/h	
8c.	Regeneration heat quality (steam)	°C, kPa	
8d.	Regeneration heat input (steam)	kJ/h	
8e.	Regeneration heat input (hot water)	kJ/h	________ Temp in _________ Temp out _________ L/s
9.	Regeneration air pressure drop	Pa	
10.	Ambient barometric pressure	kPa	
11.	Rotor/contactor speed	rph	
12.	Test duration	min	

Table 1 Test Data to be Recorded for Dry Desiccant Systems (I-P)

			Date:
Dry Desiccant Equipment			
Description		**Units**	**Value**
1.	Model number		
2.	Serial number		
3.	Process inlet airflow	acfm	
3a.	Process air inlet temperature	°F	
3b.	Process air inlet dew-point temperature	°F	
3c.	Process air inlet absolute humidity	gr/lb	
3d.	Process air inlet relative humidity	%	
4.	Process outlet airflow	acfm	
4a.	Process air outlet temperature	°F	
4b.	Process air outlet dew-point temperature	°F	
4c.	Process air outlet absolute humidity	gr/lb	
4d.	Process air outlet relative humidity	%	
5.	Process air pressure drop	in. wc	
6.	Regeneration inlet airflow	acfm	
6a.	Regeneration air inlet temperature	°F	
6b.	Regeneration air inlet dew-point temperature	°F	
6c.	Regeneration air inlet absolute humidity	gr/lb	
6d.	Regeneration air inlet relative humidity	%	
6e.	Regeneration air inlet heated to temperature	°F	
7.	Regeneration outlet airflow	acfm	
7a.	Regeneration air outlet temperature	°F	
7b.	Regeneration air outlet dew-point temperature	°F	
7c.	Regeneration air outlet absolute humidity	gr/lb	
7d.	Regeneration air outlet relative humidity	%	
8.	Regeneration heat source (stem, gas, electric, hot water, etc.)		
8a.	Regeneration heat input (electric)	kW	______ Amps ______ Volts ______ Phase ______ Hz
8b.	Regeneration heat input (gas)	Btu/h	
8c.	Regeneration heat quality (steam)	°F, psi	
8d.	Regeneration heat input (steam)	Btu/h	
8e.	Regeneration heat input (hot water)	Btu/h	________ Temp in _________ Temp out _________ L/s
9.	Regeneration air pressure drop	in. wc	
10.	Ambient barometric pressure	in. Hg	
11.	Rotor/contactor speed	rph	
12.	Test duration	min	

Table 2 Test Data to be Recorded for Liquid Desiccant Systems (SI)

			Date:
Liquid Desiccant Equipment			
Description		**Units**	**Value**
1.	Model number		
2.	Serial number		
3.	Process inlet airflow	acmh	
3a.	Process air inlet temperature	°C	
3b.	Process air inlet dew-point temperature	°C	
3c.	Process air inlet absolute humidity	g/kg	
3d.	Process air inlet relative humidity	%	
4.	Process outlet airflow	acmh	
4a.	Process air outlet temperature	°C	
4b.	Process air outlet dew-point temperature	°C	
4c.	Process air outlet absolute humidity	g/kg	
4d.	Process air outlet relative humidity	%	
5.	Conditioner air pressure drop	Pa	
6.	Conditioner coolant type (chilled water, glycol, DX, ammonia, etc.)		
7.	Coolant operating temperature	°C	
8.	Heat rejected to coolant	kJ/h	
9.	Regeneration inlet airflow	acmh	
9a.	Regeneration air inlet temperature	°C	
9b.	Regeneration air inlet dew-point temperature	°C	
9c.	Regeneration air inlet absolute humidity	g/kg	
9d.	Regeneration air inlet relative humidity	%	
10.	Regeneration outlet airflow	acmh	
10a.	Regeneration air outlet temperature	°C	
10b.	Regeneration air outlet dew-point temperature	°C	
10c.	Regeneration air outlet absolute humidity	g/kg	
10d.	Regeneration air outlet relative humidity	%	
11.	Regeneration heat source (steam, gas, electric, hot water, etc.)		
11a.	Regeneration heat input (electric)	kW	________ Amps ________ Volts ________ Phase ________ Hz
11b.	Regeneration heat input (gas)	kJ/h	
11c.	Regeneration heat quality (steam)	°C/kPa	
11d.	Regeneration heat input (steam)	kg/h	
11e.	Regeneration heat input (hot water)	kJ/h	________ Temp in ________ Temp out ________ L/s
12.	Regeneration air pressure drop	Pa	
13.	Ambient barometric pressure	kPa	
14.	Desiccant type/identity		
14a.	Desiccant concentration to conditioner	kg/kg	
14b.	Desiccant concentration in regenerator	kg/kg	
14c.	Desiccant transfer to conditioner	kg/h	
15	Weight of regenerator tank at start	kg	
16.	Weight of regenerator tank at end	kg	
17.	Test duration	min	

Table 2 Test Data to be Recorded for Liquid Desiccant Systems (I-P)

			Date:
Liquid Desiccant Equipment			
Description		**Units**	**Value**
1.	Model number		
2.	Serial number		
3.	Process inlet airflow	acfm	
3a.	Process air inlet temperature	°F	
3b.	Process air inlet dew-point temperature	°F	
3c.	Process air inlet absolute humidity	gr/lb	
3d.	Process air inlet relative humidity	%	
4.	Process outlet airflow	acfm	
4a.	Process air outlet temperature	°F	
4b.	Process air outlet dew-point temperature	°F	
4c.	Process air outlet absolute humidity	gr/lb	
4d.	Process air outlet relative humidity	%	
5.	Conditioner air pressure drop	in. wc	
6.	Conditioner coolant type (chilled water, glycol, DX, ammonia, etc.)		
7.	Coolant operating temperature	°F	
8.	Heat rejected to coolant	Btu/h	
9.	Regeneration inlet airflow	acfm	
9a.	Regeneration air inlet temperature	°F	
9b.	Regeneration air inlet dew-point temperature	°F	
9c.	Regeneration air inlet absolute humidity	gr/lb	
9d.	Regeneration air inlet relative humidity	%	
10.	Regeneration outlet airflow	acfm	
10a.	Regeneration air outlet temperature	°F	
10b.	Regeneration air outlet dew-point temperature	°F	
10c.	Regeneration air outlet absolute humidity	gr/lb	
10d.	Regeneration air outlet relative humidity	%	
11.	Regeneration heat source (steam, gas, electric, hot water, etc.)		
11a.	Regeneration heat input (electric)	kW	________ Amps ________ Volts ________ Phase ________ Hz
11b.	Regeneration heat input (gas)	Btu/h	
11c.	Regeneration heat quality (steam)	°F/psi	
11d.	Regeneration heat input (steam)	Btu/h	
11e.	Regeneration heat input (hot water)	Btu/h	________ Temp in ________ Temp out ________ L/s
12.	Regeneration air pressure drop	in. wc	
13.	Ambient barometric pressure	in. Hg	
14.	Desiccant type/identity		
14a.	Desiccant concentration to conditioner	lb/lb	
14b.	Desiccant concentration in regenerator	lb/lb	
14c.	Desiccant transfer to conditioner	lb/h	
15	Weight of regenerator tank at start	lb	
16.	Weight of regenerator tank at end	lb	
17.	Test duration	min	

Conversion of dew point to humidity ratio shall be as defined in Section 7.2 of ASHRAE Standard 41.6. Alternative conversion methods shall be accepted if correction for altitude or barometric pressure is provided for an accurate result.

6.4 Electrical Instruments

6.4.1 Electrical measurements shall be made with indicating or integrating instruments.

6.4.2 Instruments used for measuring the electrical input to heaters or other apparatus-furnished heat loads shall be accurate to ±1.0% of the quantity measured.

6.4.3 Voltages shall be measured at the equipment terminals.

6.5 Liquid Flow Measurement

6.5.1 Water and brine flow rates shall be measured with a liquid flowmeter or a quantity meter having an accuracy of ±1.0% of the indicated value.

6.5.2 Condensate collection rates shall be measured with a liquid quantity meter measuring either weight or volume and having an accuracy of ±1.0% of the indicated value.

6.6 Speed Measuring Instruments. Speed measurements shall be made with a revolution counter, tachometer, stroboscope, or oscilloscope having an accuracy of ±1.0% of reading.

6.7 Time Measurements. Time measurements shall be made with instruments having an accuracy of ±0.20% of reading.

6.8 Weight Measurements. Weight measurement shall be made with an apparatus having an accuracy of ±0.20% of reading.

6.9 Gas Fuel Measurements

6.9.1 Measurement of gas fuel rate during test shall be made with a calibrated meter of the constant-volume type. The heating value for the gas used shall be obtained from the gas company supplying the fuel during the test.

6.9.2 Heat Input—Gas Fuel. From data supplied by the gas company, obtain gas heating value H_g. From the meter readings on the data sheet, calculate the heat input rate, Q_s.

$$Q_s = [H_g \times (M_f - M_i) \times 273.2 + 20 \times P]/[(T + 273.2) \times 101.325 \times \text{Time} \times 60], \text{ kJ/s} \qquad \text{(SI)}$$

$$Q_s = [H_g \times (M_f - M_i) \times 459.3 + 68 \times P]/[(T + 459.3) \times 14.696 \times \text{Time} \times 1/60], \text{ Btu/h} \qquad \text{(I-P)}$$

where

H_g = heating value, kJ/m^3 @ 20°C, 101.325 kPa (Btu/ft^3 @ 68°F, 14.595 psia)

M_f = final meter reading, m^3 (ft^3)

M_i = initial meter reading, m^3 (ft^3)

P = gas pressure, kPa (psia)

T = gas temperature, °C (°F)

Time = elapsed time between meter readings, min

Informative Note: If the value of H_g is supplied at a reference temperature and/or reference pressure other than shown in this standard, make the appropriate changes to the references as they appear in the formula.

6.10 Airflow Measurements. All airflow measurements shall be made in accordance with ASHRAE Standard 41.2 [4].

6.11 Water Properties Measuring Apparatus

6.11.1 Temperature measuring instruments shall be placed so as to measure accurately the temperature of water entering and leaving the coil. The water lines shall be insulated at, and adjacent to, the temperature measuring instruments. To minimize possible temperature stratification, mixers shall be inserted in the inlet and outlet water lines upstream from the temperature measuring instruments. Two close-coupled 90 degree elbows, just upstream of the temperature measuring instruments, can serve as mixers provided the water velocity at the mixing station is not below 0.3 m/s (1.0 fps).

6.11.2 A suitable means shall be provided for determining the water pressure drop through the coil from inlet to outlet as shown in Figure 1.

6.12 Steam Properties and Condensate Flow Measurement

6.12.1 The properties of steam entering the test coil, and the properties and flow rate of condensate leaving the coil, shall be determined by the apparatus shown in Figure 2, or by other suitable means to achieve the required accuracy.

6.12.2 The pressure of the steam entering the coil shall be determined by a pressure measuring instrument located between the control valve and the coil.

6.12.3 The temperature measuring instruments shall be placed so as to measure accurately the temperature of the superheated steam entering the coil and of the condensate leaving the coil. Steam lines shall be insulated between the temperature measuring instruments and the heat exchange apparatus.

6.12.4 Steam entering the test coil shall be superheated to a minimum of 5.6°C (10.0°F). If necessary, superheating shall be accomplished by a suitable heating means or by throttling. A separator shall be located upstream of the superheater or throttling valve to remove condensate from the supply line.

6.12.5 The condensate flow shall be determined by a liquid quantity meter as described in Section 6.5.

6.12.6 Flashing of the condensate shall be prevented by means of a suitable heat exchanger. A condensate control valve shall be provided to regulate the condensate level. The condensate level shall be the same each time a reading is taken. The top of the insulated condensate leg shall be vented continuously during test. The vent rate shall be controlled by a specially drilled petcock as shown in Figure 3. The petcock shall be connected to the top of the condensate receiver or float trap and positioned so that only the specially drilled post is operative during the test.

6.12.7 The steam pressure drop through the coil, from inlet to outlet, shall be determined by the manometer arrangement shown in Figure 1. Both legs of the manometer, including lines leading to the inlet and outlet headers, shall be maintained with a liquid column of condensate. The effect of the water legs and the differences in static head shall be considered in determining the steam pressure drop through the coil.

6.13 Static Pressure Measurements in Air. All static pressure measurements shall be made in accordance with ASHRAE Standard 41.2 [4].

6.13.1 Static pressures shall be determined

a. at flow measurement stations and
b. on each circuit of the equipment at entering and leaving locations.

6.14 Measurement of Liquid Desiccant Concentration

6.14.1 Liquid desiccant concentration shall be determined by measuring the temperature and specific gravity of the sample.

6.14.2 The specific gravity of the sample shall be measured by using a glass hydrometer with an accuracy of ±0.001 kg/kg (lb/lb).

7. TEST PREPARATION—EQUIPMENT INSTALLATION

7.1 The equipment to be tested shall be installed in the test section in accordance with the manufacturer's standard installation instructions using the recommended procedures and accessories.

7.2 No alterations to the equipment shall be made except for the attachment of required test apparatus and instruments in the prescribed manner.

7.3 No change shall be made in fan speed or system resistance to correct for barometric variations due to weather.

8. METHOD OF TEST

8.1 Test Operating Procedure

8.1.1 The test duct, measuring equipment, and equipment under test shall be operated until steady-state conditions have been maintained for at least 15 minutes.

8.1.2 Rotary dehumidifiers shall have the speed of rotation checked before and after each series of test runs.

8.2 Airflow Measuring Procedure. Airflow rates shall be determined at each of the four measurement stations as shown in Figures 4 through 7.

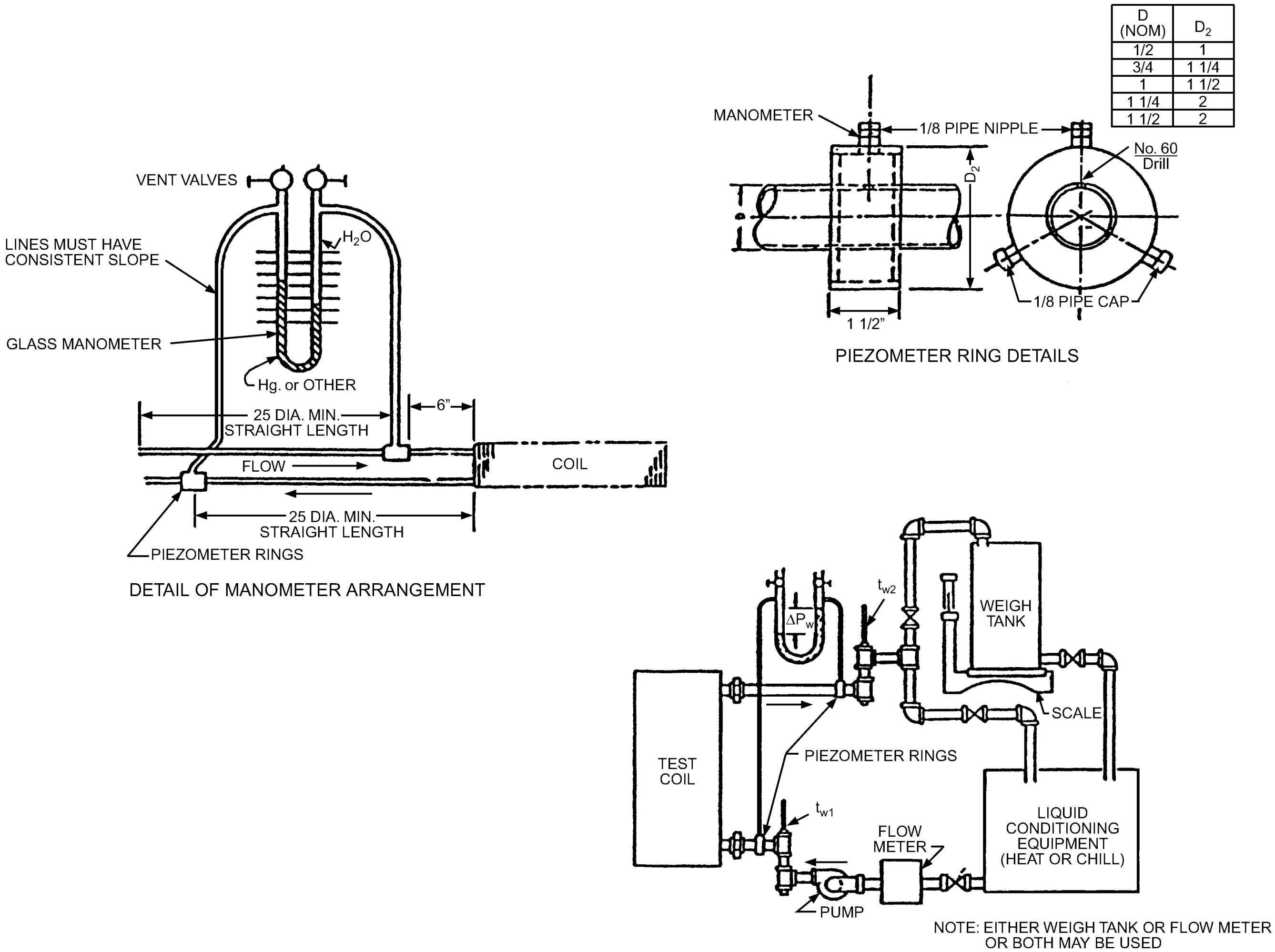

Figure 1 Measuring apparatus for determining water properties and flow.

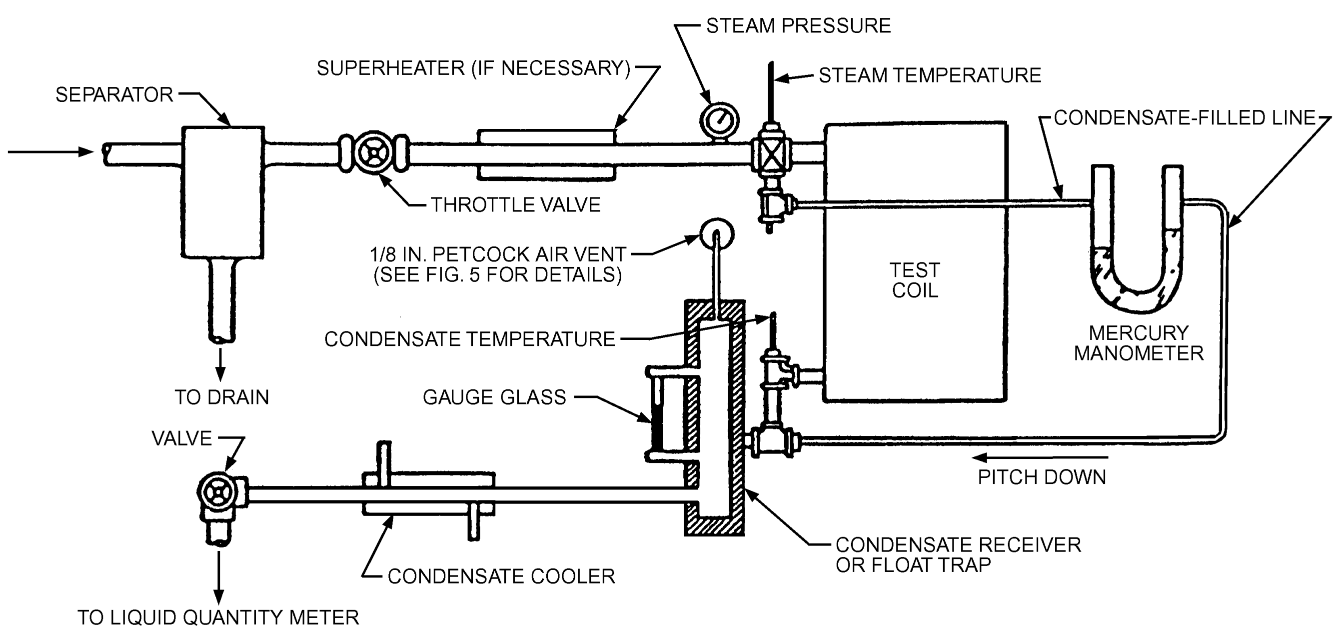

Figure 2 Measuring apparatus for determining steam and condensate flow.

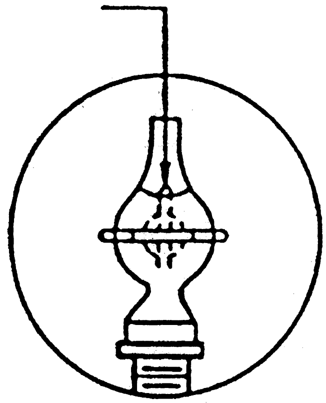

Figure 3 Detail of petcock air vent.

8.2.1 Air mass flow rates shall be determined from each nozzle station's measured pressure differential and calculated air density. See Section 9, "Data and Calculations."

The airflow through the apparatus illustrated in Figures 4 through 7 is as follows:

a. The air is passed by fans through a conditioner that adjusts the temperature and moisture content of the desired supply air conditions.
b. Air then splits, with process air passing through measuring station one.
c. The remainder of the air goes to auxiliary stations where it may be humidified and/or heated to the test specification/condition.

8.2.2 The air mass flow ratio W_{max}/W_{min} will be varied as required by means of two dampers.

8.2.3 The moisture content at each of the measuring stations will be determined at the pressure and temperature existing in each station's psychometric chamber.

8.2.4 Alternative arrangements of test equipment shall be used only if equal or better accuracy can be obtained.

9. DATA AND CALCULATIONS

9.1 The data shall be recorded as indicated in Table 1 for dry desiccant systems or Table 2 for liquid desiccant systems for each performance condition at which the equipment is to be tested. Only those data points necessary to carry out the calculations are required. Additional data points shall be added only as a reference based on interest of the user or testing authority.

Since the single point of performance data described in Table 1 or 2 can be replicated over an almost infinite number of inlet conditions, the information is capable of being displayed in curve form as a series of performance parameters. In the event the performance is typical for a series of equipment sizes, test data may be expanded appropriately.

9.2 The following calculations shall be performed and included with the test report. Mass flow rate used in the equations shall be those at duct sections one and two.

9.2.1 Moisture Removal Capacity (MRC). The moisture removal capacity of the test unit shall be calculated in kilograms (pounds) per hour as follows:

$$\text{MRC} = [\text{SCMH}_p \times 1.2\ \text{kg/m}^3 \times (G_i - G_o)]/1000 \qquad \text{(SI)}$$

or

$$\text{MRC} = \text{SCMH}_p \times 0.0012 \times (G_i - G_o)$$

where

MRC = moisture removal capacity, kg/h

SCMH_p = scmh process air (air to be dehumidified)

G_i = humidity ratio at the process air inlet

G_o = humidity ratio at the process air outlet

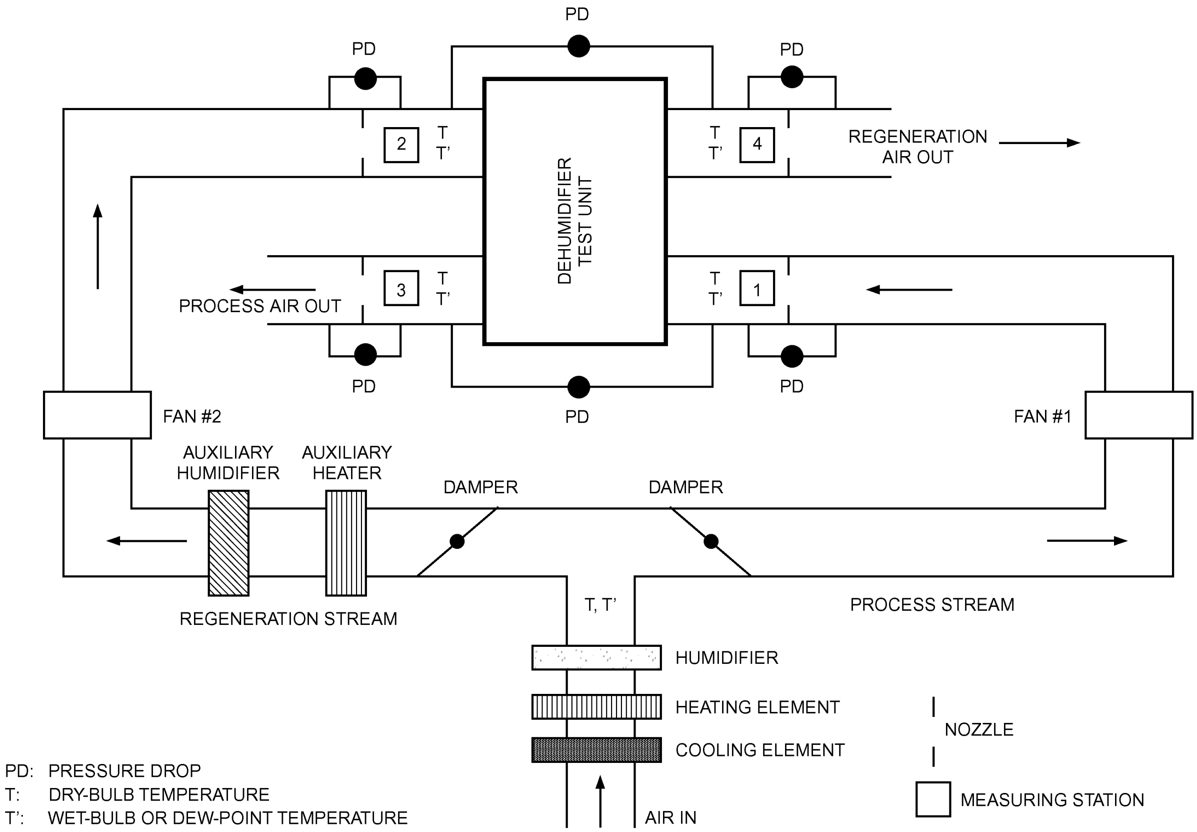

Figure 4 General test-loop configuration.

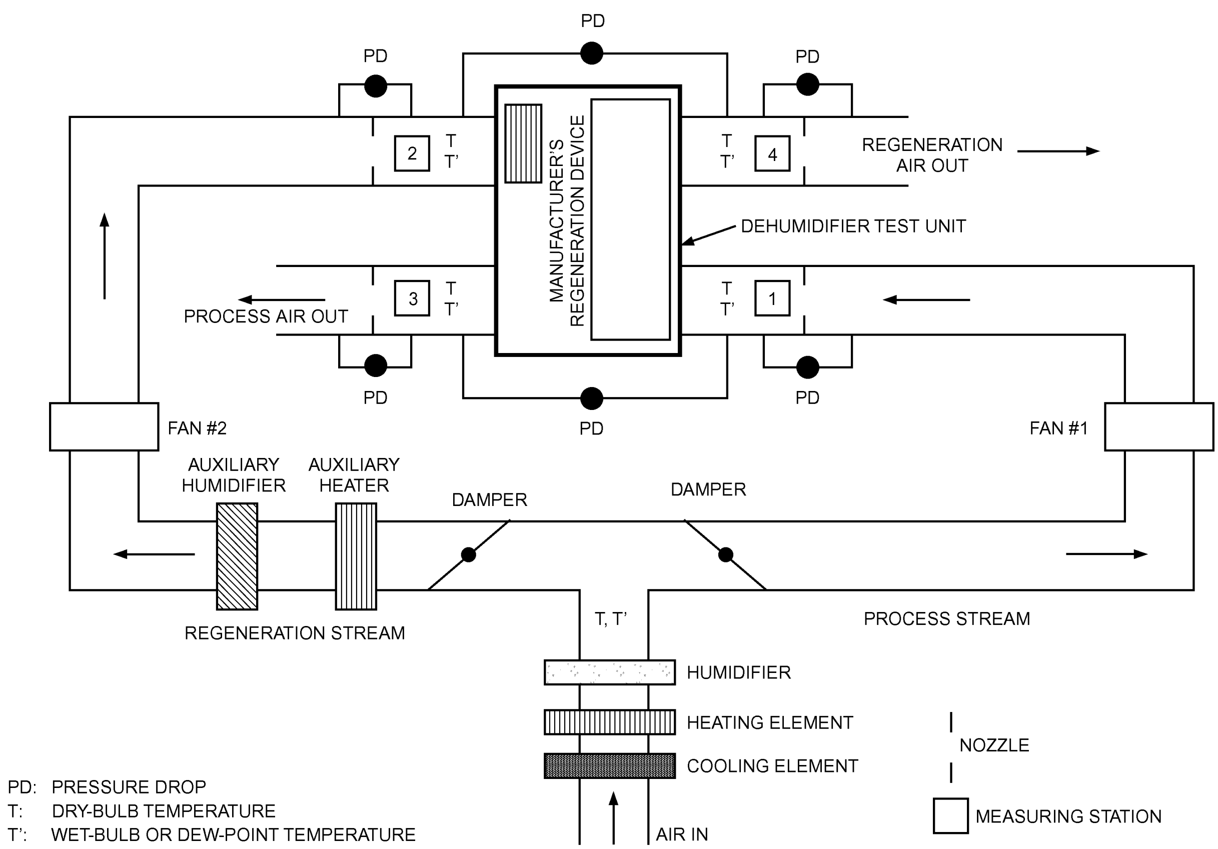

Figure 5 Test loop for solid rotary and moving vertical beds.

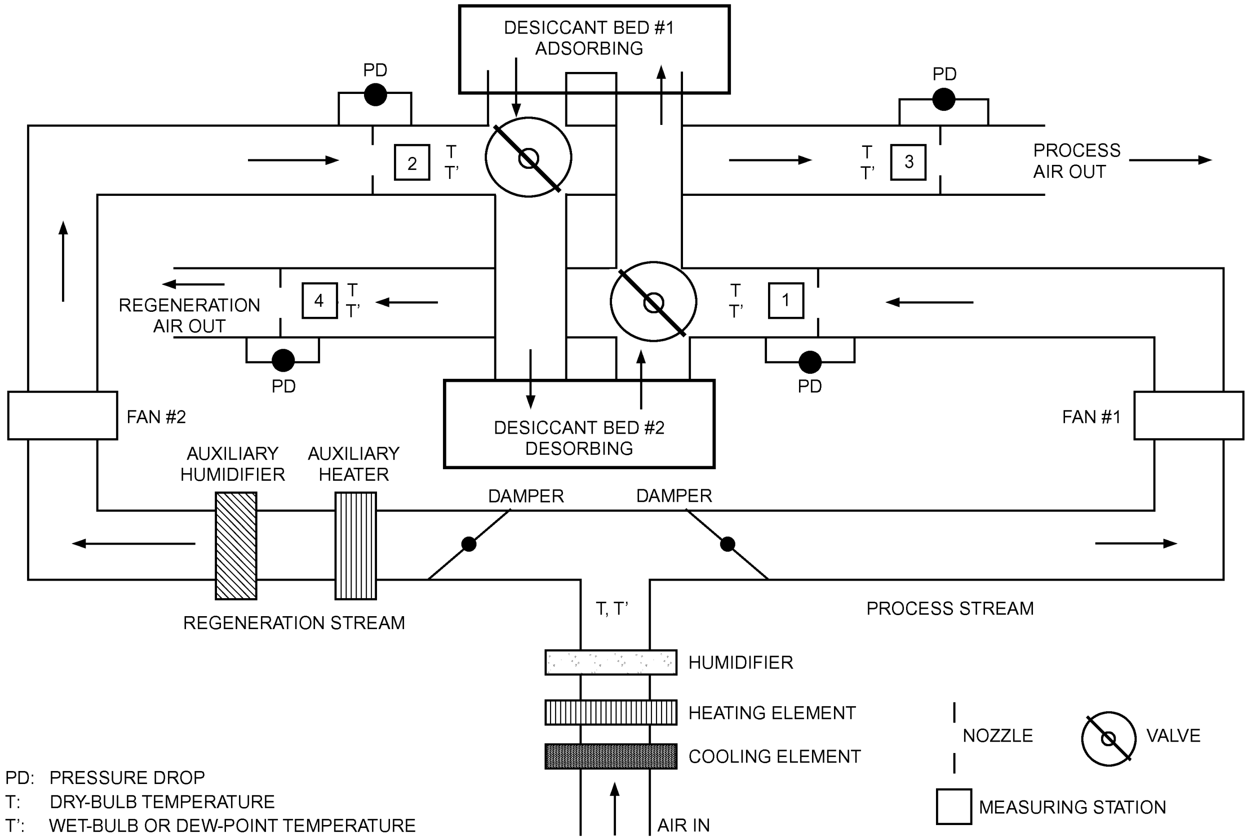

Figure 6 Test loop for dry dual fixed-bed systems.

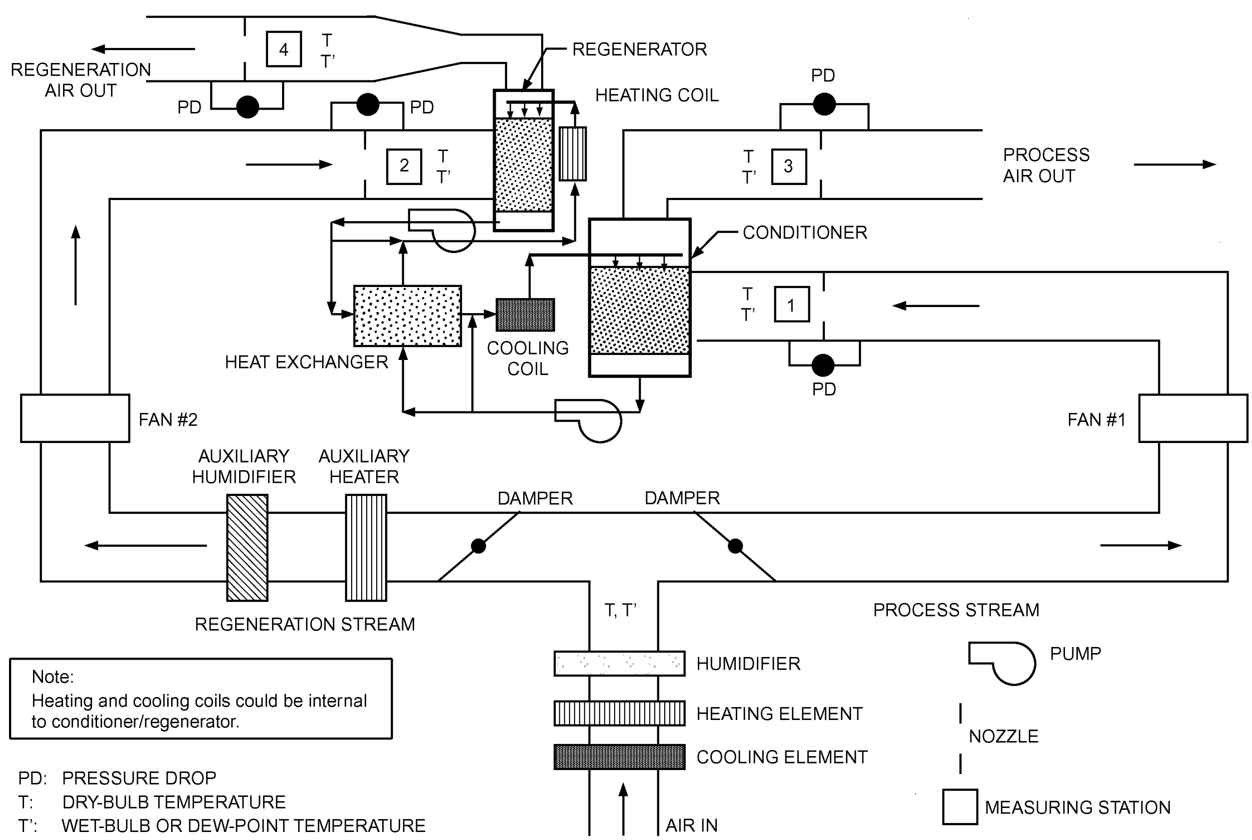

Figure 7 Test loop for liquid dehumidification systems.

$$\mathrm{MRC} = [\mathrm{SCFM}_p \times (60\ \mathrm{min/h} \times 0.075\ \mathrm{lb/ft^3}) \times (G_i - G_o)]/7000\ \mathrm{grains/lb} \qquad \text{(I-P)}$$

or

$$\mathrm{MRC} = \mathrm{SCFM}_p \times 0.0006428 \times (G_i - G_o)$$

where

MRC	=	moisture removal capacity, lb/h
SCFM_p	=	scfm, process air (air to be dehumidified)
G_i	=	humidity ratio at the process air inlet
G_o	=	humidity ratio at the process air outlet

Informative Note: 1 lb = 7000 grains.

9.2.2 Regeneration Energy. The regeneration energy shall be defined as the regeneration heat input to the regeneration heater measured at the power terminals or fuel supply at the heating device. The regeneration energy shall be stated in watts (Btu/h).

9.2.3 Regeneration Specific Heat Input (RSHI). The specific heat input shall be defined as the ratio of the regeneration energy to the moisture removal capacity. The specific heat input shall be stated in terms of thermal energy input per kilogram (pound) of moisture removal and expressed as kJ/kg (Btu/lb), and shall be calculated as follows:

$$\mathrm{RSHI} = (\mathrm{Watt} \times 3.6)/\mathrm{MRC},\ \mathrm{kJ/kg} \qquad \text{(SI)}$$

$$\mathrm{RSHI} = (\mathrm{Btu/h})/\mathrm{MRC},\ \mathrm{Btu/lb} \qquad \text{(I-P)}$$

9.2.4 Mass Balance. A calculation shall be performed to determine the ratio of the mass of moisture removed from the process air with respect to the mass of moisture rejected to the regeneration air at the test conditions. The mass ratio calculated for a specific test condition must be >0.95 and <1.05 in order for the data to be considered valid.

9.2.4.1 Dry Desiccant Units

$$\text{Mass Ratio} = \mathrm{MRC}/\mathrm{MRR}$$

$$\mathrm{MRC} = [\mathrm{SCMH}_{po} \times 0.0012 \times (G_{pi} - G_{po})] \qquad \text{(SI)}$$

$$\mathrm{MRC} = \mathrm{SCFM}_{po} \times 0.0006428 \times (G_{pi} - G_{po}) \qquad \text{(I-P)}$$

$$\mathrm{MRR} = [\mathrm{SCMH}_{ro} \times 0.0012 \times (G_{ro} - G_{ri})] \qquad \text{(SI)}$$

$$\mathrm{MRR} = \mathrm{SCFM}_{ro} \times 0.0006428 \times (G_{ro} - G_{ri}) \qquad \text{(I-P)}$$

where

SCMH_{po}	=	scmh at the process outlet
G_{pi}	=	humidity ratio at the process air inlet
G_{po}	=	humidity ratio at the process air outlet
SCFM_{po}	=	scfm at the process air outlet
SCMH_{ro}	=	scmh at the regeneration outlet
G_{ri}	=	humidity ratio at the regeneration air inlet
G_{ro}	=	humidity ratio at the regeneration air outlet
SCFM_{ro}	=	scfm at regeneration outlet

9.2.4.2 Liquid System with a Single Conditioner and Regenerator Simultaneously Tested Together

$$\text{Mass Ratio} = \mathrm{MRC}/\mathrm{MRR}$$

$$\mathrm{MRC} = [\mathrm{SCMH}_c \times 0.0012 \times (G_{ci} - G_{co})] \qquad \text{(SI)}$$

$$\mathrm{MRC} = \mathrm{SCFM}_c \times 0.0006428 \times (G_{ci} - G_{co}) \qquad \text{(I-P)}$$

$$\mathrm{MRR} = \mathrm{SCMH} \times 0.012 \times (G_{ro} - G_{ri}) \qquad \text{(SI)}$$

$$\mathrm{MRR} = \mathrm{SCFM}_r \times 0.0006428 \times (G_{ro} - G_{ri}) \qquad \text{(I-P)}$$

where

MRC = moisture removed from the air in the conditioner unit, kg/h (lb/h)
MRR = moisture added to the air in the regenerator unit, kg/h (lb/h)
$SCMH_c$ = scmh through the conditioner unit
$SCMH_r$ = scmh through the regenerator unit
$SCFM_c$ = scfm through the conditioner unit
$SCFM_r$ = scfm through the regenerator unit
G_{ci} = humidity ratio at conditioner inlet
G_{co} = humidity ratio at conditioner outlet
G_{ri} = humidity ratio at regenerator inlet
G_{ro} = humidity ratio at regenerator outlet

9.2.4.3 Liquid System with a Single Conditioner Tested

$$\text{Mass Ratio} = \text{MRC}/\text{MRT}$$

$$\text{MRC} = \text{SCMH}_{rc} \times 0.0012 \times (G_{pi} - G_{po}) \quad \text{(SI)}$$

$$\text{MRC} = \text{SCFM}_c \times 0.0006428 \times (G_{ci} - G_{co}) \quad \text{(I-P)}$$

$$\text{MRT} = \text{DT} \times [(X_r - X_c)/X_c]$$

where

MRC = moisture removed from the process air in the conditioner unit, kg/h (lb/h)
MRT = moisture carried from the conditioner to the regenerator unit by the desiccant transfer, kg/h (lb/h)
DT = desiccant solution transferred from the regenerator to the conditioner, kg/h (lb/h)
X_r = desiccant concentration in generator, $kg_{desiccant}/ kg_{solution}$ ($lb_{desiccant}/lb_{solution}$)
X_c = desiccant concentration in conditioner, $kg_{desiccant}/ kg_{solution}$ ($lb_{desiccant}/lb_{solution}$)

9.2.4.4 Liquid System with a Single Regenerator Tested

$$\text{Mass Ratio} = \text{MRR}/\text{MWA}$$

$$\text{MRR} = \text{SCMH}_r \times 0.0012 \times (G_{ro} - G_{ri}) \quad \text{(SI)}$$

$$\text{MRR} = \text{SCFM}_r \times 0.0006428 \times G_{ro} - G_{ri} \quad \text{(I-P)}$$

$$\text{MWA} = (\text{TWS} - \text{TWE}) \times (\text{TT}/60)$$

where

MWA = mass of water added to desiccant, kg/h (lb/h)
TWS = weight of water tank at beginning of test, kg (lb)
TWE = weight of water tank at end of test, kg (lb)
TT = duration of test, min

10. REFERENCES

2024 1. ASHRAE. ~~2020~~. ANSI/ASHRAE Standard 41.1, *Standard Method for Temperature Measurement*. Atlanta: ASHRAE.

2022 2. ASHRAE. ~~2014~~. ASHRAE Standard 41.3-~~2014~~, *Standard Method for Pressure Measurement*. Atlanta: ASHRAE.

2021 3. ASHRAE. 2014. ANSI/ASHRAE Standard 41.6, *Method for Measurement of Moist Air Properties*. Atlanta: ASHRAE.

2022 4. ASHRAE. ~~2018~~. ASHRAE Standard 41.2-~~2018~~, *Standard Methods for Air Velocity and Laboratory Airflow Measurement*. Atlanta: ASHRAE.

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INFORMATIVE APPENDIX A
MASS BALANCE CALCULATIONS

This appendix provides additional air and moisture mass balance calculations, which can be used to support the validity of mass balance results or to provide a troubleshooting reference to determine factors that contribute to mass balance results outside of acceptable ranges.

A1. AIR MASS BALANCE

The ratio of the air mass flow rate entering the device to the air mass flow rate leaving the device.

Acceptable range: 0.98 to 1.02

$$\text{Air Mass Balance} = \frac{\text{SCFM}_{pi} + \text{SCFM}_{ri}}{\text{SCFM}_{po} + \text{SCFM}_{ro}}$$

A2. MOISTURE MASS BALANCE

The ratio of moisture mass flow rate entering the device to the moisture mass flow rate leaving the device.

Acceptable range: 0.97 to 1.03

$$\text{Moisture Mass Balance} = \frac{(\text{SCFM}_{pi} \times G_{pi}) + (\text{SCFM}_{ri} \times G_{ri})}{(\text{SCFM}_{po} \times G_{po}) + (\text{SCFM}_{ro} \times G_{ro})}$$

A3. MOISTURE MASS RATIO

The ratio of the rate of moisture removal on the process side of the device to the rate of moisture addition on the regeneration side of the device.

Acceptable range: 0.95 to 1.05

$$\text{Moisture Mass Ratio} = \frac{\text{MRC}}{\text{MRR}_{ri}}$$

A4. DEVICE PRESSURE DIFFERENTIAL

The pressure differential between the regeneration inlet and process outlet airstreams.

Recommended range: –0.05 to +0.05 in. wc

The pressure differential between the two airstreams should be monitored, especially for wheels and other devices with physically coupled airstreams. Maximum test accuracy can be achieved by maintaining a 0 differential.

$$\text{Device Pressure Differential} = P_{ri} - P_{po}$$

A5. MOISTURE REMOVAL RATE

The quantity of moisture removed by regeneration. This metric should be calculated with the most accurate regeneration airflow rate (the regeneration inlet airflow rate with a device pressure differential of 0).

$$\text{MRR}_{ri} = \text{SCFM}_{ri} \times (G_{ro} - G_{ri})$$

where p is gage pressure in in. wc (mm wc).

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ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the Standards and Guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive Technical Committee structure, continue to generate up-to-date Standards and Guidelines where appropriate and adopt, recommend, and promote those new and revised Standards developed by other responsible organizations.

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