



# Standard Test Methods for Water Vapor Content of Electrical Insulating Gases by Measurement of Dew Point<sup>1</sup>

This standard is issued under the fixed designation D 2029; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

*This standard has been approved for use by agencies of the Department of Defense.*

## 1. Scope

1.1 These test methods describe the determination of the water vapor content of electrical insulating gases by direct or indirect measurement of the dew point and the calculation of the water vapor content.

1.2 The following four test methods are provided:

1.2.1 *Method A* describes the automatic chilled mirror method for measurement of dew point as low as  $-73^{\circ}\text{C}$  ( $-99^{\circ}\text{F}$ ).

1.2.2 *Method B* describes the manual chilled mirror or dew cup method for measurement of dew point as low as  $-73^{\circ}\text{C}$  ( $-99^{\circ}\text{F}$ ).

1.2.3 *Method C* describes the adiabatic expansion method for measurement of dew point as low as  $-62^{\circ}\text{C}$  ( $-80^{\circ}\text{F}$ ).

1.2.4 *Method D* describes the capacitance method for measurement of dew point as low as  $-110^{\circ}\text{C}$  ( $-166^{\circ}\text{F}$ ).

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.* For specific warnings, see 8.1.1, 9.2, 10.1.2 and 10.2.5.

## 2. Referenced Documents

2.1 *ASTM Standards:*<sup>2</sup>

D 1933 Specification for Nitrogen Gas as an Electrical Insulating Material

D 2472 Specification for Sulfur Hexafluoride

D 3283 Specification for Air as an Electrical Insulating Material

## 3. Terminology

3.1 *Definitions:*

<sup>1</sup> These test methods are under the jurisdiction of ASTM Committee D27 on Electrical Insulating Liquids and Gases and are the direct responsibility of Subcommittee D27.07 on Physical Test.

Current edition approved April 10, 1997. Published November 1997. Originally published as D 2029 – 64T. Last previous edition D 2029 – 92.

<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.

3.1.1 *dew point, n*—the temperature to which a gas must be cooled at constant pressure and constant water vapor content in order for saturation to occur. Any further cooling usually results in formation of the first drop of dew.

3.1.2 *hygroscopic, adj*—readily taking up and retaining moisture.

## 4. Summary of Test Methods

4.1 *Method A*—The automatic chilled mirror method uses the chilled mirror dew point condensation principle to determine the water vapor content in gas mixtures. An internal mirror, which is in the path of the test gas, is automatically cooled. Internal electronics sense the presence of moisture on the mirror. The device then automatically brings itself to equilibrium and provides a direct reading of dew point temperature.

4.2 *Method B*—This method uses the same basic condensation principle in 4.1; however, the manual chilled mirror method uses a mixture of acetone and ice or other cooling media to manually chill the dew cup polished surface which acts as the mirror.

4.3 *Method C*—Adiabatic expansion uses a process in which the test gas is cooled rapidly to determine dew point temperature. This rapid exhausting of the test gas to atmosphere results in an expansion and cooling of the gas. If the cooling is sufficient to reduce the temperature of the gas to or below the dew point, water vapor will condense out in the form of a fine mist or fog. Successive trials will determine the minimum initial pressure that will produce a fog. From this, the dew point temperature can be calculated.

4.3.1 The relationship between pressure and temperature during adiabatic expansion is as follows:

$$T_F = T_I [P_F/P_I]^{[K-1/K]}$$

where:

$K$  = ratio of specific heats for a given gas,

$T_F$  = final temperature,

$T_I$  = initial temperature,

$P_F$  = final pressure, and

$P_I$  = initial pressure.

4.4 *Method D*—The capacitance method uses a moisture sensor, typically aluminum oxide or silicon oxide, which changes its electrical output with the amount of water vapor to which it is exposed.

## 5. Significance and Use

5.1 Certain gases have excellent dielectric and electric arc interruption characteristics which make their use in electrical installations very desirable.

5.2 Water content, as the test parameter, is of great importance in determining the dielectric effectiveness of the gas. Under certain conditions, water may condense and become a conducting liquid resulting in a catastrophic dielectric breakdown of the insulation. The water content of these insulating gases as expressed by dew point is listed in Specifications D 1933, D 2473, and D 3283.

5.3 Once the dew point is determined, a conversion to moisture content may be performed using Table 1. Once moisture content is known, the lowest temperature at which gas insulated equipment can be safely operated can usually be determined by reviewing manufacturers' specifications for the equipment.

5.4 The dew point of the test gas is independent of the gas temperature but does depend on its pressure. Many moisture measurement test instruments are sensitive to pressure, and display moisture values at the instrument inlet pressure and not necessarily at the pressure of the system being sampled. It is therefore important to account for this condition to avoid serious measurement errors.

## 6. Interferences

### 6.1 Tubing:

6.1.1 Most new metal tubing contains oil deposits on the interior walls due to the manufacturing process. This residue should be removed before using these lines for gas sampling.

6.1.2 Tubing should be free of leaks, since even a pinhole leak will result in a false indication (higher dew point), due to the partial pressure of water vapor in the atmosphere.

6.1.3 When the gas being tested is extremely dry [dew point below approximately  $-40^{\circ}\text{C}$  ( $-40^{\circ}\text{F}$ )], results can be misleading until the moisture adsorbed in the system (tubing, regulators, etc.) has been removed by purging with the test gas. At this point, all moisture present within the system should be due to that contained in the test gas.

6.2 When testing gases that contain readily liquefiable impurities, it must be kept in mind that the dew point that is measured by condensation type instruments may be due to these impurities rather than to water. Under these conditions, the measured dew point is not an indication of the water content of the gas.

6.3 Measurement of water vapor in very dry gases is complicated by four considerations, as follows:

6.3.1 For Methods A, B, and C, the relatively large volume of gas required to deposit sufficient water vapor to create the "dew".

6.3.2 For Methods A, B, and C, that under very dry condition, the possibility exists to condense the test gas prior to deposition of moisture on the mirror.

6.3.3 For Methods A, B, C, and D, that the measuring system (instrument and tubing) must not entrain moisture. If any moisture is entrained, several hours may be required for the gas being measured to come into equilibrium with the measuring system.

6.3.4 For Methods B and C, the sensitivity of the human eye in determining exactly when the dew first forms.

## 7. General Requirements

7.1 *Methods A, B, and C*—Any properly constructed dew point apparatus may be used that provides a means to satisfy the following basic requirements:

7.1.1 Control the flow of gas entering and leaving the apparatus while the apparatus is at a temperature at least  $2^{\circ}\text{C}$  ( $3.6^{\circ}\text{F}$ ) above the dew point of the gas.

7.1.2 Control the cooling rate of a chamber in the apparatus through which the flowing gas passes to a temperature low enough to cause water vapor to condense from the gas.

7.1.3 Detect the deposition of dew on the cold portion of the apparatus and measure the temperature at which dew is formed.

7.1.4 Ensure that the test gas is at or near atmospheric pressure and is isolated from contamination from other gases.

7.2 *Method D*—Any properly constructed capacitive type moisture sensor may be used that provides a means to satisfy the following basic requirements:

7.2.1 Expose the sensor to a gas that is at a temperature at least  $10^{\circ}\text{C}$  ( $18^{\circ}\text{F}$ ) above the dew point of the gas.

7.2.2 Measure the partial vapor pressure of water in a gas by means of a capacitive type sensor.

7.3 These test methods provide for several techniques, each utilizing different types of apparatus for measuring dew point. The techniques in these test methods are provided for general information and are not intended as a substitute for manufacturer's instructions. When using any instrument, the manufacturer's instructions should be followed to ensure proper and safe operation.

## 8. Apparatus

### 8.1 General:

8.1.1 *Tubing*—Although not true of all applications, stainless steel, glass, and nickel alloy tubing are the best possible nonhygroscopic materials and should be used for low dew point applications  $-18$  to  $-73^{\circ}\text{C}$  ( $0$  to  $-100^{\circ}\text{F}$ ). Copper and aluminum alloys, as well as stabilized polypropylene tubing, are acceptable above  $-29^{\circ}\text{C}$  ( $-20^{\circ}\text{F}$ ) dew point. (**Warning**—All materials will adsorb moisture to some extent; therefore, the internal surface of apparatus, tubing, and fittings should be minimized to enable the system to dry out more quickly and achieve equilibrium sooner. However, it should be noted that when one switches from measurement of a high dew point to a lower dew point [that is,  $0$  to  $-60^{\circ}\text{C}$  ( $32$  to  $-76^{\circ}\text{F}$ )] copper tubing might take 1 h or more to desorb the moisture from the previous sample, whereas stainless steel will equilibrate in approximately 10 min.)

8.1.2 Although not a requirement, the addition of a chart recorder to various automated systems makes determining when the system has reached equilibrium much easier.

**TABLE 1 Relationship Between Dew Point and Moisture Content of Gases**

NOTE 1—With a known dew point which is indicated by the dew point indicator or recorder, the moisture content can be read directly from the table. The table shows the amount of water in air or other gas at various dew points at a pressure of 1 atm (14.7) psi.

Dew Point		Moisture Content			Dew Point		Moisture Content		
°C	°F	lb/1000 ft <sup>3</sup>	mg/L	volume <sup>A</sup> percent	°C	°F	lb/1000 ft <sup>3</sup>	mg/L	volume <sup>A</sup> percent
50	122.0	5.16	82.7	12.2	-16	3.2	0.079	1.27	0.149
49	120.2	4.92	78.9	11.6	-17	1.4	0.072	1.16	0.136
48	118.4	4.69	75.1	11.0	-18	-0.4	0.066	1.06	0.123
47	116.6	4.48	71.9	10.5	-19	-2.2	0.060	0.965	0.112
46	114.8	4.26	68.4	9.95	-20	-4.0	0.055	0.882	0.102
45	113.0	4.06	65.0	9.45	-21	-5.8	0.050	0.809	0.093
44	111.2	3.88	62.1	8.99	-22	-7.6	0.046	0.733	0.084
43	109.4	3.69	59.1	8.52	-23	-9.4	0.042	0.666	0.076
42	107.6	3.52	56.4	8.10	-24	-11.2	0.038	0.608	0.069
41	105.8	3.34	53.5	7.67	-25	-13.0	0.035	0.556	0.063
40	104.0	3.18	50.9	7.27	-26	-14.8	0.031	0.506	0.057
39	102.2	3.02	48.4	6.89	-26	-16.6	0.028	0.454	0.057
38	100.4	2.87	46.0	6.54	-28	-18.4	0.025	0.411	0.046
37	98.6	2.74	43.8	6.20	-29	-20.2	0.023	0.377	0.042
36	96.8	2.60	41.6	5.87	-30	-22.0	0.021	0.343	0.038
35	95.0	2.46	39.4	5.55	-31	-23.8	0.019	0.307	0.034
34	93.2	2.34	37.4	5.25	-32	-25.6	0.017	0.273	0.030
33	91.4	2.22	35.6	4.96	-33	-27.4	0.015	0.246	0.027
32	89.6	2.11	33.8	4.70	-34	-29.2	0.014	0.229	0.025
31	87.8	2.00	32.0	4.44	-35	-31.0	0.013	0.202	0.022
30	86.0	1.89	30.3	4.19	-36	-32.8	0.012	0.185	0.020
29	84.2	1.84	29.2	4.01	-37	-34.6	0.010	0.167	0.018
28	82.4	1.69	27.1	3.7	-38	-36.4	0.0093	0.149	0.016
27	80.6	1.60	25.7	3.52	-39	-38.2	0.0082	0.131	0.014
26	78.8	1.52	24.4	3.33	-40	-40.0	0.0074	0.119	0.0127
25	77.0	1.44	23.0	3.12	-41	-41.8	0.0068	0.107	0.0113
24	75.2	1.35	21.7	2.94	-42	-43.6	0.0060	0.096	0.0102
23	73.4	1.28	20.6	2.78	-43	-45.4	0.0054	0.086	0.0090
22	71.6	1.21	19.4	2.61	-44	-47.2	0.0047	0.076	0.0080
21	69.8	1.14	18.3	2.46	-45	-49.0	0.0042	0.068	0.0071
20	68.0	1.08	17.3	2.31	-46	-50.8	0.0038	0.061	0.0063
19	66.2	1.02	16.3	2.17	-47	-52.6	0.0034	0.054	0.0056
18	64.4	0.961	15.4	2.04	-48	-54.4	0.0031	0.049	0.0050
17	62.6	0.899	14.4	1.91	-49	-56.2	0.0027	0.043	0.0044
16	60.8	0.855	13.7	1.80	-50	-58.0	0.0024	0.038	0.0039
15	59.0	0.799	12.8	1.68	-51	-59.8	0.0021	0.034	0.0034
14	57.2	0.749	12.0	1.57	-52	-61.6	0.0019	0.030	0.0030
13	55.4	0.706	11.3	1.48	-53	-63.4	0.0017	0.027	0.0027
12	53.6	0.668	10.7	1.39	-54	-65.2	0.0014	0.023	0.0023
11	51.8	0.620	9.94	1.29	-55	-67.0	0.0013	0.021	0.0021
10	50.0	0.584	9.37	1.21	-56	-68.8	0.0011	0.018	0.0018
9	48.2	0.547	8.76	1.13	-57	-70.6	0.0010	0.016	0.0016
8	46.4	0.516	8.27	1.06	-58	-72.4	0.00087	0.014	0.0014
7	44.6	0.482	7.73	0.988	-59	-74.2	0.00075	0.012	0.0012
6	42.8	0.452	7.25	0.924	-60	-76.0	0.00069	0.011	0.0011
5	41.0	0.424	6.79	0.861	-61	-77.8	0.00059	0.0095	0.00092
4	39.2	0.399	6.36	0.804	-62	-79.6	0.00052	0.0083	0.00080
3	37.4	0.370	5.94	0.748	-63	-81.4	0.00046	0.0073	0.00070
2	35.6	0.346	5.55	0.696	-64	-83.2	0.00040	0.0064	0.00061
1	33.8	0.323	5.18	0.649	-65	-85.0	0.00035	0.0056	0.00053
0	32.0	0.302	4.84	0.602	-66	-86.8	0.00030	0.0048	0.00045
-1	30.2	0.280	4.49	0.556	-67	-88.6	0.00027	0.0043	0.00040
-2	28.4	0.258	4.14	0.511	-68	-90.4	0.00022	0.0036	0.00034
-3	26.6	0.238	3.81	0.470	-69	-92.2	0.00019	0.0031	0.00029
-4	24.8	0.220	3.52	0.431	-70	-94.0	0.00017	0.0027	0.00025
-5	23.0	0.202	3.24	0.396	-71	-95.8	0.00015	0.0024	0.00022
-6	21.2	0.186	2.98	0.364	-72	-97.6	0.00013	0.0021	0.00019
-7	19.4	0.171	2.74	0.333	-73	-99.4	0.00011	0.0018	0.00016
-8	17.6	0.158	2.53	0.306	-74	-101.2	0.00009	0.0015	0.00014
-9	15.8	0.145	2.32	0.280	-75	-103.0	0.00008	0.0013	0.00012
-10	14.0	0.134	2.14	0.257	-76	-104.8	0.00007	0.0011	0.00010
-11	12.2	0.122	1.96	0.235	-77	-106.6	0.00006	0.0010	0.00009
-12	10.4	0.113	1.81	0.215	-78	-108.4	0.00005	0.0008	0.00007
-13	8.6	0.103	1.65	0.196	-79	-110.2	0.00004	0.0007	0.00006
-14	6.8	0.095	1.52	0.179	-80	-112.0	0.00004	0.0006	0.00005
-15	5.0	0.086	1.38	0.163	-81	-113.8	0.00003	0.0005	0.00004

<sup>A</sup>Vapor pressures in atmospheres at various dew points can be obtained by dividing the values for "volume percent" in this table by 100. Calculations for this table were made by using the International Critical Table values for the vapor pressure of ice and liquid water. The vapor pressure of liquid water was used for values from 50 to 0°C. The vapor pressure of ice was used from 0 to - 81°C.

8.2 *Method A*—The automated chilled mirror dew point apparatus shown in Fig. 1 fulfills the requirements of 7.1. The apparatus typically consists of a test chamber having the following components:

8.2.1 *Thermoelectric Heat Pump*, equipped with a suitable temperature sensor embedded within the mirror that forms the condensation surface on the heat pump/mirror assembly.

8.2.2 *Condensate Detector*, with a suitable light source and photo detector bridge network.

8.2.3 *Internal Power Supplies and Amplifiers* as necessary to integrate above components into a system.

8.2.4 *Tubing for Test Gas*, one end connected to the test gas supply, the other end directed so that the test gas will flow over the face of the pump/mirror assembly.

8.2.5 *Orifice and Tubing*, for exhausting the test gas to atmosphere, as required.

8.3 *Method B*—The manual chilled mirror dew point apparatus shown in Fig. 2 fulfills the requirements of 7.1. The apparatus typically consists of the following:

8.3.1 *Outer Metal Container*, with a sealed safety glass observation window and inlet and outlet ports integral with the container. The inlet port shall be threaded. The overall tight construction eliminates possible error in readings due to atmospheric moisture.

8.3.2 *Cup*, nickel-plated, having a polished mirror surface positioned inside the container by means of a guide ring, which ensures that the cam-locks on the cap will be properly engaged and the cup assembly will be locked on an “O” ring.

8.3.3 *Thermometer*, graduated from  $-100$  to  $+50^{\circ}\text{C}$  ( $-148$  to  $+122^{\circ}\text{F}$ ).

8.3.4 *Tubing*, flexible metal, to connect test gas supply to the threaded inlet port.

8.4 *Method C*—The apparatus shown in Fig. 3 is suitable for dew point measurements using the adiabatic expansion method and fulfills the requirements of 7.1. The apparatus typically consists of the following:

8.4.1 *Tubing*, flexible metal, to connect test gas supply to threaded inlet port.

8.4.2 *Hand Pump*, to introduce the test gas into the observation chamber at some pressure above atmospheric.

8.4.3 *Fog Chamber*, with an observation window and a light source.

8.4.4 *Pressure Ratio Gage*, with unity adjustment.

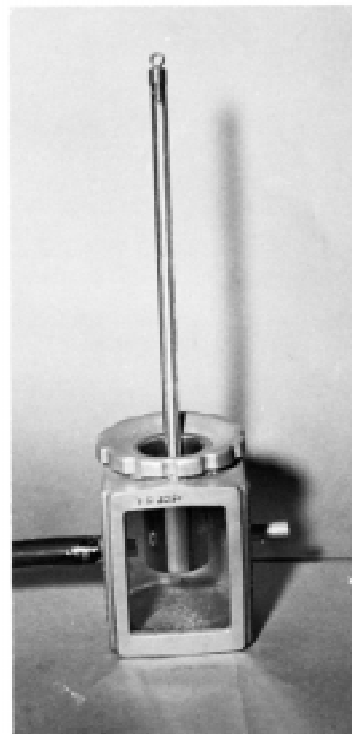


FIG. 2 Dew Point Apparatus Using Manual Chilled Mirror

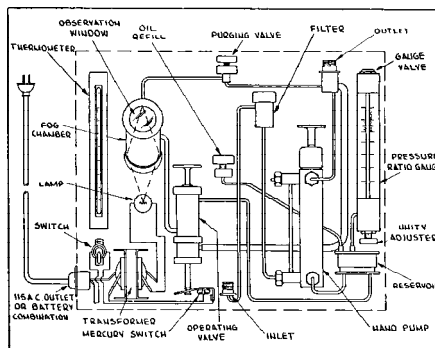


FIG. 3 Schematic Diagram of a Dew Point Apparatus Using Adiabatic Expansion

8.4.5 *Thermometer*, to measure test gas temperature.

8.4.6 *Operating Valve*, which closes the line from the inlet and pressure ratio gage, turns on the fog chamber light source, and rapidly opens the line from the fog chamber to the atmosphere.

8.4.7 *Purge Valve*, to allow flushing the instrument with the test gas.

8.5 *Method D*—The apparatus shown in Fig. 4 is suitable for dew point measurements using the capacitance method. The apparatus typically consists of the following:

8.5.1 *Capacitance Type Sensor*, capable of sensing various levels of moisture content in test gas mixtures.

NOTE 1—These test sensors are typically of the aluminum oxide or silicon oxide type. The water vapor is transported to the oxide layer which changes sensor capacitance in proportion to the amount of moisture absorbed.

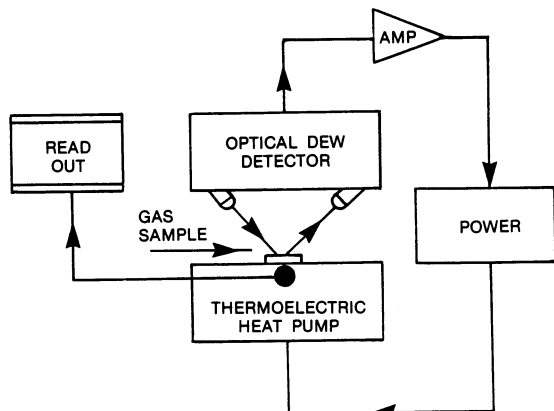
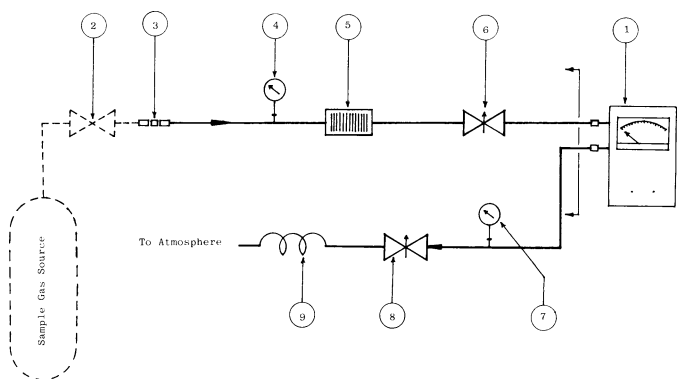


FIG. 1 Dew Point Apparatus Using Automatic Chilled Mirror



Item	Description
1	Hygrometer with sensor
2	Isolating valve
3	Union
4, 7	Pressure regulator
5	In-line filter
6, 8	Fine metering valve
9	Venting coil

FIG. 4 Dew Point Apparatus Using Capacitance Method

8.5.2 *Enclosure*, or other type isolation package which houses the sensor and allows for introduction of the test gas while maintaining test gas integrity.

8.5.3 *Microprocessor*, or equivalent electronics capable of computation and display of the dew point of the sample under test.

8.5.4 *Valves, Tubing and Line Filters*, as required for sample isolation and introduction into the test instrument.

## 9. Sampling

9.1 The sampling procedure is not defined since the test methods include four types of test systems which can be used for a wide variety of laboratory and industrial use.

9.2 When sampling is performed on electrical apparatus, all local safety rules should be followed to ensure personnel safety and equipment protection.

NOTE 2—Certain electrical systems, such as underground electrical cables which are blanketed with SF<sub>6</sub> gas may fail or become inoperative if gas pressure is too low. Before sampling these systems, a review of sampling and operating procedures with the appropriate personnel is recommended.

9.3 Moisture adsorption and desorption characteristics of sampling lines and accessories should be considered prior to sampling. Inadequate purging of the sampling system or leaks into or out of the system will cause measurement errors.

9.4 Most conversion tables for dew point to parts per million, grains per pound, etc., are made at atmospheric pressure (14.7 psia); therefore, if accurate absolute moisture content measurements are to be converted to atmospheric pressure referenced values, the pressure must be known.

9.5 *Pressure Regulator*—When sampling pressurized systems, the addition of a pressure regulator allows for direct measurement of system pressure while also providing regulation of the test gas into the sampling system.

## 10. Procedure

### 10.1 Method A—Automated Chilled Mirror Method:

10.1.1 Purge the entire gas system of the test unit with dry nitrogen gas until the hygrometer gives a constant reading. This is necessary to remove any residual moisture in the test system.

10.1.2 Connect the test gas to the inlet of the test unit using appropriate metal tubing. (**Warning**—If the test gas is at high pressure, make the connection to the test chamber through a pressure regulator.)

10.1.3 Purge the entire gas system (see 10.1.1), which now includes the high pressure regulator.

10.1.4 With the system now purged, adjust the flow of the test gas (using a suitable flowmeter) to the rate recommended by the instrument manufacturer.

NOTE 3—The addition of hardware such as flowmeters and regulators increases the internal surface area of the apparatus. Therefore, when regulators and other devices are placed upstream of the measurement sensor, system equilibration (time for the system to dry completely) will take longer.

10.1.5 Purging rates (gas flow) and time (duration of purge) are dependent upon the constituency of the test gas, the tubing used, the test instrument, etc. The manufacturers' operating manuals should be reviewed prior to test.

10.1.6 Measure the dew point of the gas directly from the instrument meter.

NOTE 4—The condensation hygrometer typically can cool to approximately 66°C (120°F) below the ambient temperature. Ancillary cooling can increase this range, and this capability in the instrument should be considered if dew points below approximately -43°C (-45°F) are to be measured.

NOTE 5—Where a liquid phase is present in the gas to be tested, determination of results is dependent upon the temperature at which the sample is taken. This should be recognized when interpreting the results.

### 10.2 Method B—Manual Chilled Mirror Method:

10.2.1 Connect the test gas to the inlet of the dew point apparatus by means of flexible metal tubing and allow the gas to flow at a rate of approximately 0.14 m<sup>3</sup>(5 ft<sup>3</sup>)/h. Use area-type flowmeters. Do not use water manometers across flow restrictors.

10.2.2 Pour acetone to a height of approximately 50 mm (2 in.) into the cup.

10.2.3 Allow the gas to purge the test chamber for about 5 min; then add small amounts of dry ice to the acetone and stir constantly with the thermometer.

10.2.4 At the first sign of dew appearing on the polished surface of the cup, read the temperature on the thermometer. This temperature is the dew point of the gas.

NOTE 6—It is suggested that the temperature of the acetone-dry ice mixture should be lowered slowly in order to minimize any error due to temperature lag.

10.2.5 Use a reasonably bright light, preferably equipped with a shade to illuminate the polished cup, so that the very first faint trace of dew can be detected. Hold the light in such a position that there will be the least glare from the polished surface. In measuring dew points, the surface of the polished cup should be clean and free of any gases, dirt, etc. (**Warning**—Caution should be exercised in making these tests, due to the flammability of certain gases and acetone in confined spaces.)

NOTE 7—Changes in this procedure may be necessary when taking samples directly from the equipment.

### 10.3 Method C—Adiabatic Expansion:

10.3.1 Connect the test gas to the instrument with flexible metal tubing. Slowly stroke the hand pump ten to fifteen times to purge the test system. Rapid pumping will have a significant effect on the dew point measurement.

10.3.2 Close the purging valve and slowly pump the test gas sample into the instrument. Look into the observation window and depress the operating valve.

10.3.2.1 A fog will appear if the gas was cooled to or below the dew point. Subsequent trials at higher pressure ratios will yield the dew point temperature.

10.3.2.2 If a fog does not appear, it indicates that the gas was not cooled to its dew point and subsequent trials should be made at lower pressure ratios.

10.3.3 Repeat the process until the maximum pressure ratio is determined that will just produce a fog.

10.3.4 Use the instrument temperature and pressure ratio readings to calculate the dew point from the adiabatic expansion equation in 4.3.1.

### 10.4 Method D—Capacitance Method:

10.4.1 Connect the sample cell to the test gas using appropriate flexible tubing. Needle valves may be used on the inlet and outlet of the sample cell to control flow and pressure. A gage may be used downstream of the sample cell to monitor pressure.

10.4.2 Purge the cell with test gas until the hygrometer gives a constant reading. Low flow rates may be used if it is important to conserve the sample gas.

NOTE 8—If the test unit is left with a small purge of dry gas when not in use, it will equilibrate more quickly when the test gas is introduced.

10.4.3 Take the dew point reading directly when the readout indicator is steady.

10.4.3.1 Stability can be confirmed by sharply reducing the flow rate through the instrument. If the sampling system is in equilibrium with the sample gas, changing the flow rate will have no effect on the reading. If the dew point temperature rises when the flow rate is decreased, allow more time for sample line purging.

10.5 Various dew point instruments require calibration periodically and before use. The user of this method should review the calibration section of the manufacturer's operating manual prior to instrument use.

## 11. Conversion

11.1 The relationship between dew point and moisture content of gases is given in Table 1. In this table, the water vapor in air or other gas at various dew points and at a pressure of 1 atm (14.7 psi) is given in pounds per 1000 cubic feet, milligrams per litre, and volume percent. These values were obtained by calculations based on the International Critical Tables for vapor pressure over water (Vol III).

## 12. Report

12.1 Report the following information:

12.1.1 The test method used,

12.1.2 Test gas type along with its pressure and temperature,

12.1.3 A description of the apparatus under test,

12.1.4 Identification of the sampling point(s).

12.1.5 Weather or other appropriate ambient conditions observed during the test (indoors, outdoors, etc.) where applicable, and

12.1.6 A description of the instrument including its serial or other identification number.

## 13. Precision and Bias

13.1 No standard materials are presently available for round robin testing; therefore no precision and bias statements have been developed for these test methods. For information on various instrument accuracies, refer to the manufacturer's operating manuals.

## 14. Keywords

14.1 adiabatic expansion; aluminum oxide; chilled mirror; condensation; dew point; electrical insulating gas; fog; hygrometer; moisture content; SF<sub>6</sub>; silicon oxide; water vapor content

*ASTM International takes no position respecting the validity of any patent rights asserted in connection with any item mentioned in this standard. Users of this standard are expressly advised that determination of the validity of any such patent rights, and the risk of infringement of such rights, are entirely their own responsibility.*

*This standard is subject to revision at any time by the responsible technical committee and must be reviewed every five years and if not revised, either reapproved or withdrawn. Your comments are invited either for revision of this standard or for additional standards and should be addressed to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend. If you feel that your comments have not received a fair hearing you should make your views known to the ASTM Committee on Standards, at the address shown below.*

*This standard is copyrighted by ASTM International, 100 Barr Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959, United States. Individual reprints (single or multiple copies) of this standard may be obtained by contacting ASTM at the above address or at 610-832-9585 (phone), 610-832-9555 (fax), or service@astm.org (e-mail); or through the ASTM website (www.astm.org).*