This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

Designation: D2029 – 26

# Standard Test Methods for Water Vapor Content of Electrical Insulating Gases by Measurement of Dew Point[1]

This standard is issued under the fixed designation D2029; 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 (ε) indicates an editorial change since the last revision or reapproval.

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

## 1. Scope

1.1 These test methods describe the determination of the water vapor content of electrical insulating gases by directly or indirectly measuring the dew point and calculating the water vapor content.

1.2 The following three test methods are provided:

1.2.1 *Method A* describes the automatic chilled mirror method for measurement of dew point as low as –73 °C (–99 °F).

1.2.2 *Method B* describes the adiabatic expansion method for measuring dew point as low as –62 °C (–80 °F).

1.2.3 *Method C* describes the capacitance method for measurement of dew point as low as –110 °C (–166 °F).

1.3 This standard will also provide insight into the direct measurement of dew point in electrical insulating gas from in-field servicing of various gas insulating equipment.

1.4 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.* For specific warnings, see 8.1.1, 9.2, and 10.1.2.

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## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1933 Specification for Nitrogen Gas as an Electrical Insulating Material
D2472 Specification for Sulfur Hexafluoride
D3283 Specification for Air as an Electrical Insulating Material

## 3. Terminology

3.1 *Definitions:*

3.1.1 *adiabatic expansion, n*—a thermodynamic process where a system expands without any heat transfer between the system and its surroundings.

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

3.1.3 *dielectric, adj*—having strong insulation properties.

3.1.4 *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 in the path of the test gas is automatically cooled. Internal electronics sense the presence of moisture on the mirror. The device automatically equilibrates and directly reads the dew point temperature.

4.2 *Method B*—Adiabatic expansion involves rapidly cooling the test gas to determine the dew point temperature. This quick release of the test gas into the atmosphere causes the gas to expand and cool. If the cooling lowers the gas temperature to or below the dew point, water vapor will condense as a fine mist or fog. Successive trials will identify the minimum initial

[1] These test methods are under the jurisdiction of ASTM Committee D27 on Electrical Insulating Liquids and Gasesand are the direct responsibility of Subcommittee D27.07 on Physical Test.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at www.astm.org/contact. For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.

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pressure required to produce fog. From this, the dew point temperature can be calculated.

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

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

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.

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

## 5. Significance and Use

5.1 Certain gases have excellent dielectric and electric arc interruption characteristics, making their use in electrical installations desirable.

5.2 Water content, as the test parameter, is important in determining the gas's dielectric effectiveness. Under certain conditions, water may condense and become a conducting liquid, breaking down the gas's dielectric properties. The water content of these insulating gases, as expressed by dew point, is listed in Specifications D1933, D2472, and D3283.

5.3 Once the dew point is determined, Table 1 may be used to convert it into moisture content. Once moisture content is known, the lowest temperature at which gas-insulated equipment can be safely operated is typically determined by reviewing the equipment's specifications.

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 sampled system. 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. A pinhole leak would 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 °C (–40 °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 the content of the test gas.

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

6.3 Measurement of water vapor in very dry gases is complicated due to three considerations, as follows:

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

6.3.2 For Methods A and C, the test gas may condense before moisture is deposited on the mirror under very dry conditions.

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

## 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 °C (3.6 °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 dew deposition 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 C*—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 °C (18 °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 several techniques for measuring dew point, each utilizing different types of apparatus. The techniques are provided for general information and are not intended as a substitute for the manufacturer's instructions. The manufacturer's instructions should be followed when using any instrument 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 non- hygroscopic materials and should be used for low dew point applications –18 °C to –73 °C (0 °F to –100 °F). Copper and aluminum alloys and stabilized polypropylene tubing are acceptable above –29 °C (–20 °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