



Standard Test Method for Water Vapor Content of Gaseous Fuels by Measurement of Dew-Point Temperature¹

This standard is issued under the fixed designation D1142; 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 This test method covers the determination of the water vapor content of gaseous fuels by measurement of the dew-point temperature and the calculation therefrom of the water vapor content.

NOTE 1—Some gaseous fuels contain vapors of hydrocarbons or other components that easily condense into liquid and sometimes interfere with or mask the water dew point. When this occurs, it is sometimes very helpful to supplement the apparatus in Fig. 1 with an optical attachment that uniformly illuminates the dew-point mirror and also magnifies the condensate on the mirror. With this attachment it is possible, in some cases, to observe separate condensation points of water vapor, hydrocarbons, and glycolamines as well as ice points. However, if the dew point of the condensable hydrocarbons is higher than the water vapor dew point, when such hydrocarbons are present in large amounts, they may flood the mirror and obscure or wash off the water dew point. Best results in distinguishing multiple component dew points are obtained when they are not too closely spaced.

NOTE 2—Condensation of water vapor on the dew-point mirror may appear as liquid water at temperatures as low as 0 to -10°F (-18 to -23°C). At lower temperatures an ice point rather than a water dew point likely will be observed. The minimum dew point of any vapor that can be observed is limited by the mechanical parts of the equipment. Mirror temperatures as low as -150°F (-100°C) have been measured, using liquid nitrogen as the coolant with a thermocouple attached to the mirror, instead of a thermometer well.

1.2 *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.*

2. Terminology

2.1 Definitions of Terms Specific to This Standard:

2.1.1 *saturated water vapor or equilibrium water-vapor content*—the water vapor concentration in a gas mixture that is in equilibrium with a liquid phase of pure water that is

¹ This test method is under the jurisdiction of ASTM Committee D03 on Gaseous Fuels and is the direct responsibility of Subcommittee D03.05 on Determination of Special Constituents of Gaseous Fuels.

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saturated with the gas mixture. When a gas containing water vapor is at the water dew-point temperature, it is said to be saturated at the existing pressure.

2.1.2 *specific volume*—of a gaseous fuel, the volume of the gas in cubic feet per pound.

2.1.3 *water dew-point temperature*— of a gaseous fuel, the temperature at which the gas is saturated with water vapor at the existing pressure.

3. Significance and Use

3.1 Generally, contracts governing the pipeline transmission of natural gas contain specifications limiting the maximum concentration of water vapor allowed. Excess water vapor can cause corrosive conditions, degrading pipelines and equipment. It can also condense and freeze or form methane hydrates causing blockages. Water-vapor content also affects the heating value of natural gas, thus influencing the quality of the gas. This test method permits the determination of water content of natural gas.

4. Apparatus

4.1 Any properly constructed dew-point apparatus may be used that satisfies the basic requirements that means must be provided:

4.1.1 To permit a controlled flow of gas to enter and leave the apparatus while the apparatus is at a temperature at least 3°F above the dew point of the gas.

4.1.2 To cool and control the cooling rate of a portion (preferably a small portion) of the apparatus, with which the *flowing* gas comes in contact, to a temperature low enough to cause vapor to condense from the gas.

4.1.3 To observe the deposition of dew on the cold portion of the apparatus.

4.1.4 To measure the temperature of the cold portion on the apparatus on which the dew is deposited, and

4.1.5 To measure the pressure of the gas within the apparatus or the deviation from the known existing barometric pressure.

4.1.6 The apparatus should be constructed so that the “cold spot,” that is, the cold portion of the apparatus on which dew

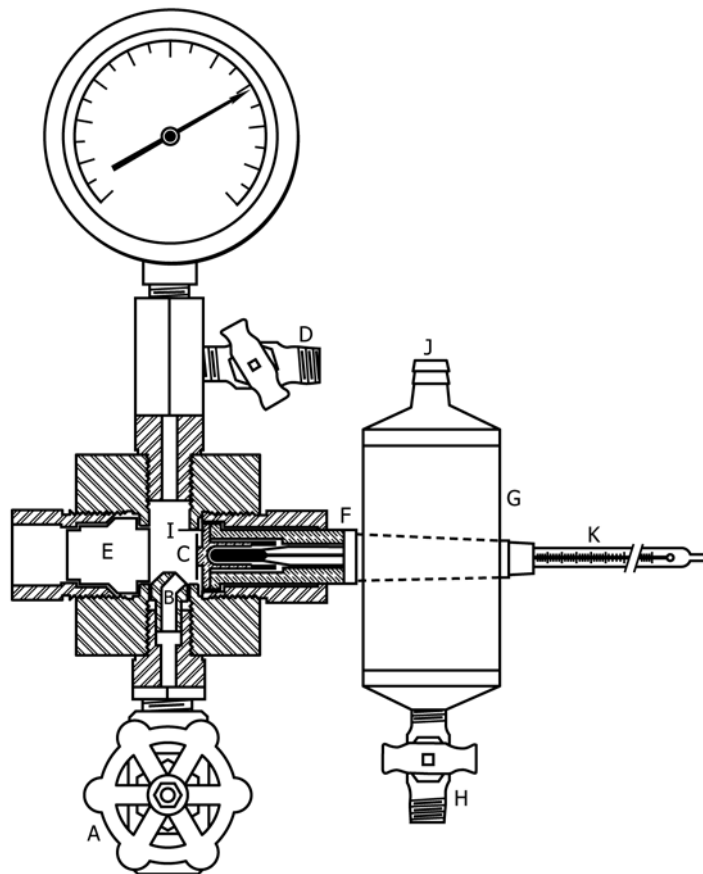


FIG. 1 Bureau of Mines Dew-Point Apparatus

is deposited, is protected from all gases other than the gas under test. The apparatus may or may not be designed for use under pressure.

4.2 The Bureau of Mines type of dew-point apparatus² shown in Fig. 1 fulfills the requirements specified in 4.1. Within the range of conditions in Section 1, this apparatus is satisfactory for determining the dew point of gaseous fuels. Briefly, this apparatus consists of a metal chamber into and out of which the test gas is permitted to flow through control valves A and D. Gas entering the apparatus through valve A is deflected by nozzle B towards the cold portion of the apparatus, C. The gas flows across the face of C and out of the apparatus through valve D. Part C is a highly polished stainless steel “target mirror,” cooled by means of a copper cooling rod, F. The mirror, C, is silver-soldered to a nib on the copper thermometer well fitting, I, which is soft-soldered to the cooling rod, F. The thermometer well is integral with the fitting, I. Cooling of rod F is accomplished by vaporizing a refrigerant such as liquid butane, propane, carbon dioxide, or some other liquefied gas in the chiller, G. The refrigerant is throttled into the chiller through valve H and passes out at J. The chiller body is made of copper and has brass headers on either end. The lower header is connected with the upper

header by numerous small holes drilled in the copper body through which the vaporized refrigerant passes. The chiller is attached to the cooling rod, F, by means of a taper joint. The temperature of the target mirror, C, is indicated by a calibrated mercury-in-glass thermometer, K, whose bulb fits snugly into the thermometer well. Observation of the dew deposit is made through the pressure-resisting transparent window, E.

4.2.1 Note that only the central portion of the stainless steel target mirror, C, is thermally bonded to the fitting, I, through which C is cooled. Since stainless steel is a relatively poor thermal conductor, the central portion of the mirror is thus maintained at a slightly lower temperature than the outer portion, with the result that the dew first appears on the central portion of the mirror and its detection is aided materially by the contrast afforded. The arrangement for measuring the temperature of the target mirror, C, also should be noted. The temperature is read with a thermometer or RTD, K, inserted in the cooling rod, F, so that the bulb of the temperature measuring device is entirely within the thermometer well in fitting, I. The stud to which the stainless steel mirror is silver-soldered is a part of the base of the thermometer well, and as there is no metallic contact between the thermometer well and the cooling tube, other than through its base, the thermometer or RTD indicates the temperature of the mirror rather than some compromise temperature influenced by the temperature gradient along the cooling tube as would be the

²Deaton, W. M., and Frost, E. M., Jr., “Bureau of Mines Apparatus for Determining the Dew Point of Gases Under Pressure,” *Bureau of Mines Report of Investigation 3399*, May 1938.

case if this type of construction were not used. The RTD will include suitable electronics and display.

4.2.2 Tests with the Bureau of Mines type of dew-point apparatus are reported² to permit a determination with a precision (reproducibility) of $\pm 0.2^\circ\text{F}$ ($\pm 0.1^\circ\text{C}$) and with an accuracy of $\pm 0.2^\circ\text{F}$ ($\pm 0.1^\circ\text{C}$) when the dew-point temperatures range from room temperature to a temperature of 32°F (0°C). It is estimated that water dew points may be determined with an accuracy of $\pm 0.5^\circ\text{F}$ (0.3°C) when they are below 32°F (0°C) and not lower than 0°F (-17.8°C), provided ice crystals do not form during the determination.

5. Procedure

5.1 *General Considerations*—Take the specimen so as to be representative of the gas at the source. Do not take at a point where isolation would permit condensate to collect or would otherwise allow a vapor content to exist that is not in equilibrium with the main stream or supply of gas, such as the sorption or desorption of vapors from the sampling line or from deposits therein. The temperature of the pipelines leading the specimen directly from the gas source to the dew-point apparatus, and also the temperature of the apparatus, shall be at least 3°F (1.7°C) higher than the observed dew point. The determination may be made at any pressure, but the gas pressure within the dew-point apparatus must be known with an accuracy appropriate to the accuracy requirements of the test. The pressure may be read on a calibrated bourdon-type pressure gage; for very low pressures or more accurate measurements, a mercury-filled manometer or a dead-weight gage should be used.

5.2 *Detailed Procedure for Operation of Bureau of Mines Dew-Point Apparatus*—Introduce the gas specimen through valve A (Fig. 1), opening this valve wide if the test is to be made under full source pressure (Note 3), and controlling the flow by the small outlet valve, D. The rate of flow is not critical but should not be so great that there is a measurable or objectionable drop in pressure through the connecting lines and dew-point apparatus. A flow of 0.05 to 0.5 ft³/min (1.4 to 14 L/min) (measured at atmospheric pressure) usually will be satisfactory. With liquefied refrigerant gas piped to the chiller throttle valve, H, “crack” the valve momentarily, allowing the refrigerant to vaporize in the chiller to produce suitable lowering in temperature of the chiller tube, F, and target mirror, C, as indicated by the thermometer, K. The rate of cooling may be as rapid as desired in making a preliminary test. After estimating the dew-point temperature, either by a preliminary test or from other knowledge, control the cooling or warming rate so that it does not exceed $1^\circ\text{F}/\text{min}$ ($0.5^\circ\text{C}/\text{min}$) when this temperature is approached. For accurate results, the cooling and warming rates should approximate isothermal conditions as nearly as possible. The most satisfactory method is to cool or warm the target mirror stepwise. Steps of about

0.2°F (0.1°C) allow equilibrium conditions to be approached closely and favor an accurate determination. When dew has been deposited, allow the target mirror to warm up at a rate comparable to the recommended rate of cooling. The normal warming rate usually will be faster than desired. To reduce the rate, “crack” valve H momentarily at intervals to supply cooling to the cooling tube, F. Repeat the cooling and warming cycles several times. The arithmetic average of the temperatures at which dew is observed to appear and disappear is considered to be the observed dew point.

NOTE 3—If the water-vapor content is to be calculated as described in 6.2, the gas specimen should be throttled at the inlet valve, A, to a pressure within the apparatus approximately equal to atmospheric pressure. The outlet valve may be left wide open or restricted, as desired. The pressure existing within the apparatus must, however, be known to the required accuracy.

6. Calculation

6.1 If an acceptable chart showing the variation of water-vapor content with saturation or water dew-point temperatures over a suitable range of pressures for the gas being tested is available, the water-vapor content may be read directly, using the observed water dew-point temperature and the pressure at which the determination was made.

6.2 If such a chart is not available, the water-vapor content of the gas may be calculated from the water dew-point temperature and the pressure at which it was determined (see Note 3), as follows:

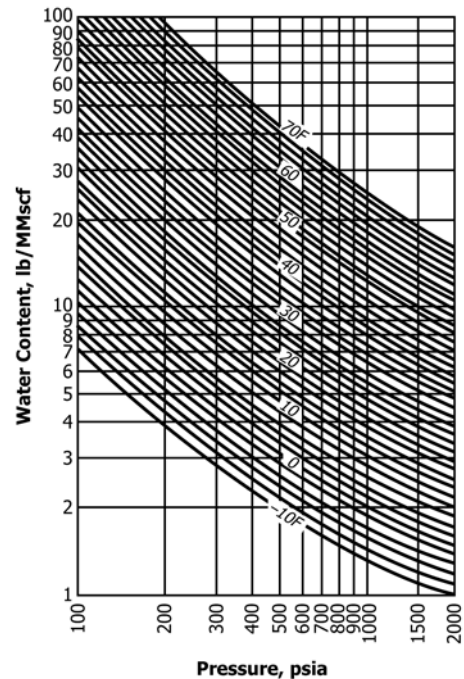


FIG. 2 Equilibrium Water Vapor Content of Natural Gases