Designation: ~~D7607/D7607M – 11$^{\varepsilon 1}$~~ D7607/D7607M – 19

Standard Test Method for Analysis of Oxygen in Gaseous Fuels (Electrochemical Sensor Method)[1]

This standard is issued under the fixed designation D7607/D7607M; 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.

~~ε[1] NOTE—This standard was revised editorially in October 2013 to reflect dual designation.~~

1. Scope

1.1 This test method is for the determination of oxygen (O_2) in gaseous fuels and fuel type gases. It is applicable to the measurement of oxygen in natural gas and other gaseous fuels. This method can be used to measure oxygen in helium, hydrogen, nitrogen, argon, carbon dioxide, mixed gases, process gases, and ambient air. The applicable range is 0.1 ppm(v) to ~~25%~~25 % by volume.

1.2 *Units*—The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system ~~may~~are not ~~be~~necessarily exact equivalents; therefore, to ensure conformance with the standard, each system shall be used independently of the ~~other. Combining~~other, and values from the two systems ~~may result in non-conformance with the standard.~~shall not be combined.

~~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*.~~

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1.4 *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.*

2. Referenced Documents

2.1 *ASTM Standards*:[2]

D4150 Terminology Relating to Gaseous Fuels

~~D5503~~E177 Practice for ~~Natural Gas Sample-Handling and Conditioning Systems for Pipeline Instrumentation~~Use of the Terms Precision and Bias in ASTM Test Methods ~~(Withdrawn 2017)~~

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 For general terminology, see Terminology D4150.

3.2 *Definitions:*

3.2.1 *electrochemical ~~sensor—~~sensor, n—*~~A~~a chemical sensor that quantitatively measures an analyte by the electrical output produced by the sensor.

3.2.2 *span ~~calibration—~~calibration, n—*~~The~~the adjustment of the transmitter electronics to the sensor's signal output for a given oxygen standard.

[1] This test method is under the jurisdiction of ASTM Committee D03 on Gaseous Fuels and is the direct responsibility of Subcommittee D03.12 on On-Line/At-Line Analysis of Gaseous Fuels.

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

3.2.3 *zero ~~calibration—~~calibration, n—~~The~~the* adjustment of the transmitter electronics to the sensor's signal output for a sample gas containing less than ~~0.1ppm(v)~~0.1 ppm(v) oxygen.

4. Summary of Test Method

4.1 Measurement of oxygen is accomplished by comparing the electrical signal produced by an unknown sample with that of a known standard using an oxygen specific electrochemical sensor. A gaseous sample at constant flow and temperature is passed over the electrochemical cell. Oxygen diffuses into the sensor and reacts chemically at the sensing electrode to produce an electrical current output proportional to the oxygen concentration in the gas phase. Experience has shown that the types of sensors supplied with equipment used in this standard typically have a linear response over the ranges of application which remains stable during the sensor's useful life. The analyzer consists of a sensor, a sample flow system, and the electronics to accurately determine the sensor signal.

5. Significance and Use

5.1 This test method is primarily used to monitor the concentration of oxygen in gases to verify gas quality for operational needs and contractual obligations. Oxygen content is a major factor influencing internal corrosion, fuel quality, gas quality, and user and operator safety.

6. Interferences

6.1 Interfering gases such as oxides of sulfur, oxides of nitrogen, and hydrogen sulfide can produce false readings and reduce the expected life of the sensor. Scrubbers are used to remove these compounds. Special sensors suitable for gas containing high fractions of carbon dioxide are available from manufacturers.

7. Apparatus

7.1 *Sensor*—The sealed sensor is contained in a housing constructed of stainless steel or other non-permeable material. The sensor contains a cathode and an anode in an electrolyte solution. A fluorocarbon membrane allows the oxygen from the sample to diffuse into the sensor. Oxygen in the sample is reduced at the cathode and is simultaneously oxidized at the anode. The electrons released at the surface of the anode flow to the cathode surface when an external electrical path is provided. The current is proportional to the amount of oxygen reaching the cathode and is used to measure the oxygen concentration in the gas phase. The electrochemical reactions for a lead anode cell are as follows:

~~$O_2+2H_2O+4e^-\rightarrow 4OH$~~ ~~(cathode half reaction)~~

$O_2+2H_2O+4e^-\rightarrow 4OH^-$ (cathode half reaction)

$2Pb+4OH^-\rightarrow 2PbO+2H_2O+4e^-$ (anode half reaction)

$2Pb+O_2\rightarrow 2PbO$ (overall cell reaction)

Any electrochemical cell with different materials can be employed if the cell can give the same performance for selective oxygen detection with similar sensitivity.

7.2 *Electronics*—Various electronic circuits are used to amplify and filter the sensor signal. The signal output may be corrected for the gas sample temperature.

7.3 *Output*—Automatic digital or range selectable analog display of parts per million or percent oxygen reading by volume.

7.4 *Sampling System*—Sample gas must be introduced to the sensor of the analyzer. A flow control metering valve is positioned upstream of the analyzer to provide a gas sample flow rate of 0.5 to 2 L/min [1 to 5 SCFM]. If necessary, a pressure regulator with a metallic diaphragm can be used upstream of the flow control valve to provide 35 to 200 kPa [5 to 30 psig] inlet pressure. A leak-free sample pump may be used for low pressure sampling. Stainless steel tubing and connections should be used to minimize any air intrusion into the sampling system. Gas scrubbers may be necessary to remove interfering gases such as oxides of sulfur, oxides of nitrogen, and hydrogen sulfide. A suitable coalescing or particulate filter can be used to remove condensation, moisture, ~~and/or particulates~~ or particulates, or a combination thereof, to prevent erroneous analysis readings and damage to the sensor. A meter, such as a rotameter, is used to monitor the sample gas flow through the analyzer.

8. Hazards

8.1 Use safe and proper venting if using this method for the analysis of hazardous or flammable gases. Failure to follow manufacturer's instructions for the instrumentation used in this test method may result in a hazardous condition.

8.2 Do not open the sensor. The sensor contains a corrosive liquid electrolyte that could be harmful if touched or ingested. Refer to the Material Safety Data Sheet provided by the sensor manufacturer.