



Designation: D7164 – 05

Standard Practice for On-line/At-line Heating Value Determination of Gaseous Fuels by Gas Chromatography¹

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1. Scope

1.1 This practice is for the determination of heating value in high methane content gaseous fuels such as natural gas using an on-line/at-line gas chromatograph.

1.2 The values stated in SI units are standard. Values stated in other units are for information only.

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.*

2. Referenced Documents

2.1 ASTM Standards:²

- D1070 Test Methods for Relative Density of Gaseous Fuels
- D1945 Test Method for Analysis of Natural Gas by Gas Chromatography
- D1946 Practice for Analysis of Reformed Gas by Gas Chromatography
- D3588 Practice for Calculating Heat Value, Compressibility Factor, and Relative Density of Gaseous Fuels
- D3764 Practice for Validation of the Performance of Process Stream Analyzer Systems
- D4626 Practice for Calculation of Gas Chromatographic Response Factors
- D5287 Practice for Automatic Sampling of Gaseous Fuels
- D5503 Practice for Natural Gas Sample-Handling and Conditioning Systems for Pipeline Instrumentation
- D6122 Practice for Validation of the Performance of Mul-

tivariate Process Infrared Spectrophotometer Based Analyzer Systems

D6299 Practice for Applying Statistical Quality Assurance and Control Charting Techniques to Evaluate Analytical Measurement System Performance

D6621 Practice for Performance Testing of Process Analyzers for Aromatic Hydrocarbon Materials

E260 Practice for Packed Column Gas Chromatography

E594 Practice for Testing Flame Ionization Detectors Used in Gas or Supercritical Fluid Chromatography

E1510 Practice for Installing Fused Silica Open Tubular Capillary Columns in Gas Chromatographs

3. Terminology

3.1 Definitions:

3.1.1 *direct sampling*—sampling where there is no direct connection between the medium to be sampled and the analytical unit.

3.1.2 *in-line instrument*—instrument with an active element installed in a pipeline, which is used to measure pipeline contents or conditions.

3.1.3 *on-line instrument*—instrument that samples gas directly from a pipeline, but is installed externally.

3.1.4 *at-line instrument*—instrumentation requiring operator interaction that samples gas directly from the pipeline.

3.1.5 *continuous fuel monitor*—instrument that samples gas directly from the pipeline on a continuous or semi-continuous basis.

3.1.6 *heating value*—in general terms, the heating value is the total energy per volume transferred as heat from the complete, ideal combustion of the gas at a specified temperature and pressure. The heating value can be reported on a net or gross basis for a gaseous stream that is assumed to be fully water vapor saturated.

3.1.7 *gross heating value*—(also called higher heating value)—the amount of energy per volume transferred as heat from the complete, ideal combustion of the gas at standard temperature in which all the water formed by the reaction condenses to liquid.

¹ This practice 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.

3.1.8 *net heating value*—(also called lower heating value)—the amount of energy per volume transferred as heat from the complete, ideal combustion of the gas at standard temperature in which all the water formed by the reaction remains in the vapor state.

4. Summary of Practice

4.1 A representative sample of the Gaseous Fuel is extracted from a process pipe or a pipeline and is transferred in a timely manner to an analyzer sampling system. After appropriate conditioning steps that maintain the sample integrity are completed, a precise volume of sample is injected onto an appropriate gas chromatographic column. Excess extracted process or pipeline sample is vented to atmosphere, a flare header, or is returned to the process in accordance with applicable economic and environmental requirements and regulations.

4.2 Sample constituents are separated in the column to elute individually for identification and quantification by the detector and its data handling system. The heating value is calculated using the results of the compositional analysis using an appropriate algorithm.

4.3 Calibration, maintenance, and performance protocols provide a means to validate the analyzer operation.

5. Significance and Use

5.1 On-line, at-line, in-line and other near-real time monitoring systems that measure fuel gas characteristics such as the heating value are prevalent in the natural gas and fuel gas industries. The installation and operation of particular systems vary on the specific objectives, process type, regulatory requirements, and internal performance requirements needed by the user. This protocol is intended to provide guidelines for standardized start-up procedures, operating procedures, and quality assurance practices for on-line, at-line, in-line and other near-real time heating value monitoring systems.

6. Apparatus

6.1 *Instrument*—Any instrument of standard manufacture, with hardware necessary for interfacing to a natural gas or other fuel gas pipeline and containing all the features necessary for the intended application(s) can be used.

6.1.1 *Chromatographic-based Systems*—The chromatographic parameters employed generally should be capable of obtaining a relative retention time repeatability of 0.05 min (3 s) for duplicate measurements. Instrumentation should satisfy or exceed other chromatographic and analytic performance characteristics for accuracy and precision for the intended application without encountering unacceptable interference or bias. In addition, components in contact with sample streams such as tubing and valving must be constructed of suitable inert materials to ensure constituents in the fuel stream do not degrade these components or alter the composition of the sampled gas. Additional information related to analyzing gaseous fuels using gas chromatography can be found in Test Method D1945 and Practice D1946.

6.2 *Sample Probes/Sample Extraction*—The location and orientation of sampling components are critical for ensuring

that a representative sample is analyzed. The locations and orientation of sampling components should be selected based upon sound analytic and engineering considerations. Sampling practices for gaseous fuels can be found in Practice D5287.

6.3 *Sample Inlet System*—The siting and installation of an at-line or on-line monitor is critical for collecting representative information on heating value content. Factors that should be considered in siting an instrument include ease of calibration, ease of access for repair or maintenance, sample uniformity at the sampling point, appropriateness of samples from a sampling location, ambient conditions, and of course safety issues. An automated gas sampling valve is required in many applications. All sampling system components in contact with the fuel stream must be constructed of inert or passivated materials. Care should be taken to ensure that the extracted sample is maintained in a single clean gaseous phase. The addition of heat at the point of pressure reduction or along the sample line to the analyzer may be required to ensure that the sample is maintained in the gas phase. The need for heat tracing and the extent to which it is required will be site specific. In general, considerations impacting heat tracing decisions include sample compositions and the expected variations, ambient temperature fluctuations, operating pressures, and anticipated pressure differentials in sample system components. Sample filtration should be utilized as required to remove particulate matter from the extracted sample. The sampling frequency relative to the process bandwidth is critical to ensuring that the reported analytical results adequately represent the process being monitored. The Nyquist-Shannon sampling criterion of a sampling frequency that exceeds twice the process bandwidth can be used to establish a minimum analytical cycle time. Sample handling and conditioning system practices can be found in Practice D5503.

6.3.1 *Carrier and Detector Gas Control*—Constant flow control of carrier and detector gases is critical for optimum and consistent analytical performance. Control is achieved by use of pressure regulators and fixed flow restrictors. Temperature control is generally vital for ensuring consistent operation of these devices. The gas flow is measured by appropriate means and adjusted as necessary. Mass flow controllers, capable of maintaining gas flow constant to $\pm 1\%$ at the flow rates necessary for optimal instrument performance are generally used.

6.3.2 *Detectors*—A thermal conductivity detector (TCD) is commonly used. Other detectors, such as the flame ionization detector (FID), Practice E594, can be used but should at least meet TCD linearity, sensitivity, and selectivity in the selected application.

6.4 *Columns*—A variety of columns, ranging from packed columns to open tubular capillary columns, can be used in the determination of the Heating Value of a gaseous fuel. Packed columns and open tubular capillary columns are covered in Practices E260 and E1510 respectively. Columns should be conditioned in accordance with the manufacturer's recommendations. The selected column must provide retention and resolution characteristics that satisfy the intended application. The column must be inert towards gaseous fuel components. If the selected column utilizes a liquid phase, bleeding at high