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Standard Practice for Automatic Sampling of Gaseous Fuels[1]

This standard is issued under the fixed designation D 5287; 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.

1. Scope

1.1 This practice covers the collection of natural gases and their synthetic equivalents using an automatic sampler.

1.2 This practice applies only to single-phase gas mixtures that vary in composition. A representative sample cannot be obtained from a two-phase stream.

1.3 This practice includes the selection, installation, and maintenance of automatic sampling systems.

1.4 This practice does not include the actual analysis of the acquired sample. Other applicable ASTM standards, such as Test Method D 1945, should be referenced to acquire that information.

1.5 The selection of the sampling system is dependent on several interrelated factors. These factors include source dynamics, operating conditions, cleanliness of the source gases, potential presence of moisture and hydrocarbon liquids, and trace hazardous components. For clean, dry gas sources, steady source dynamics, and normal operating conditions, the system can be very simple. As the source dynamics become more complex and the potential for liquids increases, or trace hazardous components become present, the complexity of the system selected and its controlling logic must be increased. Similarly, installation, operation, and maintenance procedures must take these dynamics into account.

1.6 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.7 *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:*

D 1945 Test Method for Analysis of Natural Gas by Gas Chromatography[2]

2.2 *Other Standards:*

AGA Report Number 7 Measurement of Gas by Turbine Meters[3]

API 14.3 Part 2 (AGA Report Number 3)[4]

GPA Standard 2166 Methods of Obtaining Natural Gas Samples for Analysis by Gas Chromatography[5]

NACE Standard MR-01-75 Standard Material Requirements. Sulfide Stress Cracking Resistant-Metallic Materials for Oilfield Equipment[6]

2.3 *Federal Documents:*

Code of Federal Regulations, Title 49, 173, 34(e), p. 389[7]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *automatic sampler*—(see Fig. 1(*a*) and (*b*)) a mechanical system, composed of a sample probe, sample loop, sample extractor, sample vessel, and the necessary logic circuits to control the system throughout a period of time, the purpose of which is to compile representative samples in such a way that the final collection is representative of the composition of the gas stream.

3.1.2 *representative sample*—a volume of gas that has been obtained in such a way that the composition of this volume is the same as the composition of the gas stream from which it was taken.

3.1.3 *retrograde condensation*—the formation of liquid phase by pressure drop at constant temperature on a dew-point gas stream.[8]

3.1.4 *sample extractor*—a device to remove the sample from the sample loop and put it into the sample vessel.

3.1.5 *sample loop*—the valve, tubing, or manifold(s), or combination thereof, used for conducting the gas stream from the probe to the sampling device and back to the source pipe (or atmosphere).

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[1] This practice is under the jurisdiction of ASTM Committee D03 on Gaseous Fuels and is the direct responsibility of Subcommittee D03.01 on Collection and Measurement of Gaseous Samples.

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[2] *Annual Book of ASTM Standards*, Vol 05.06.

[3] Available from American Gas Association, 400 N. Capitol St. N.W., Washington, DC 20001.

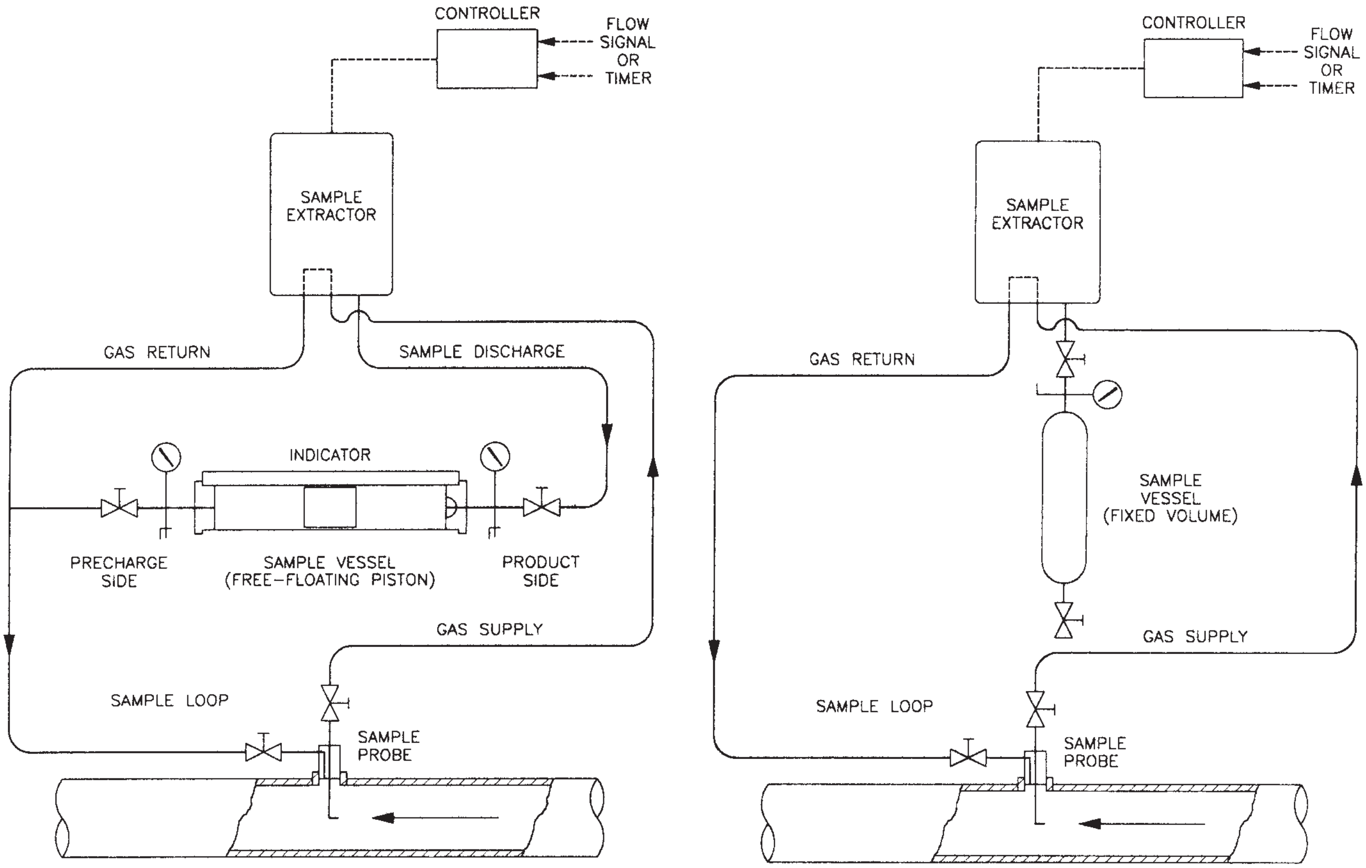
[4] Available from the American National Standards Institute, 25 W. 43rd St., 4th Floor, New York, NY 10036.

[5] Available from Gas Processors Assn, 6526 E. 60th St., Tulsa, OK 74145.

[6] Available from National Association of Corrosion Engineers, 1440 South Creek Dr., Houston, TX 77084.

[7] Available from Superintendent of Documents, Government Printing Office, Washington, DC 20402.

[8] Bergman, D. F., Tek, M. R., and Katz, D. L., *Retrograde Condensation in Natural Gas Pipelines*, American Gas Association, Arlington, VA, 1975.



(a) Free-Floating Piston Vessel

(b) Fixed Volume Vessel

FIG. 1 Continuous Composite Samplers

3.1.6 *sample probe*—that portion of the sample loop attached to and extending into the pipe containing the gas to be sampled.

3.1.7 *sample vessel*—the container in which the sample is collected, stored, and transported to the analytical equipment.

3.1.8 *source dynamics*—changes in gas supplies, operating pressures, temperatures, flow rate, and other factors that may affect composition or state, or both.

4. Significance and Use

4.1 This practice should be used when and where a representative sample is required. A representative sample is necessary for accurate billing in custody transfer transactions.

4.2 This practice is not intended to preempt existing contract agreements.

4.3 Principles pertinent to this practice may be applied in most contractual agreements.

5. Material Selection

5.1 The sampling system should be constructed of materials that will not corrode as a result of ambient conditions.

5.2 The selected material should be inert to all expected components of the gas stream.

5.3 If sour gas (gas that contains hydrogen sulfide and carbon dioxide) is suspected, NACE standard MR-01-75 should be adhered to.

6. Sample Probe (see Fig. 2 and Fig. 3)

6.1 The sample probe should be mounted vertically in a horizontal run.

6.2 The sample probe should penetrate into the center one third of the pipeline.

6.3 The sample probe should not be located within the defined meter-tube region. (See API 14.3, Part 2, Paragraph 2.5.1).

6.4 The sample probe should be constructed of stainless steel.

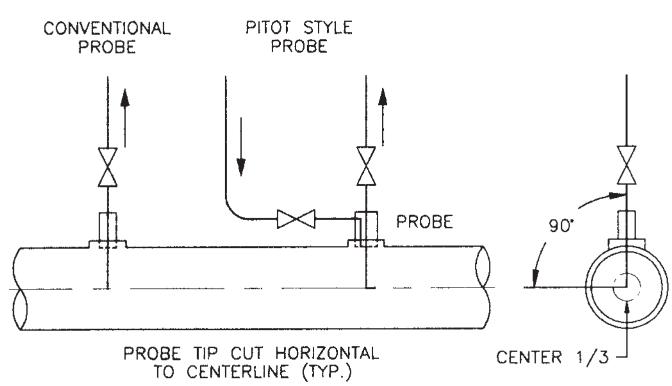


FIG. 2 Acceptable Probe Types and Installations

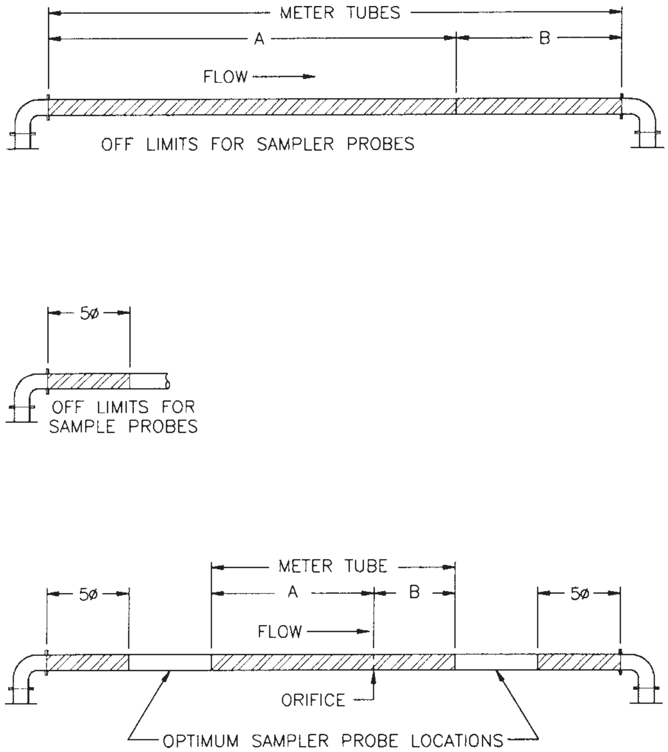


FIG. 3 Probe Locations

6.5 The sample probe should be a minimum of five pipe diameters from any device that could cause aerosols or significant pressure drop.

7. Sample Loop (see Fig. 4)

7.1 All valves should be straight bore, full opening, stainless steel valves.

7.2 The sample loop should be ¼-in. (6.25-mm) or less outside diameter stainless steel tubing.

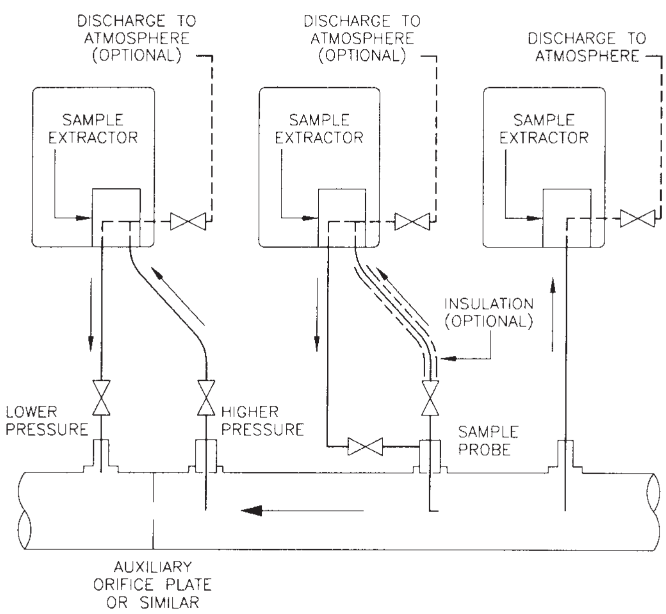


FIG. 4 Schematics of Acceptable Sample Loops

7.3 The supply line shall slope from the probe up to the sampler. All traps caused by low points shall be avoided.

7.4 The return line should slope down from the sampler to a connection of lower pressure on the pipeline.

7.5 The supply line should be as short as possible, with a minimum number of bends.

7.6 The sample loop should be insulated or heat traced, or both, if ambient temperature conditions could cause condensation of the gas flowing through the loop.

7.7 Filters or strainers that could cause the sample to be biased are not allowed in the sample loop.

7.8 Flow through the sample loop should be verified.

8. Automatic Sampler (see Fig. 1(*a*) and (*b*))

8.1 *Installation*—The sampler shall be mounted higher than the sample probe. It should be as close to the sample probe as conditions allow. Manufacturer's specific instructions should be referenced.

8.2 *Maintenance*—The sampler should be designed for easy field maintenance. A preventative maintenance schedule as outlined by the manufacturer should be followed.

8.3 *Verification*—The sampling personnel should be able to verify that the sample vessel was filled as planned. This can be accomplished by several methods.

8.3.1 *Chart Recorder*—(see Fig. 5) This should be con-

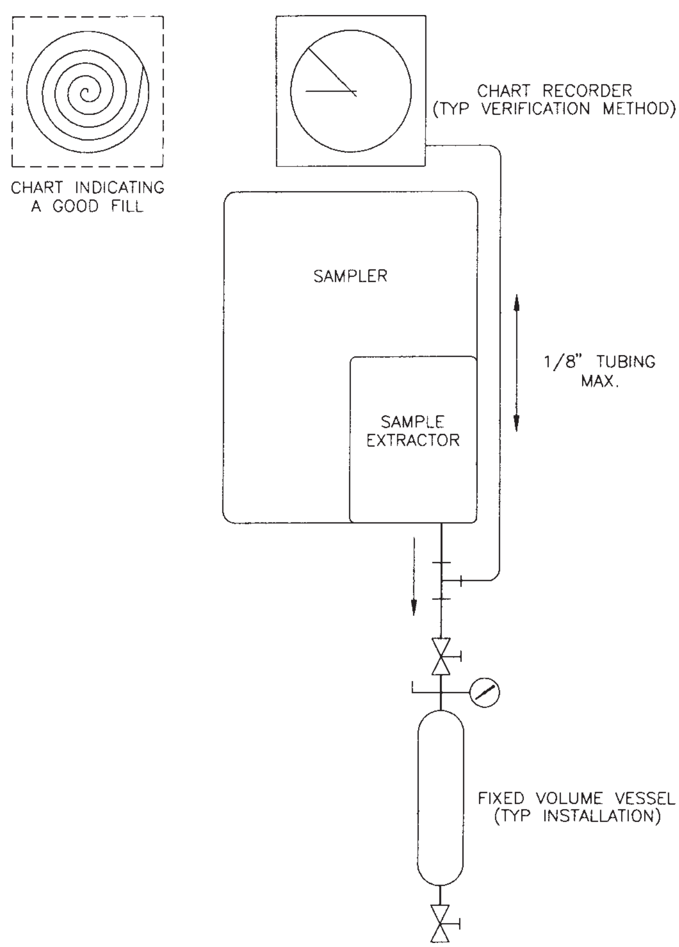


FIG. 5 Chart Recorder

nected to the sample vessel to indicate and record the increase in pressure as the sample extractor adds increments to the sample vessel. This only applies to the fixed volume vessels.

8.3.2 *Verification of Sample Extractor's Output*—Numerous devices are available to check the output of the sample pump. The device's output may be a contact closure, a 4 to 20 mA signal, a power pulse, or any other type that can be recorded. This applies to all vessel types.

8.3.3 *Pressure Transducer*—Like the chart recorder, the pressure transducer measures the increasing pressure within the fixed volume vessel.

8.3.4 *Calculation Method*—When a free-floating piston-type vessel is properly installed with full pipeline pressure on the precharge side, the only way product can move the piston is by way of the sample extractor. If the frequency and displacement are known, the piston's position is verification of proper fill (calculated flow from the sample extractor should equal shown displacement in the free-floating piston vessel). Compensate for changes in pipeline pressure.

8.4 *Control Methods*—(see Fig. 1(*a*) and (*b*)) Two methods of controlling samplers are currently recognized:

8.4.1 *Proportional-to-Flow Control*—This method paces the sampler with respect to flow. The controller shall be capable of tracking the pipeline's flow rate accurately. This method should be used when the variance of flow rates is significant or when flow ceases periodically.

8.4.2 *Time-Based Control*—This method paces the sample with respect to time only. Take care to avoid sampling from a stagnant source. The use of differential pressure switches and other similar devices may be used to stop the sampling process.

9. Sample Vessels

9.1 *Types*—There are currently two recognized types, both of which are in the shape of a cylinder:

9.1.1 *Variable Volume—Constant Pressure* (see Fig. 1(*a*))—These cylinders are commonly manufactured as free-floating piston configurations. Pipeline pressure communicates with one side of this piston. The sampler communicates with the other side. The sampler pumps the gas into the product side of the vessel and moves the piston, thus displacing the precharge gas back into the pipeline. The sample gas stays at or near pipeline pressure during the entire sample period.

9.1.2 *Constant Volume—Variable Pressure* (see Fig. 1(*b*))—These cylinders are commonly referred to as spun bottom single-cavity vessels. Impact extrusion vessels also fit within this category. A connection on each end should be provided to allow for proper purge procedures. The pressure gradually builds as the sampler puts the gas into the sample vessel.

9.2 *Vessel Selection*—Several factors shall be considered in selecting a vessel, including phase changes, pressure, and volumes required by various test methods.

9.2.1 The variable-volume vessel and volumes required to obtain a representative composite sample should be used when the phase envelope indicates the possibility of retrograde condensation.[8]

9.2.2 The constant-volume vessel may be used when condensation is not a consideration.

9.2.3 One atmosphere (98 kPa) of sample gas is normally in the sample vessel at the start of the sampling cycle. To reduce the impact of that initial volume, at least ten additional volumes should be collected in the sample period. If the composition of the initial volume is known and can be mathematically extracted from the sample analysis, this would not apply.

9.3 *Vessel Installation*—All vessels should be installed in a manner that will minimize dead space between the sample extractor and the vessel.

9.3.1 Variable-volume vessels should be connected so that the precharge side communicates with line pressure and can be displaced without contaminating the sample. The product side should be connected with minimum dead volume (see Fig. 1(*a*)). Purge the sample lines with sample gas after connection of the variable-volume vessel.

9.3.2 Constant-volume vessels (see Fig. 1(*b*)) should be in the vertical position when purging. After connecting the constant-volume vessel to the sampling device, the system shall be adequately purged with sample gas to displace any gas in the system. (See GPA Standard 2166 for further explanation of these techniques.)

9.3.3 Constant-volume vessels shall be insulated if the ambient temperature can affect the sample fill rate. Failure to do this will render the sample useless.

9.3.4 Only one sample vessel at a time is allowed to be connected to the sample extractor.

9.4 *Cleaning*—All vessels should be free of contaminants from previous samples before they are reinstalled on the sampler. If, however, the remaining contents are known and are accounted for, they are not considered contaminants.

9.4.1 *Cleaning Solvents*—A solvent should be chosen that will meet the following requirements:

9.4.1.1 Dissolves all constituents of the gas stream,

9.4.1.2 Has a low enough boiling point to vaporize, leaving no measurable residue (measurable by the means used to analyze the natural gas sample),

9.4.1.3 Does not react with the seals found in the valves or free-floating piston vessels, and

9.4.1.4 Gives a characteristic chromatographic peak that does not interfere with the hydrocarbon peaks of interest.

9.4.2 *Cleaning Methods*—The list below of methods are for reference only. There are many other acceptable methods.

9.4.2.1 *Method for Fixed-Volume Vessels*:

(*1*) Evacuate the sample gas.

(*2*) Connect the sample cylinder to a solvent source and a solvent return.

(*3*) Open all valves.

(*4*) Fill the cylinder from bottom to top with solvent.

(*5*) Flush solvent through the cylinder for a minimum of 3 min (longer if needed).

(*6*) Drain the cylinder.

(*7*) Purge the cylinder with dry, inert gas, or natural gas.

(*8*) Close the valves.

(*9*) Remove the cylinder from the manifold. Label and store as needed.

9.4.2.2 *Alternative Method for Fixed-Volume Vessels*—The method outlined in 9.4.2.1 can be used with the exception of steam being substituted for the solvent. The steam should be pushed by an inert gas such as nitrogen.

9.4.2.3 *Method for Free-Floating Piston Vessels*—The following conditions should be met:

(*1*) The solvent source should be pressurized to 8 to 10 psig (55 to 69 kPa).

(*2*) The solvent source should be plumbed to allow bidirectional flow.

(*3*) This source should be connected to the valve on the product side of the free-floating piston vessel.

(*4*) An inert gas source should be available at a pressure of approximately 15 to 20 psig (103 to 138 kPa).

(*5*) The inert gas source should be plumbed as to allow bidirectional flow.

(*6*) The inert gas supply is to be connected to the precharge side of the vessel.

(*7*) The inert pressure switching valve is to be toggled to allow the piston to evacuate the cylinder and then allow the vessel to fill with solvent.

(*8*) Purge the vessel and fill with solvent at least three times.

(*9*) Purge the vessel with an inert gas source, seal, and store.

9.5 *Lubrication of Free-Floating Piston Vessels*—The lubricant on the floating piston moving parts should be as light as possible. No components of the gas to be sampled can be soluble in the lubricant.[9]

9.6 *Leak Inspection*—All vessels should be free of leaks.

9.6.1 *Fixed-Volume Vessels*:

9.6.1.1 *Leak Test*—Pressurize the cylinder only using an inert gas source. Do not exceed the vessel's maximum rated working pressure or that of the relief device. Helium is extremely reliable. Its ability to reveal small leaks surpasses most of the commonly used inert gases. The vessel shall be free of any observable leaks when immersed in water.

9.6.2 *Free-Floating Piston Vessels*:

9.6.2.1 *Visual Inspection*—A visual inspection should be made to check for obvious mechanical defects.

9.6.2.2 *Leak Test*:

(*1*) Pressurize the cylinder to 1000 psig (6.9 MPa) or near the maximum allowed by the installed relief device, using an inert gas source on one side only. Bubble test the valves and piston seals.

(*2*) Depressurize and pressurize the other side. Bubble test the valves and piston seals.

9.6.3 Mark the cylinders as inspected. Seal and store for reinstallation.

9.7 *Department of Transportation*—A periodic retesting or reinspection of 3E specified cylinders is not currently required by the Department of Transportation (DOT). This also applies to DOT-E vessels manufactured under DOT-3E compliance (free-floating piston vessels marked as such). Reference Code of Federal Regulations, Title 49, 173, 34(e), p. 389, for additional and further information. The manufacturer's DOT exemption papers should also be referenced. Other types of cylinders may require periodic requalification.

10. Keywords

10.1 gaseous fuels

[9] The sole source of supply of Krytox AC and AD known to the committee at this time is DuPont Co., Chemicals & Pigments Dept., 1007 Market St., Wilmington, DE 19898. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee [1], which you may attend.