Designation: D5287 – 08

Standard Practice for Automatic Sampling of Gaseous Fuels[1]

This standard is issued under the fixed designation D5287; 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 gaseous fuels and their synthetic equivalents using an automatic sampler.

1.2 This practice applies only to single-phase gas mixtures. This practice does not address 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 D1945, should be used 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 standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

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:*[2]

D1945 Test Method for Analysis of Natural Gas by Gas Chromatography

2.2 *Other Standards:*

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

API 14.1 Collecting and Handling of Natural Gas Samples for Custody Transfer[4]

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]

ISO-10715 Natural Gas—Sampling Guidelines[6]

NACE Standard MR-01-75 Standard Material Requirements. Sulfide Stress Cracking Resistant-Metallic Materials for Oilfield Equipment[7]

2.3 *Federal Documents:*

CFR 49 Code of Federal Regulations, Title 49,173, 34(e), p. 389[8]

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 total composition of the gas stream for that period of time.

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 total composition of the gas stream from which it was taken.

[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] 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] Available from American Gas Association, 400 N. Capitol St. N.W., Washington, DC 20001, http://www.aga.org/.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

[5] Available from Gas Processors Association (GPA), 6526 E. 60th St., Tulsa, OK 74145, http://www.gasprocessors.com.

[6] Available from International Organization for Standardization (ISO), 1, ch. de la Voie-Creuse, Case postale 56, CH-1211, Geneva 20, Switzerland, http://www.iso.ch.

[7] Available from NACE International (NACE), 1440 South Creek Dr., Houston, TX 77084-4906, http://www.nace.org.

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

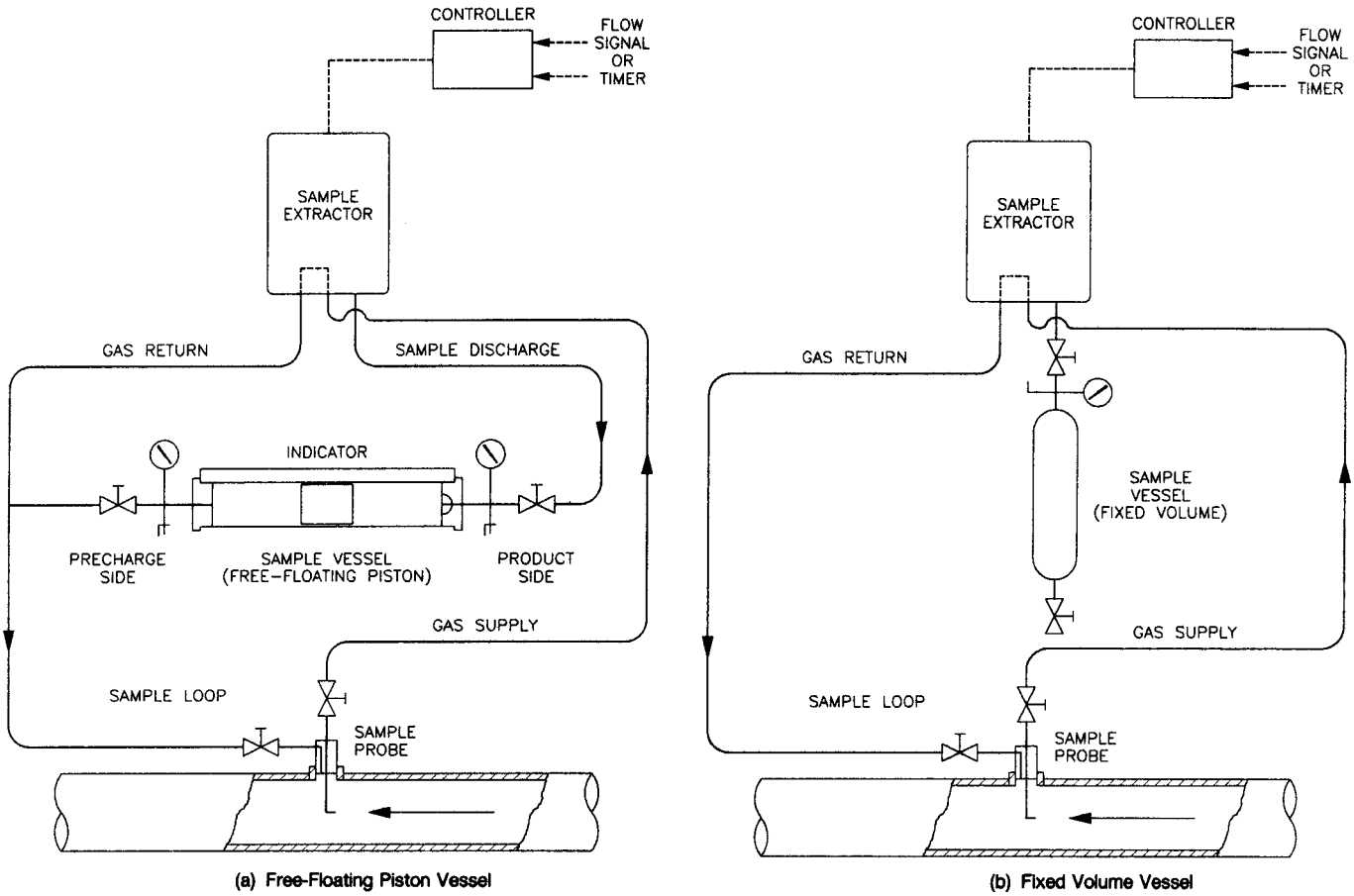


FIG. 1 Continuous Composite Samplers

3.1.3 *retrograde condensation*—the formation of liquid phase by pressure drop or temperature increase on a gas stream at or below hydrocarbon dew point.[9]

3.1.4 *sample extractor*—a device to remove the sample from the flowing stream or 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).

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. This is also referred to as a sample cylinder.

3.1.8 *source dynamics*—changes in gas supplies, operating pressures, temperatures, flow rate, hydrocarbon dew point, 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, accurate compositional analysis of the flowing stream, gravity determination for flow calculations and other desired information concerning the properties of the stream contents.

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

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

4.4 **Warning—**Many gages are extremely flammable and can contain toxic substances. Caution should be taken in all aspects of sample collection and handling. Sample vessels should only be handled in well ventilated locations away from sparks and flames. Improper handling can result in an explosion or injury, or both.

5. Material Selection

5.1 The sampling system (including probes, tubing, valving and other components) should be constructed of suitable inert, or passivated, materials that are compatible with all aspects of the product and the sampling practice, both internal and external conditions to ensure that constituents in the fuel stream do not degrade these components or alter the composition of the sampled gas.

5.2 The selected material should be inert to and not absorptive of all expected components in the gas stream.

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

5.3 When sour gas (gases that contain hydrogen sulfide or carbon dioxide, or both) are present or suspected, consult the recommendations in NACE Standard MR-01-75.

5.4 Contaminates, other than those listed above, should be identified and addressed by the appropriate industry recommendations, guidelines and standards.

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 measurement region. (For example see API 14.3, Part 2, Paragraph 2.5.1).

6.4 The sample probe should be constructed of stainless steel. (See also, 5.2.)

6.5 The sample probe should be a minimum of five pipe diameters downstream from any device that could cause aerosols or significant pressure drop such as orifice plates, thermowelds, elbows and the like.

6.6 The probe should be designed using probe calculations with regard to wake frequency and resonant vibration impact. (See API 14.1, paragraph 7.4.1)

7. Sample Loop (see Fig. 4)

7.1 All valves should be straight bore, full opening, stainless steel ball valves or full ported valves. In some applications, specially coated or passivated materials may be required.

7.2 The sample loop should be ¼-in. (6.25-mm) or less outside diameter stainless steel tubing. In some applications, specially coated or passivated materials may be required.

7.3 The supply line shall slope from the probe up to the sampler and not possess regions or traps where condensate or fluid can collect.

7.4 The return line should slope down from the sampler to a connection of lower pressure on the pipeline and not possess regions or traps where condensate or fluid can collect.

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.

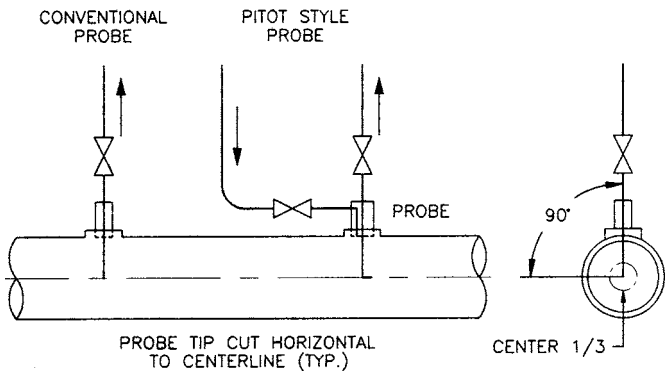
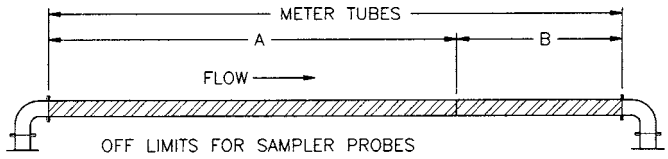
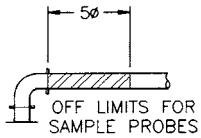


FIG. 2 Acceptable Probe Types and Installations





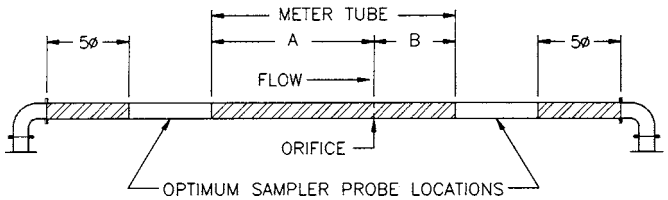


FIG. 3 Probe Locations

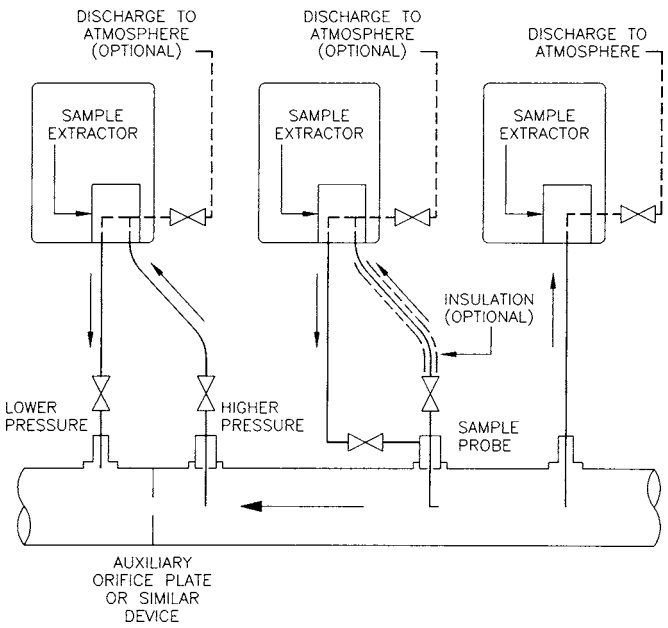


FIG. 4 Schematics of Acceptable Sample Loops

7.7 Filters or strainers that could cause the sample to be biased or altered 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 *Cylinder Filling Verification*—See Fig. 5.

8.3.1.1 *Chart Recorder*—The recorder should be commonly connected to a constant (fixed) volume sample vessel to indicate and record the increased in pressure as the sample extractor adds incremental grabs (samples) to the sample vessel. This only applies to the fixed volume vessels.

8.3.1.2 *Electronic Tracing*—A magnetic type system can be attached to the constant pressure piston style cylinders to track the movement of the internal piston during the filling process. A 4–20 ma signal system (or similar technology) can be monitored by computer systems or by preset signal verification process.

8.3.1.3 *Pressure Verification*—While not verifying the filling time frame, a simple test of the cylinder pressure can validate that it was filled to pipeline line pressure.

8.3.2 *Verification of Sample Extractor's Output*—Numerous devices are available to check the output of the sample extractor. 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.

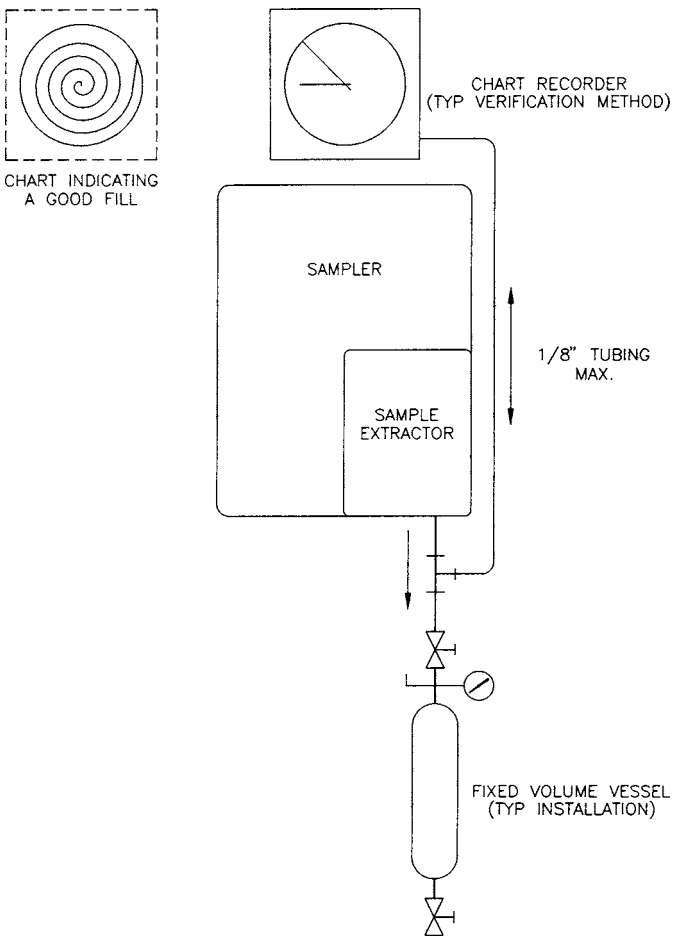


FIG. 5 Chart Recorder

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

8.3.4 *Calculation Method*—When a free-floating piston-type vessel is properly installed with full pipeline pressure on the pre-charge 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 filling (estimated volume displacement) from the sample extractor and should be equal to the determined displacement in the free-floating piston vessel. 100 sample bites, grabs or aliquots of 0.5 cc volume should equal 50 cc in the cylinder.) Compensation for changes in pipeline pressure and ambient temperature changes must be considered when present.

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 the flow rate is significant or when flow ceases periodically or is intermittent.

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 is maintained on the "pre-charge" side of this piston. The sampler connects with the "product" side of the piston. The sampler pumps the gas into the product side of the vessel and moves the piston, thus displacing the pre-charge gas back into the pipeline. The sample gas stays at or near pipeline pressure during the entire sample period. Laboratories should maintain the pre-charge pressure during the sample analysis so as to maintain a constant pressure on the remaining sample, thus avoiding a phase change due to pressure loss.

9.1.2 *Constant (Fixed) Volume—Variable Pressure* (see Fig. 1(*b*))—These cylinders are commonly referred to as spun end, single-cavity vessels. Impact extrusion vessels also fit within this category. If purging is required, connection on each end would be preferable and can be provided to allow for easier handling during approved purging procedures. Single ended cylinders maybe used as long as caution is exercised to not trap liquids in the bottom of the vessel. The pressure gradually builds up as the sampler puts 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, as well as materials of construction. (See 5.2.)

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.[9]

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

9.2.3 One atmosphere (101.325 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 initial volume and composition is known, computer software can sometimes be used to convert raw analytic results into values representative of the sample stream.

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 pre-charge 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*)). Purging the sample lines with sample gas after connection of the variable-volume vessel is necessary before collecting a sample.

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

9.3.3 Constant-volume vessels used with bleed style sampling systems shall be insulated if the ambient temperature can affect the sample fill rate or result in phase changes of the sampled gas. Failure to insulate constant volume cylinders on bleed systems can result in inaccurate and unacceptable results. Sampling systems with positive displacement pumps will overcome any ambient temperature effects on a non-insulated cylinder.

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

9.4 *Cleaning*—All vessels should be free of contaminants from previous samples before they are reinstalled on the sampler. One method of verification is to fill the vessel with Helium and analyzing the gas according to Test Method D1945 or Test Method or other test method used to measure the analytes of interest. If the remaining contents are known and are considered in the analytic treatment, then further cleaning is unnecessary.

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 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 signature or peak in the analytic method that does not interfere with the hydrocarbon peaks of interest or other components 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.

(*10*) As needed, preform an analysis of the final purge gas in vessel for substances of interest.

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. An inert gas such as nitrogen should be used as carrier gas for "pushing" the steam through the vessel.

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 used 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.

(*10*) As needed, preform an analysis of the final purge gas in vessel for substances of interest.

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.[10]

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. 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

[10] 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.

observable leaks when immersed in water. Alternatively, an electronic leak detector maybe used to verify the vessel is leak free.

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, such as dents, cracks, or other damage.

9.6.2.2 *Leak Test*:

(*1*) Pressurize the cylinder to 500 psig (3.5 MPa) or near the maximum allowed by the installed relief device, through the product inlet side using an inert gas. Bubble test the valves and piston seals. When using helium, an electronic leak detector may be used to confirm the cylinder is leak free.

(*2*) Depressurize and pressurize, preform the test in *(1)* though the pre-charge side of the vessel.

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

9.7 *Cylinder Transportation*—Cylinders should be properly labeled and identified for safety purposes and to satisfy regulatory requirements. Local governmental regulations and guides should be consulted before transporting vessels. For example, United States CFR 49 (latest edition) offers rules and regulations for transport with the United States. Transport Canada B399 for B340 (latest editions) are similar documents for Canada. Other world regions have similar guidance documents. The manufacturer's exemption papers or manuals should also be referenced.

10. Keywords

10.1 gaseous fuels