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Standard Guide for Equipment for Sampling Water and Steam in Closed Conduits[1]

This standard is issued under the fixed designation D 1192; 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 guide covers only that equipment commonly used for the sampling of water and steam in closed conduits. It does not cover specialized equipment required for and unique to a specific test or method of analysis. Items such as valves, fittings, piping/tubing, cooling coils and condensers, filters, pumps, sample containers, and packaging materials are included, but items such as sampling nozzles that are used for obtaining steam or water samples from their source and apparatus used in subsequent methods of test and analysis are excluded.

1.2 For information on specialized sampling equipment or tests, or both, or methods of analysis, reference should be made to the *Annual Book of ASTM Standards* relating to water. [2]

1.3 The following safety hazards caveat pertains only to the test methods portion of this guide. *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*. For specific safety precautions, see 4.2.2.

2. Referenced Documents

2.1 *ASTM Standards:*

A106 Specification for Seamless Carbon Steel Pipe for High-Temperature Service[3]

A179/A179M Specification for Seamless Cold-Drawn Low-Carbon Steel Heat-Exchanger and Condenser Tubes[3]

A269 Specification for Seamless and Welded Austenitic Stainless Steel Tubing for General Service[3]

A335/A335M Specification for Seamless Ferritic Alloy-Steel Pipe for High-Temperature Service[3]

D1066 Practice for Sampling Steam[4]

D1129 Terminology Relating to Water[4]

D3370 Practices for Sampling Water from Closed Conduits[4]

D3694 Practices for Preparation of Sample Containers and for Preservation of Organic Constituents[5]

D4453 Practice for Handling of Ultra-Pure Water Samples[4]

D5540 Practice for Flow Control and Temperature Control for On-Line Water Sampling and Analysis[4]

3. Terminology

3.1 *Definitions*—For definitions of terms used in this guide, see Terminology D 1129.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *sample cooler*—small heat exchanger designed to provide primary or secondary cooling, or both, of small process sampling streams of water or steam.

3.2.2 *pressure reducer*—device designed to reduce pressure, and therefore control flow, of cooled sample to a pressure level where it can easily be regulated.

3.2.3 *back pressure regulator*—device designed to maintain a constant pressure upstream of itself (variable or fixed back pressure regulators are available) to maintain constant flow to analyzers.

3.2.4 *head cup*—method used to achieve constant pressure (see *back pressure regulator*). It incorporates plumbing of the sample to a selected height above the inlet to the analyzer inlet line(s) to achieve the required inlet pressure for the analyzers. It is occasionally used downstream of colorimetric analyzers in order to increase sample flow past the analyzer. The sample flows to an open cup with an overflow. This fixed head provides the constant pressure, assuming inlet flow to the head cup exceeds outlet flow to the grab sample and analyzers.

3.2.4.1 *Discussion*—Contemporary designs of back pressure regulators provide excellent sensitivity to pressure changes and have limited the need for head cups and the concurrent space and maintenance problems as well as sample contamination potential.

3.2.5 *variable rod in tube orifice*—type of pressure reducer that uses a retractable tapered rod inside a reamed tube to provide a variable orifice for pressure reduction that is parallel with the sample flow. This eliminates wear of the orifice and provides variable pressure reduction and flow.

4. Materials and Manufacture

4.1 *Sample Lines*:

4.1.1 *General*—Sample lines should be designed so that the

[1] This guide is under the jurisdiction of ASTM Committee D-19 on Water and is the direct responsibility of Subcommittee D19.03 on Sampling of Water and Water-Formed Deposits, Surveillance of Water, and Flow Measurement of Water.

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[2] *Annual Book of ASTM Standards*, Vols 11.01 and 11.02.

[3] *Annual Book of ASTM Standards*, Vol 01.01.

[4] *Annual Book of ASTM Standards*, Vol 11.01.

[5] *Annual Book of ASTM Standards*, Vol 11.02.

sample is representative of the source. They shall be as short as feasible and of the smallest practicable bore to facilitate flushing, minimize conditioning requirements, reduce lag time and changes in sample composition, and provide adequate velocity/turbulence. The lines shall have sufficient strength to prevent structural failure. The designer is responsible for ensuring that applicable structural integrity requirements are met. Small tubing is vulnerable to mechanical damage and should be protected. See Practices D 1066 and D 3370 for additional information.

4.1.1.1 Avoid traps and pockets in which solids might settle, since they may be partially emptied with changes in flow conditions and may result in sample contamination. Shape sample tubing so that sharp bends, dips, and low points are avoided, thus preventing particulates from collecting. Provide expansion loops or other means to prevent undue buckling and bending when large temperature changes occur. Such buckling and bending may damage the lines and allied equipment. Plan routing to protect sample lines from exposure to extreme temperatures.

NOTE 1—Studies **(1-5)**[6] on particle transport in sampling lines have indicated that sample velocity rate and stability are important factors in determining deposition and erosion rates on sample tube walls and time required to reach and maintain equilibrium. Although limited, other work has also noted effects of sorption of dissolved species within tube wall deposits. Velocities near 1.8 m/s (6 f/s) seem to optimize these factors, but, other velocities can provide acceptable results. Sample velocity should be considered as a key design issue along with type of sample, lag time, pressure drop, new or existing sample lines, etc. when determining sample flow rates. Maintaining the selected velocity is necessary to achieve sample representivity.

NOTE 2—Saturated and superheated steam samples present difficult transport problems between the source and the primary sample cooling equipment. Cooling near the surface is recommended, especially on superheated steam samples. Traditionally saturated steam samples with initial steam velocities above 11 m/s (36 ft/s) were considered to provide adequate turbulent flow to ensure transport of most particulates and ionic components. More recent studies find that because many sample lines are long and uninsulated, steam samples are frequently fully condensed prior to reaching the sample station. Often fully condensed samples have a velocity too low to prevent excessive deposition. System pressure, sample line length, and desired steam sample flow rate should all be considered when sizing steam sample lines. Excessively large or small steam sample lines will affect the sample quantity and quality. If the sample line is too large, condensation is accelerated with extremely slow condensate velocities resulting. When the sample tubing inside diameter (ID) is too small, the pressure drop is excessive and the amount of sample available is limited. In the case of superheated steam, significant ionic deposition can occur in the sample tubing as the steam desuperheats. This can significantly affect sample analysis accuracy. Superheated samples should use a process to inject cooled sample into the sample line at or near the nozzle outlet to desuperheat the sample to minimize deposition in the initial portion of the tubing run.

4.1.2 *Materials*—The material from which the sample lines are made shall conform to the requirements of the applicable specifications as follows:

4.1.2.1 Pipe (seamless or welded carbon steel for high-temperature service), Specification A 106.

4.1.2.2 Pipe (seamless ferritic alloy-steel for high-temperature service), Specification A 335/A 335M.

4.1.2.3 Tubing (seamless carbon-steel for high-temperature service), Specification A 179/A 179M.

4.1.2.4 Tubing (seamless or welded alloy-steel for high-temperature service), Specification A 269.

4.1.2.5 Tubing, Plastic (polyethylene), or equivalent non-leaching inert materials,

4.1.3 Carbon steel pipe or tubing may be satisfactory for sampling lines where levels of contaminants in the sample are high or sample constituents require it. For sampling high-purity waters or corrosive waters, the sampling lines shall be made of stainless steel that is at least as corrosion resistant as 18 % chromium–8 % nickel steel (AISI 304 or 316 austenitic stainless steels are commonly used) **(6)**.

NOTE 3—Plastic tubing should be avoided where low values of dissolved oxygen are to be measured since atmospheric gases may diffuse through the tubing and cause an analytical bias. The selection of the sample line material should be based on the parameters of interest.

4.2 *Valves and Fittings*:

4.2.1 *Materials*—Valve and fitting materials should be compatible with the sample and the sample line material selected. AISI 316 austenitic stainless steel is commonly used **(6)**. Pressure and temperature ratings should be selected based on the specific service of the valve/fitting.

4.2.2 *Isolation Valves*—At least one shut off valve (commonly referred to as a root valve) shall be placed immediately after the point from which the sample is withdrawn so that the sample line may be isolated when desired. For safety purposes, an isolation valve should be placed at the sample cooler inlet and be rated in accordance with the pressure/temperature of the sample source.

4.2.3 *Pressure Reducers*—The pressure reducer, in combination with properly sized sample lines, is the primary component necessary to control the sample flow at the rates required to give the most representative sample (see Note 1 and Note 2). Flow control is accomplished at the same time sample pressure is reduced.

4.2.3.1 For samples equal to or greater than 500 psig (3447 kPa), the pressure reducer shall be a rod-in-tube type orifice or capillary (variable or fixed). Variable rod-in-tube devices are recommended since they offer two advantages: (*a*) they are capable of varying the pressure drop and, therefore, the flow; and (*b*) they are cleanable in place (exercising the position of the tapered rod in the tube).[7] Forepressure regulators are not recommended for large pressure reductions because of susceptibility to erosion, plugging, and wire drawing of the stem or seat.

4.2.3.2 For samples less than 500 psig (3447 kPa), the pressure reducer shall be a needle valve or forepressure regulator. A needle valve is preferred since it will not hunt with small pressure variations.

4.2.4 *Pressure Regulators*—Since most on-line analyzers are flow sensitive, as well as temperature sensitive, the flow rate in the branch circuits shall also be controlled to ensure repeatable analytical results. This is achieved by establishing a

[6] The boldface numbers in parentheses refer to a list of references at the end of this guide.

[7] The VREL pressure reducer manufactured by Sentry Equipment Corp., P.O. Box 127 Oconomowoc, WI 53066 has been found to be satisfactory for this service.

constant pressure zone where the sample line feeds the analyzer branch lines. See Practice D 5540 for additional information. Because of the relationship of pressure and flow, a zone of constant pressure will ensure that each analyzer fed from this zone gets a constant flow rate independent of actions taken in the other branch lines, while maintaining constant flow in the main sample line. Two methods are available to achieve this constant pressure zone in conjunction with the upstream pressure reducer: back pressure regulator (fixed or variable) or head cup. Using a forepressure regulator without a back pressure regulator or head cup is not recommended. A forepressure regulator alone will not provide a constant sample line flow. Flow changes in the branch lines below the regulator result in the forepressure regulator closing or opening to maintain the analyzer inlet pressure thereby changing the main sample line flow and disrupting the representivity of the sample from its source.

4.2.4.1 Use of a back pressure regulator is the preferred method to achieve the constant pressure zone. Total sample flow is established using the primary pressure reducer with all flow going through the back pressure regulating valve to drain, recovery, or for grab sample. The regulating valve establishes a fixed pressure at the valve inlet. Branch lines to each analyzer are connected to this fixed pressure zone. When flow is initiated to an analyzer the back pressure regulator will close slightly to maintain the pressure at the regulator inlet. Similarly, when flow to an analyzer is shut off, the regulator will open to accommodate the increased flow. Since the pressure at the branch connections to the other analyzers is maintained constant, their flow is not affected by changes of flow to other analyzers.

4.2.4.2 A head cup works in a similar way. Full flow from the pressure reducer flows up a vertical tube to a trough. The overflow goes to drain or recovery. The analyzer branch line(s) is connected at the bottom of the vertical tube. When flow is established through the analyzer, the flow up the vertical tube is reduced that same amount. To avoid sample contamination the trough must overflow at all sampling conditions. The head cup can be used in pure water applications when clear atmospheric conditions exist. However, some analyses (pH, conductivity, and dissolved gases) can be affected by dissolved gas contamination as the sample is exposed to the atmosphere.

4.2.5 *Other Valves*—Blowdown/flushing valves may be used to purge sample lines that are not in continuous service and can be located prior to or after the roughing or primary sample cooler. Other valves should be selected based on specific requirements, for example, analyzer flow metering, secondary isolation, grab sampling, etc. Selecting a ball valve for grab sample use without a flow metering valve in series with it can starve the constant pressure zone created by the back pressure regulator/head cup and disrupt sample flow. Systems shall be provided with a method to protect components from overpressurization. Acceptable methods include suitable back pressure regulator with built-in relieving capacity, head cup, or suitable relief valve.

4.2.6 *Fittings*—If feasible, bends, rather than fittings, should be used to change direction of sample tubing. Compression or socket weld fittings can be selected for sample lines. Because improperly welded joints are susceptible to plugging by suspended solids, compression fittings are preferred. The ends of cut tubes shall be ream cut to restore the full bore of the pipe diameter. If not installed properly, both socket weld and compression fittings can include fine annuli between tube and fittings that may hold contaminants.

4.3 *Sample Cooler or Condenser*:

4.3.1 High efficiency sample coolers or condensers used for primary temperature reduction/condensation shall be capable of normally reducing the incoming sample temperature to within 5°F (2.8°C) of the cooling water inlet temperature for water samples and 10°F (5.6°C) of the cooling water inlet temperature for steam samples at sample flows that are sufficient to provide a representative sample (See 4.1.1). Cooling water requirements should be as low as possible but shall not exceed 12 gpm (2.7 m^3/h) per cooler except for very large sample flows (1 gpm (0.3 m^3/h)). Sample coolers used for secondary cooling shall be capable of a 1°F (0.5°C) approach to the chilled water temperature when the primary cooler is specified as detailed above. The tube through which the sample will flow shall be one continuous piece and shall extend completely through the cooler without deformation and so there is no possibility of sample contamination or dilution from the cooling water. The tube shall be of sufficient strength to withstand the full pressure and temperature of the fluid being sampled.

4.3.2 The cooler or condenser tube shall be made of stainless steel that is at least as corrosion resistant as 18 % chromium–8 % nickel steel. Specific water chemistry could dictate different materials for improved corrosion resistance, for example, alloy 600 for high chlorides. The diameter of the tube shall be as small as practicable based on representative sample flows so that storage within the coil is low and the time lag of the sample through the cooler is minimal.

4.3.3 Fig. 1 and Fig. 2 show typical sample coolers. Fig. 1 is a helical coil heat exchanger with removable, one piece, shell type sample cooler. Fig. 2 is a double concentric helical coil, or tube within a tube type sample cooler. The portion of the sample cooler (shell or outer tube) containing the cooling water should provide for adequate cooling water velocity to achieve required sample cooler efficiency as noted above and be made of material that is corrosion resistant to the cooling water in use. Materials that have corrosion resistance to the ambient atmosphere around the sample cooler itself should also be considered to avoid exterior corrosion, pitting, etc., on the sample cooler.

NOTE 4—The scaling/fouling tendencies of the cooling water available should be given careful consideration when selecting a sample cooler or condenser. Water that is extremely hard or contains considerable slime or algae or suspended solids may cause rapid fouling of the cooling water side of the cooler, such that its efficiency may be seriously impaired. If it is necessary to use such a cooling water, the sample cooler should be one that can be cleaned readily and effectively with the least possible delay, for example, submerged helical coil in shell sample cooler (see Fig. 1). Concentric (tube in tube) type coolers (Fig. 2), are subject to plugging and fouling.

4.4 *Flow Meters*—A visual means of reading main and branch sample line(s) flow shall be used. Rotameters or other

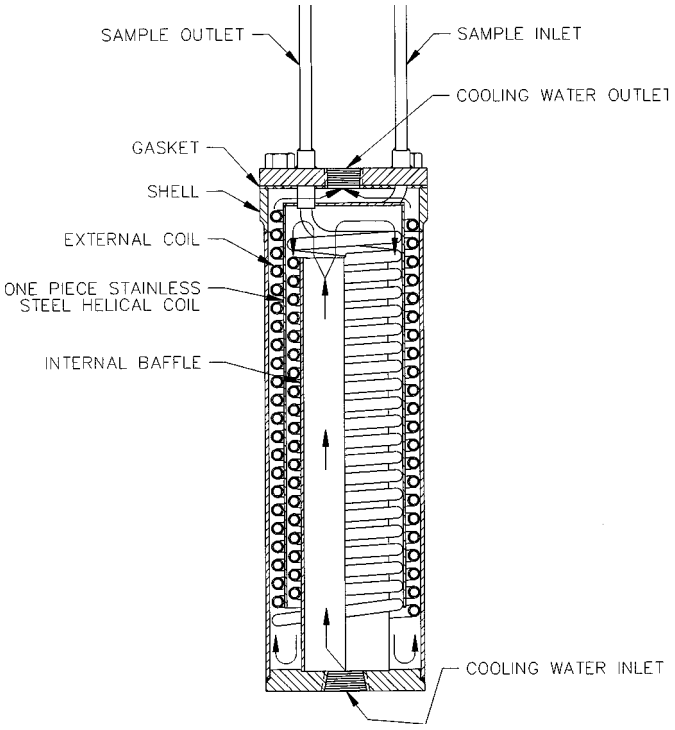

FIG. 1 Helical Coil Heat Exchanger with Removeable Shell

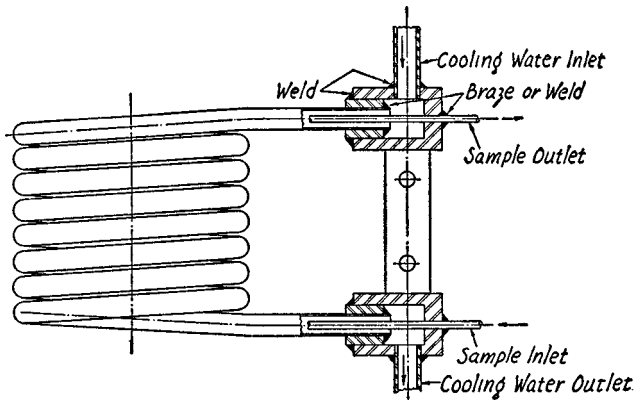

FIG. 2 Double-Tube Helical Coil Heat Exchanger

mechanical or electronic flow measuring devices are recommended. This is the only way to ensure that the sample is flowing at a velocity that assures a representative sample. See 4.1.1.

4.5 *Sample Filters*—Use of sample filters to remove suspended solids such as metal oxides can dramatically change the analytical results. Metal oxides react with other chemicals in water and steam **(7)** and change the ratio of the total/dissolved chemicals. Use of sample filters should, therefore, be evaluated with respect to analytical and control requirements.

4.6 *Pumps*—Withdrawing a water sample under subatmospheric pressure may require the use of pumps. Small centrifugal pumps with casing or suction side vent to the source, magnetically coupled gear pumps or diaphragm pumps may be used. Pumps employing built in filters should have them removed. The suction sampling line shall be sloped downward over its entire length without pockets to avoid gas binding. Consideration must be given to possible contamination of the sample due to pump material depending on the particular constituents to be analyzed. Also, consideration must be given to ensure that the pump is designed to handle low net positive suction head (NPSH) that is typically seen in subatmospheric samples.

4.7 *Sample Containers*—Sample containers shall be made of materials that will not contaminate the sample and, before use, shall be cleaned thoroughly to remove all extraneous surface dirt. Chemically resistant glass and polyethylene are suitable materials for the containers. The closures for the sample containers shall be glass stoppers that have been thoroughly washed, or plastic caps with suitable liners. See Practices D 3694 and D 4453 for additional information.

4.8 *Sample Labels*—Provide space for the following information on an etched area of the bottle, a gummed label, or a cardboard or linen tag securely affixed to the container:

4.8.1 Sample number,

4.8.2 Date and time of sampling,

4.8.3 Source of sample,

4.8.4 Point of sampling (designated in sufficient detail to enable anyone to collect a second sample from the identical spot from which the first sample was taken),

4.8.5 Temperature and rate of flow of the fluid in the equipment from which the sample was taken,

4.8.6 Temperature of sample,

4.8.7 Results of field tests made on the sample, and

4.8.8 Signature of sampler.

4.9 *Sample Shipping Containers*—The stoppers closing the sample containers shall be fixed in place by wire, tape, or cord to prevent leakage in transit. The sample containers shall be of such size that when filled with the desired amount of sample, space roughly equivalent to 1 % of the volumetric capacity of the containers will be available for expansion of the liquid. The sample shipping container shall be a case having a separate compartment for each sample container. The compartment around each container shall be lined with corrugated paper or other suitable material, with the containers held in place with spring clips; or an elastic packing material may be used.

4.10 *Shipping Labels*—Plainly print the addresses of consignee and consignor upon two sides of the outer container, or attach firmly thereon by cards or labels. Attach warning and descriptive labels to the outer container, such as “Fragile”,“ Liquid”, “Glass”, etc., when applicable. In cold weather, attach the label “Keep from Freezing” to the outer container.

5. Keywords

5.1 back pressure regulator; equipment for sampling water and steam; pressure reducer; sample cooler; variable rod-in-tube orifice

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