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

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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

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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.