Designation: D5540 – 08

Standard Practice for
Flow Control and Temperature Control for On-Line Water Sampling and Analysis[1]

This standard is issued under the fixed designation D5540; 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 conditioning of a flowing water sample for the precise measurement of various chemical and physical parameters of the water, whether continuous or grab. This practice addresses the conditioning of both high- and low-temperature and pressure sample streams, whether from steam or water.

1.2 This practice provides procedures for the precise control of sample flow rate to minimize changes of the measured variable(s) due to flow changes.

1.3 This practice provides procedures for the precise control of sample temperature to minimize changes of the measured variable(s) due to temperature changes.

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

1.5 *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]
D1066 Practice for Sampling Steam
D1129 Terminology Relating to Water
D3370 Practices for Sampling Water from Closed Conduits
D3864 Guide for Continual On-Line Monitoring Systems for Water Analysis

3. Terminology

3.1 *Definitions*—For definitions of terms used in this practice, refer to Terminology D1129.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *approach temperature*—this is a term that is used in heat exchanger applications. It applies to all types of heat exchangers and is defined as: the difference in outlet temperature in one stream and the inlet temperature on the other stream. The definition as it applies to sample coolers used for cooling water or steam samples as noted in this standard is as follows: Approach Temperature—the difference in temperature between cooling water temperature in and sample temperature out.

3.2.2 *crud deposition*—deposition on interior surfaces of sample tubing or other hardware of fine insoluble particles of iron oxides and other byproducts of metallic corrosion that are present throughout the system. The term "crud" is generally used for all types of fouling.

3.2.3 *sample conditioning*—reduction of the temperature and pressure of a flowing sample from process conditions to a controlled temperature and pressure, and maintenance of a constant flow rate both in incoming sample lines and through on-line analyzers.

3.2.4 *sample cooler*—a small heat exchanger designed to cool small streams of water or steam.

3.2.5 *temperature compensation*—adjustment of the analyzer measured value for variation in temperature of the sample from a preestablished value by the use of electronic adjustment or data manipulation.

4. Summary of Practice

4.1 This practice covers the system design, operating procedures, and selection of equipment to help ensure the appropriate flow and temperature control for analysis of water and steam samples. This control is essential to ensure the accuracy and repeatability of on-line analyzers. Variations in types of analysis, sample characteristics, and their effect on sample conditioning are included.

4.2 The equipment and procedures described in this practice are intended to represent current state-of-the art technology

available from major manufacturers of sample conditioning equipment. Refer to Practices D1066 and D3370 and Guide D3864 for additional information on sampling.

5. Significance and Use

5.1 Sample conditioning systems must be designed to accommodate a wide range of sample source temperatures and pressures. Additionally, efforts must be made to ensure that the resultant sample has not been altered during transport and conditioning and has not suffered excessive transport delay. Studies have shown that sample streams will exhibit minimal deposition of ionic and particulate matter on wetted surfaces at specific flow rates (1–5). [3]

5.1.1 To ensure that the physical and chemical properties of the sample are preserved, this flow rate must be controlled throughout the sampling process, regardless of expected changes of source temperature and pressure, for example, during startup or changing process operating conditions.

5.2 The need to use analyzer temperature compensation methods is dependent on the required accuracy of the measurement. Facilities dealing with ultra-pure water will require both closely controlled sample temperature and temperature compensation to ensure accurate measurements. The temperature can be controlled by adding a second or trim cooling stage. The temperature compensation must be based on the specific contaminants in the sample being analyzed. In other facilities in which some variation in water chemistry can be tolerated, the use of either trim cooling or accurate temperature compensation may provide sufficient accuracy of process measurements. This does not negate the highly recommended practice of constant temperature sampling, especially at 25°C, as the most proven method of ensuring repeatable and comparable analytical results.

5.3 A separate class of analysis exists that does not require or, in fact, cannot use the fully conditioned sample for accurate results. For example, the collection of corrosion product samples requires that the sample remain at near full system pressure, but cooled below the flash temperature, in order to ensure a representative collection of particulates. Only some of the primary conditioning criteria apply in this case, as in others. Temperature compensation is not applicable since the material being analyzed is not in a liquid state.

6. Interferences

6.1 Samples can be degraded by the loss of ionic or particulate components, introduction of contaminants by components or leaks, changes of sample flow rate through an analyzer, excessively long sample lines, sample temperature changes, and inaccurate temperature compensation of on-line analysis equipment.

6.2 Studies (3–5) have shown that the loss of ionic and particulate components is minimized by maintaining the water sample velocity at 1.8 m/s in the sample tubing transporting the sample. The turbulent flow at 1.8 m/s (6 ft/s) presents a stable

condition of deposition and removal. Changes in sample flow rate or flow rates beyond a median range of approximately 1.8 m/s can upset this equilibrium condition.

6.3 Saturated steam and superheated steam samples present difficult transport problems between the source and the primary sample cooling equipment (4). Saturated steam samples with transport velocities typically above 11 m/s (36 ft/s) provide adequate turbulent flow to ensure the transport of most particulates and ionic components. Excessively large or small steam sample lines can affect the sample quality and quantity significantly. If the sample tubing has too large an inside diameter, the steam velocity may be too low to transport the condensed portion of the steam along with the vapor. If the sample tubing has too small an inside diameter, the pressure drop may be excessive, reducing the quantity of sample available at the sample panel. In the case of super-heated steam, significant ionic deposition can occur in the sample tubing transport as the steam desuperheats. This can affect sample analysis accuracy significantly. Superheated samples should use a process to inject cooled sample into the sample line at or near the nozzle outlet to desuperheat the sample so as to minimize deposition in the initial portion of the tubing run.

6.4 Samples may become contaminated by products introduced into the stream by the tubing, valves, or other associated conditioning hardware. To minimize contamination of the sample, high-grade tubing, such as Type 316 SS, must be used. Cobalt contamination from valve hardening material can introduce significant error in transition metal analysis by ion chromatography.

6.5 Air leakage into sample lines can affect pH, conductivity (specific, cation, and degassed), and especially dissolved oxygen measurements.

6.6 The operation of a sample system includes periodically taking grab samples and adding and removing on-line analyzers. The accuracy of the analyses can be affected if the flow rate through any on-line analyzer changes because of these procedures. The same is true if these actions change the flow rate in the incoming sample line to the system.

6.7 Changing the temperature of the sample flowing through an on-line analyzer can alter the accuracy of the analysis. Sample temperature can change because of a change in flow rate through the heat exchangers, because of a change of flow rate of the cooling water in the heat exchangers, or from a change in temperature of the heat exchanger cooling water supply. Every effort should be made to ensure constant sample temperature. The ideal sample temperature is 25 ± 0.5°C (77 ± 1°F) because this is the standard for comparing readings of temperature-sensitive analyses.

6.8 Electronic compensation is able to compensate for the deviations in sample temperature for a known chemical matrix (contamination). If an unknown source of contamination is introduced, the analyzer may not be programmed, or programmable, to respond to the new solution. An error is introduced as a result. The further the sample temperature deviates from 25°C (77°F), the greater the error.

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[3] The boldface numbers in parentheses refer to the list of references at the end of this practice.