Designation: D 2186 – 84 (Reapproved 1999)ε1

An American National Standard

Standard Test Methods for
Deposit-Forming Impurities in Steam[1]

This standard is issued under the fixed designation D 2186; 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.

ε1 NOTE—Footnotes were editorially removed in June 1999.

1. Scope

1.1 These test methods cover the determination of the amount of deposit-forming impurities in steam. Determinations are made on condensed steam samples in all test methods. Test Methods A, B, and C give a measure of the amount of total deposit-forming material present; Test Method D deals with special constituents that may be present. Special precautions and equipment, calculation procedures, and ranges of applicability are described. The following test methods are included:

	Sections
Test Method A (Gravimetric or Evaporative)	6 to 12
Test Method B (Electrical Conductivity)	13 to 19
Test Method C (Sodium Tracer)	20 to 26
Test Method D (Silica and Metals)	27 to 30

1.2 Test Method A is applicable for determining total dissolved and suspended solids in concentrations normally not less than 0.1 mg/L (ppm). It is applicable only to long-time steady-state conditions and is not applicable for transients.

1.3 Test Method B will measure minimum impurity concentrations varying from 3 mg/L (ppm) down to at least 0.005 mg/L (ppm), depending on the means for removing dissolved gases from the steam condensate. The means for removing dissolved gases also affects the storage capacity of steam condensate in the system and, thus, affects the response of the system to transients.

1.4 Because of the high sensitivity of methods for measuring sodium in steam condensate, Test Method C provides the most sensitive measure of impurity content for samples in which sodium is an appreciable percentage of the impurities present. Concentrations as low as 0.6 µg/L (ppb) can be detected by flame photometry and as low as 0.5 µg/L (ppb) by sodium ion electrode. The apparatus can be designed with low volume, and, therefore, Test Method C is the most responsive to transient conditions.

1.5 Test Method D covers the determination of silica and metals in steam, which are not included in Test Methods B and C and are not individually determined using Test Method A.

1.6 *This standard does not purport to address 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 512 Test Methods for Chloride Ion in Water[2]
D 515 Test Methods for Phosphorus in Water[2]
D 516 Test Method for Sulfate Ion in Water[2]
D 857 Test Methods for Aluminum in Water[2]
D 859 Test Method for Silica in Water[2]
D 992 Test Method for Nitrate Ion in Water[3]
D 1066 Practice for Sampling Steam[2]
D 1068 Test Methods for Iron in Water[2]
D 1125 Test Methods for Electrical Conductivity and Resistivity of Water[2]
D 1129 Terminology Relating to Water[2]
D 1339 Test Methods for Sulfite Ion in Water[4]
D 1428 Test Methods for Sodium and Potassium in Water and Water-Formed Deposits by Flame Photometry[4]
D 1687 Test Methods for Chromium in Water[2]
D 1688 Test Methods for Copper in Water[2]
D 1886 Test Methods for Nickel in Water[2]
D 1888 Test Methods for Particulate and Dissolved Matter, Solids, or Residue in Water[2]
D 2791 Test Method for Continuous Determination of Sodium in Water[2]
D 3082 Test Method for Boron in Water[2]
D 3370 Practices for Sampling Water from Closed Conduits[2]

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[1] These test methods are under the jurisdiction of ASTM Committee D-19 on Water and are the direct responsibility of Subcommittee D19.03 on Sampling of Water and Water-Formed Deposits, and Surveillance of Water.

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[2] *Annual Book of ASTM Standards*, Vol 11.01.
[3] *Discontinued*—See 1983 *Annual Book of ASTM Standards*, Vol 11.01.
[4] *Discontinued*—See 1989 *Annual Book of ASTM Standards*, Vol 11.02.

3. Terminology

3.1 *Definitions*—For definitions of terms used in these test methods, refer to Terminology D 1129.

4. Significance and Use

4.1 Limiting the concentration of deposit-forming impurities in steam is of significance to protect both steam generators and steam turbines from damage or degradation of performance, or both.

4.1.1 Steam entering superheaters and reheaters of steam generators always contains some impurities. If the concentration of impurities is sufficiently low, the impurities are dissolved in superheated steam and are carried out of the steam generator. However, if the steam contains a sufficient amount of any substance to exceed its solubility limit in steam, the substance is likely to form a deposit on the heat-transfer surface. Because heat transfer in superheaters and reheaters in fossil-fueled steam generators is controlled principally by the low heat-transfer coefficient on the gas side, the formation of steam-side deposits will have little effect on the overall heat-transfer rate. However, steam-side deposits will increase the operating temperature of the heat-transfer surface. Such temperature increases can lead to swelling and ultimately to rupture of the tubing. Also, aggressive materials can concentrate under solid deposits of porous materials, such as magnetite (Fe_3O_4), and can cause serious corrosion of the tubing.

4.1.2 As steam flows through turbines, its temperature and pressure decrease rapidly. Because the ability of steam to dissolve impurities decreases with decreasing temperature and pressure, impurities in steam may exceed their solubility limit and form deposits on the turbine. Such deposits reduce steam flow area, particularly in the high-pressure portion of the turbine where flow passages are small, and the roughness of deposits and their effect on blade contours result in losses of turbine efficiency. All of these effects lead to reduction of the plant maximum capacity, which appreciably reduces the financial return on the capital investment in the power plant. Furthermore, aggressive materials, such as sodium hydroxide (NaOH) and sodium chloride (NaCl), may condense and deposit on turbine surfaces. Such deposits occasionally contribute to failure due to cracking of highly stressed turbine blades and rotors. Repairs and outages are extremely costly.

4.1.3 By monitoring the concentration of deposit-forming impurities in steam, a power plant operator can take steps necessary to limit the impurities to tolerable concentrations and thus minimize or eliminate losses due to excessive deposits.

5. Sampling

5.1 Collect the samples in accordance with Practice D 1066 and Practices D 3370 as applicable.

5.2 The concentrations of sodium and silica in steam samples are usually well below 1 mg/L (ppm). Because these materials exist in relative abundance in normal plant and laboratory environments, even in atmospheric dust, extreme caution must be used when collecting and handling samples to avoid contamination. The use of a continuously flowing sample, which eliminates the need for collecting, handling, and storing individual samples, is preferred.

TEST METHOD A—GRAVIMETRIC OR EVAPORATIVE

6. Scope

6.1 The gravimetric test method is recommended for applications for which an average value of impurities over a period of several days or weeks is desired. It is particularly useful for samples in which a large percentage of the impurities are insoluble, do not contain sodium, or do not contribute appreciably to the electrical conductivity of the samples, because the other methods are not satisfactory for these conditions. Examples of such impurities are metals and metal oxides. It is not applicable when short-time trends are of interest or when immediate results are desired. The test method is useful for the determination of concentrations of impurities of 0.25 mg/L (ppm) or greater when a previously collected sample is used and for impurities concentrations of 0.1 mg/L (ppm) or greater when continuous sampling is used. Concentrations less than 0.1 mg/L (ppm) can be determined if a continuously flowing sample is evaporated for an extremely long period of time.

7. Summary of Test Method

7.1 This test method involves the evaporation of a quantity of steam condensate at a temperature below the boiling point and the weighing of the residue to determine the amount of impurities in the sample. The evaporation process may be carried out on a steam condensate sample previously collected, or the sample may be taken continuously as the evaporation process is continued.

8. Interferences

8.1 Possible interferences for this test method are described in Test Methods D 1888.

9. Apparatus

9.1 Apparatus shall be provided in accordance with the applicable test method of Test Methods D 1888.

10. Procedure

10.1 Proceed in accordance with Test Method A or B of Test Methods D 1888, as applicable.

11. Calculation

11.1 Calculate the concentration of impurities in the sample in accordance with Test Methods D 1888.

11.2 Dissolved matter and total matter are usually of greatest interest in the determination of impurities in steam. The determination of fixed solids after ignition at some temperature greater than 103°C (217°F) may be of more significance than the measurement taken at 103°C, depending on the type of solids in the sample and the maximum temperature to which the steam is to be heated in the application.

12. Precision and Bias

12.1 The precision of the analytical results is given in Test Methods D 1888. Because of the uncertainties involved in sampling steam, it is not possible to state the overall precision of this test method.

TEST METHOD B—ELECTRICAL CONDUCTIVITY

13. Scope

13.1 *Ion-Exchange Degasser*—An ion-exchange degasser consists of an ion-exchange resin that exchanges hydrogen ions for all cations in the sample, thereby eliminating all basic dissolved gases, including volatile amines. By converting mineral salts to their acid forms, it also increases the specific conductance of the impurities. As a result, the linear relationship between conductivity and impurity content is extended to a much lower level, depending on the carbon dioxide content. The test method is very useful for measuring low concentrations of impurities, such as condenser cooling water leakage, in steam condensate, and it is especially useful, for indicating small or intermittent changes in impurity content from some normal value. The test method is not satisfactory for the determination of impurities in steam condensate samples that contain acidic gases, such as carbon dioxide, large percentages of insoluble matter, or substances that ionize weakly. The sensitivity and accuracy of the method are decreased for samples in which hydroxides represent an appreciable percentage of the impurities, because hydroxides, which contribute to the formation of deposits, are converted to water by the ion-exchange resin. This characteristic is particularly significant when steam is generated at sufficiently high pressure to cause appreciable vaporization of sodium hydroxide from the boiler water.

13.2 *Mechanical and Ion-Exchange Degasser*—By combining mechanical and ion-exchange degassing of steam or condensed steam, or both, effective elimination of both acidic and basic dissolved gases is attained. This arrangement has the same advantages and limitations as the ion-exchange degasser alone, except that it will remove acidic gases, and the greater sensitivity afforded by measuring the conductance at atmospheric boiling water temperature extends the linear relationship between conductivity and the ionized impurity content down to about at least 0.005 mg/L (ppm). Although the relationship becomes somewhat nonlinear, the conductance is sensitive to concentration changes down to at least 0.005 mg/L (ppm). [5]

14. Summary of Test Method

14.1 Because the concentrations of impurities in steam condensate are usually very low, most impurities are assumed to be completely dissolved and completely ionized. Therefore, the electrical conductivity of the condensate sample is a measure of the concentration of ionized impurities in the sample.

14.2 Most steam contains gases from decomposition of certain substances in boiler feedwater and from the addition of chemicals to boiler water or boiler feedwater for the control of corrosion. These gases dissolve and ionize in the condensed steam samples. Since such gases normally do not form deposits, their contribution to conductivity should be eliminated by degassing the sample before its electrical conductivity is measured. Because mechanical degassing is not completely effective, the amount of residual gases must be determined and the measured conductivity value must be corrected for their effect. Although mechanical degassers may still be used to a limited extent, they are no longer available commercially. The use of mechanical degassers should be considered obsolete.

14.3 Basic dissolved gases, many of which are not effectively removed by mechanical degassing, are converted to water by an ion-exchange degasser. The ion-exchange degasser also converts mineral salts to their acid form by exchanging hydrogen ions for the metallic cations. Since the specific conductance of the acid form is roughly three times that of the original mineral salts at 25°C (77°F), the sensitivity of measurement is increased. If the conductance measurement is made at the atmospheric boiling point (approximately 100°C (212°F)), the specific conductances of the ions are increased and the sensitivity of measurement is improved still further.

15. Interferences

15.1 Residual gases remaining in steam condensate samples after mechanical degassing constitute interference with the conductivity measurement. The concentrations of these gases remaining in the samples shall be determined, and appropriate corrections shall be subtracted from the measured conductivity values.

16. Apparatus

16.1 Apparatus shall be provided in accordance with Test Methods D 1125.

16.2 *Ion-Exchange Degasser*—The ion exchange column shall consist preferably of sulfonated styrenedivinyl-benzene resin in a container of plastic or other corrosion-resistant material. A column of approximately 38-mm (1.5-in.) internal diameter and 305 mm (12 in.) in length, containing about 272 g (0.6 lb) of resin, is satisfactory for most applications. Woven plastic fabric or similar corrosion-resistant material is required at each end of the column to retain the resin and to permit the condensate sample to enter and leave the column. An example of an ion-exchange column, equipped with a conductivity cell, flowmeter, and thermometer, is shown in Fig. 1.
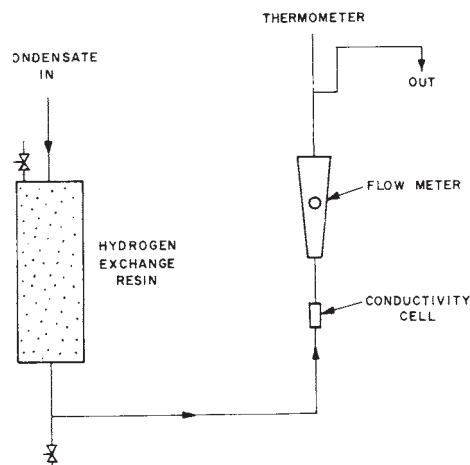

FIG. 1 Larson-Lane Condensate Analyzer

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[5] Lane, R. W., Sollo, F. W., and Neff, C. H., "Conductance Conductivity Monitoring of Anions in High-Purity Water", *Symposium on Power Plant Instrumentation for Measurement of High-Purity Water Quality, ASTM STP 742*, 1981.

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