



## Standard Test Methods for Accumulated Deposition in a Steam Generator Tube<sup>1</sup>

This standard is issued under the fixed designation D 3483; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

### 1. Scope

1.1 These test methods cover the determination of the weight per unit area of waterside deposits on heat-transfer surfaces of steam generator tubes. ~~Two~~ The following test methods are ~~given as follows:~~ included:

Test Method B—Solvent Removal	Sections Test Method A—Mechanical Removal	—6 to 11
Test Method A—Mechanical removal by scraper or vibrating tool-removed deposit weight method	12 to 18	
Test Method B—Chemical removal by solvent-tube weight loss method	7 to 16	
Test Method C—Mechanical removal by glass-bead blasting-tube weight loss method	17 to 27	
	28 to 37	

1.2 Neither test method is normally applicable to fire-tube boilers.

1.3 A comparison of the results obtainable with the two test methods is shown in Fig. 1.

1.4 A scope section is provided in each test method. It is the responsibility of the analyst to determine the acceptability of these test methods for each situation.

1.5

1.2 Test Method A is a procedure applicable to deposits ranging from 16 to 76 g/ft<sup>2</sup>. This method allows the discretionary selection of the area on the tube to be sampled. The removed deposit allows for further chemical analysis.

1.3 Test Method B is a method applicable to deposits ranging from 28 to 73 g/ft<sup>2</sup>. The method averages out the heavier and lighter deposited areas. The solvent solution produced allows for further chemical analysis.

1.4 Test Method C is a procedure applicable to deposits ranging from 17 to 88 g/ft<sup>2</sup>. The method averages out the heavier and lighter deposited areas. The removed deposit does not allow for further chemical analysis.

1.5 These test methods have been generally evaluated on the types of waterside deposits generally found on heat-transfer surfaces of steam generator tubes. It is the user's responsibility to ensure the validity of these test methods for other types of deposits or high temperature scale.

1.6 These methods are sometimes used for accumulated deposition in rifled steam generator tubes. Experience has shown that there is a significant difference in the deposition in the grooves and on the lands on some rifled steam generator tubes. The grooves have been shown to hold more deposit. Test Method B and Test Method C will average out this difference. In Method A the choice exists, either to choose to remove the deposition from the groove if it is visually determined to be more heavily deposited, or to remove equally over the grooves and lands. It is important that it be understood what choices were made and that the report reflect the choices made when using Test Method A on rifled steam generator tubes.

1.7 There are some steam generator tubes where it is apparent that half of the tube is exposed to the flame from the external appearance, this side is typically called the fireside or hot side. The other half of the tube is not exposed to the flame from the external appearance is typically called the casing side or cold side. These test methods also require that the tube be split in half, so the tube is generally split along these lines. On these tubes it is generally found that more internal deposition exists on the fireside or hot side. Some users of these methods will determine the deposition only on side where it appears visually that more deposition exists. Some users will determine the deposition on both sides and report the results separately and some will average the two results. It is important that the user of the data be aware of the choices made and that the report of the results be specific.

1.8 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.

1.9 This standard does not purport to address the safety concerns, if any, associated with its use. It is the responsibility of the

<sup>1</sup> These test methods are under the jurisdiction of ASTM Committee D19 on Water and are 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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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:<sup>2</sup>

D 887 [Practices for Sampling Water-Formed Deposits](#)

D 1129 [Terminology Relating to Water](#)

D 1193 ~~[Specification for Reagent Water](#)~~<sup>3</sup> [Specification for Reagent Water](#)

D 2777 [Practice for Determination of Precision and Bias of Applicable Test Methods of Committee D19 on Water](#)

G 1 [Practice for Preparing, Cleaning, and Evaluating Corrosion Test Specimens](#)

### 2.2 Other Documents:

[NACE Standard TM0199-99, Item No. 21236, Standard Test Method for Measuring Deposit Mass Loading \(“Deposit Weight Density”\) Values for Boiler Tubes by the Glass-Bead-Blasting Technique](#)

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<sup>2</sup> Annual Book of ASTM Standards, Vol 11.02.

<sup>3</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For Annual Book of ASTM Standards volume information, refer to the standard’s Document Summary page on the ASTM website.

NACE International Publication 7H100, Item No. 24206, Evaluation of Boiler Tube Deposit Mass Loading (Deposit Weight Density) Methodology

### 3. Terminology

3.1 *Definitions:* —For definitions of terms used in this test method, refer to Terminology D 1129.

### 4. Significance and Use

4.1 The weight per unit area measurement is an indication of the relative cleanliness or dirtiness of the boiler; therefore, it is important that a tube sample be selected that represents near maximum deposition.

4.1 The weight per unit area measurement is an indication of the relative cleanliness or dirtiness of the boiler. It is used to determine the effectiveness of the boiler chemical treatment program and to determine the need for chemically cleaning the boiler systems. Allowing the internal deposition to accumulate unchecked will likely lead to boiler tube failures by mechanisms of under deposit corrosion and tube metal overheating.

### 5. Reagents and Materials

5.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. Unless otherwise indicated, it is intended that all reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society.<sup>3</sup> Other grades may be used, provided it is first ascertained that the reagent is of sufficiently high purity to permit its use without lessening the accuracy of the determination.

5.2 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean reagent water conforming to Specification D 1193, Type 4.

### 6. Sampling

6.1 Select a tube section likely to have the heaviest deposit. Experience has shown that deposit accumulation is usually heaviest on tube surfaces that receive the highest heat transfer. Representative areas of especially high absorption heat transfer are:

6.1.1 The center of the division wall at the top burner elevation in a boiler with a division panel wall where firing occurs on opposite sides.

6.1.2 The side wall near the top burner elevation, at about 1/3 furnace depth from the burner wall, in a boiler without a division wall.

6.1.3 Other high heat absorption areas in a more complex boiler design as delineated by the boiler manufacturer.

6.2 Areas in the boiler where impaired circulation is suspected may also be sampled.

6.3 After selecting the boiler tube to be sampled, provide suitable identification, showing location in the boiler, the direction of flow, and the hot and shielded sides in accordance with Practices D 887

6.1.3 Other high heat transfer areas in a more complex boiler design as indicated by the boiler manufacturer.

6.2 Areas in the boiler where impaired circulation is suspected may also be sampled.

6.3 The optimal tube removal method is by dry cutting. No oil or water is to be used in the tube cutting process. The length of sample should be 24 to 36 in., but allow an extra 12 in. on each end if the sample is cut out by torch.

6.4 After the tube sample is removed, provide suitable identification, showing location in the boiler, orientation of tube, and the hot and cold sides of the tube in accordance with Practices D 887.

6.3.1 Remove a sufficient portion of the tube to contain a selected 600-mm (24-in.) section, allowing at least 300 mm (12 in.) more on each side of the sample if a cutting torch is used.

Note 1—No oil or water is to be used in any mechanical cutting operation.

6.3.2 Separate a selected 600-mm (24-in.) section by careful application of an anchored pipe vise and a tube cutter.

## TEST METHOD A—MECHANICAL REMOVAL

### 6. Scope

6.1 The mechanical removal test method is preferred when deposition is comparatively heavy and the deposits are relatively easy to dislodge. The deposit, so removed, may serve as the sample for determining the composition of the material.

## TEST METHOD A—MECHANICAL REMOVAL BY SCRAPER OR VIBRATING TOOL

### 7. Summary of Test Method

7.1 A section of the most heavily fouled portion of the sampled tube is selected on a visual basis. After dividing the tube, the water-formed deposit is removed mechanically from a measured area. The weight of the dry material is reported as milligrams of

<sup>3</sup> *Annual Book of ASTM Standards*, Vol 11.01-Reagent Chemicals, American Chemical Society Specifications, American Chemical Society, Washington, DC. For suggestions on the testing of reagents not listed by the American Chemical Society, see *Analar Standards for Laboratory Chemicals*, BDH Ltd., Poole, Dorset, U.K., and the *United States Pharmacopeia and National Formulary*, U.S. Pharmaceutical Convention, Inc. (USPC), Rockville, MD.

deposit per square millimetre of boiler tube surface. Scope

7.1 This test method covers the determination of accumulated deposition in a steam generator tube by the mechanical removal of the deposit by scraper or vibrating tool, the collection and weighing of the dry deposit. This collected deposit is then available for further chemical analysis, if desired. The method also allows for discretionary removal of the deposit from the tube in areas of the most interest.

## 8. Summary of Test Method

8.1 The tube is split and the area to be tested is determined after examination; usually the area judged to be most heavily deposited. The deposits are removed mechanically by scraping or vibrating from a measured area. The collected deposit is weighed and the result is usually reported as grams of deposit per square foot of boiler tube surface.

## 9. Interferences

9.1 There are no interferences, only errors in collecting the deposit, removing sufficient deposit, not removing base metal, determination of the sample weight and the sampled area.

## 10. Apparatus

8.1

10.1 Cutting Tool or Torch, removing a suitable portion of boiler tube and a vise for crimping.

NOTE 2—Lightly crimping the sample tube in a vise may be effective in removal of very brittle deposits. However, any physical change that the tube specimen is subjected to may affect any subsequent metallographic examination.

8.2, for removing a suitable portion of the boiler tube.

10.2 Tube Cutter.

8.3

10.3 Tube End Sealers, to protect the sample if the determination is to be made elsewhere than on the site.

8.4 Milling Machine (Preferred) or Band Saw, to separate the fireside half of the tube from the shielded half by longitudinal sectioning (dry cut).

8.5, to protect the sample until the determination can be made.

10.4 Milling Machine or Band Saw, to separate the tube into halves by longitudinal sectioning (dry cut).

10.5 Magnet, to remove metal chips from the deposited material, especially if a band saw is used.

8.6, to remove cutting metal chips from the deposited material.

10.6 Scraping Tool, for removing the less adherent deposits (like a scalpel or a heavy screwdriver, the end of which has been thinned).

8.7, for removal of less adherent deposits. Scraper material of construction needs to be of sufficient hardness as not to contaminate the deposit sample.

10.7 Vise, for removal of brittle deposits.

8.8, sometimes is used to crimp tube to remove brittle deposits.

10.8 Vibrating Tool, to remove more adherent deposits (deposits. A small head should be available for use within pits); pits.

8.9 10.9 Oven, for drying the deposits.

8.10, for drying deposits.

10.10 Analytical Balance.

## 9., for weighing deposits.

## 11. Procedure

9.1 Take the 600-mm (24-in.) tube section obtained in 5.3.2.

9.2 Separate (dry cut) the fireside half of the tube longitudinally from the shielded (or casing) half, being careful to affect the deposit as little as possible. If a band saw is used, carefully remove all fragments of metal with a magnet. Observe closely to be sure that only metal fragments are removed.

9.3 Examine the water-formed deposit (photograph if desired), and select and mark off the boundaries of the 150-mm (6-in.) specimen of tubing on the internal fireside that appears to be most heavily fouled and relatively uniform (undiminished by spalling). Mark a similar area on the internal casing half of the tube for comparison.

9.4 Carefully scrape the surface to dislodge and individually collect the more easily removable deposits from between the boundaries of each sample. Complete the deposit removal by brushing or applying an electric vibrating tool, or both. Dry the removed material in an oven at 105°C for 1 h. Grind sufficiently to pass through a No. 325 (45-µm) stainless steel sieve and weigh the screened portion of each half; record the weights in milligrams.

NOTE 3—Drying the sample may affect subsequent analysis by X-ray diffraction.

NOTE 4—The purpose of the grinding and screening operation is to prevent a weighing error from chips of steel that may have been lodged in the deposit during the sample-cutting operation.

9.5 Determine the areas from which the two deposits were removed, measuring each dimension to the nearest 1 mm. Trim sheets of paper to make patterns of the actual surfaces that were stripped. If the pattern is regular in shape, determine the area by direct measurement. If the pattern is irregular, determine the area by comparing the weight of the pattern to the weight of a sheet of paper of known area.

#### 10.

11.1 Split the tube sample taken in Section 6 in halves longitudinally, separating the hot side from the cold side if the distinction is apparent from the external surface or from labeling. Be careful to disturb the internal deposit as little as possible. Carefully remove all cutting fragments from the deposit with the magnet.

11.2 Examine and photograph the internal surfaces, if desired. Determine the area to be tested and mark off the boundaries. This will usually be the area of heaviest deposit and will be on the hot side section of the tube. A similar area can be marked off and tested on the cold side section for comparison, if desired.

11.3 Carefully, scrape the surface to dislodge and individually collect the more easily removable deposits from the selected area. Complete the deposit removal by brushing or applying an electric vibrating tool, or both. Dry the removed material in an oven at 105°C for 1 hour if it appears to be hydrated. It is optional to grind the removed deposit sufficiently to pass through a No. 325 (45- $\mu$ m) stainless steel sieve and weigh the screened portion. Record the weight in milligrams.

11.4 Determine the area from which the deposit was removed, measuring each dimension to the nearest 1 mm. If the area has a regular shape, direct measurement can be used. If the area has an irregular shape, one technique used to determine the area is to trim paper to the pattern of the actual surface that had deposit removed. Then determine the area by comparing the weight of the irregular paper pattern to the weight of a paper of known area.

#### 12. Calculation

10.1 Determine the weight of accumulated deposits per unit area, in milligrams per square millimetre, directly by dividing the weight of deposit in milligrams by the area in square millimetres.

#### 11.

12.1 Determine the weight of accumulated deposits per unit area, by dividing the removed deposit weight by the measured area.

#### 13. Report

13.1 The results are usually reported as g/ft<sup>2</sup>.

#### 14. Precision and Bias

11.1 See 18.1

14.1 Practice D 2777 is not applicable to this Standard Test Method because a known and repeatable standard reference deposit contained within a steam generator tube cannot be produced.

14.2 Factors that produce errors in mass loss measurement include improper balance calibration, loss of removed deposition prior to weighing, incomplete deposition removal, and removal of base metal. Generally, modern analytical balances if calibrated and used correctly are not considered to be a significant source of error. The other factors are considered more significant.

14.3 The determination of the sample area is likely the least precise step with this method, particularly for rifled tubes.

14.4 This method was tested by five laboratories. These collaborative test data were obtained on sections of boiler tube samples from two specific boilers. For other boiler tube samples, these data may not apply.

14.4.1 *Precision*—An example of the precision obtained on these specific boiler tubes is shown in Fig. 1.

### TEST METHOD B—SOLVENT REMOVAL

#### 12. Scope

12.1 The solvent removal test method is preferable where deposition is relatively light and the deposit is adherent to the base metal.

#### 13.

14.4.2 *Bias*—Bias data could not be determined because of the lack of a boiler tube containing a known and consistent deposit.

14.5 Data for this estimated procedure variance is from NACE International Publication 7H100, Item No. 24206, "Evaluation of Boiler Tube Deposit Mass Loading (Deposit Weight Density) Methodology."

#### 15. Quality Control (QC)

15.1 In order to be certain that analytical values obtained using this test method are valid and accurate within the confidence limits of the test, the following QC procedures must be followed when running the test:

15.2 A method has been shown to determine the optimum length of time or other variable factors concerning the cleaning procedure, which indicates the optimum point where deposition has been removed but base metal has not been removed, as shown in ASTM Standard G 1 Standard Practices for Preparing, Cleaning, and Evaluating Corrosion Test Specimens.

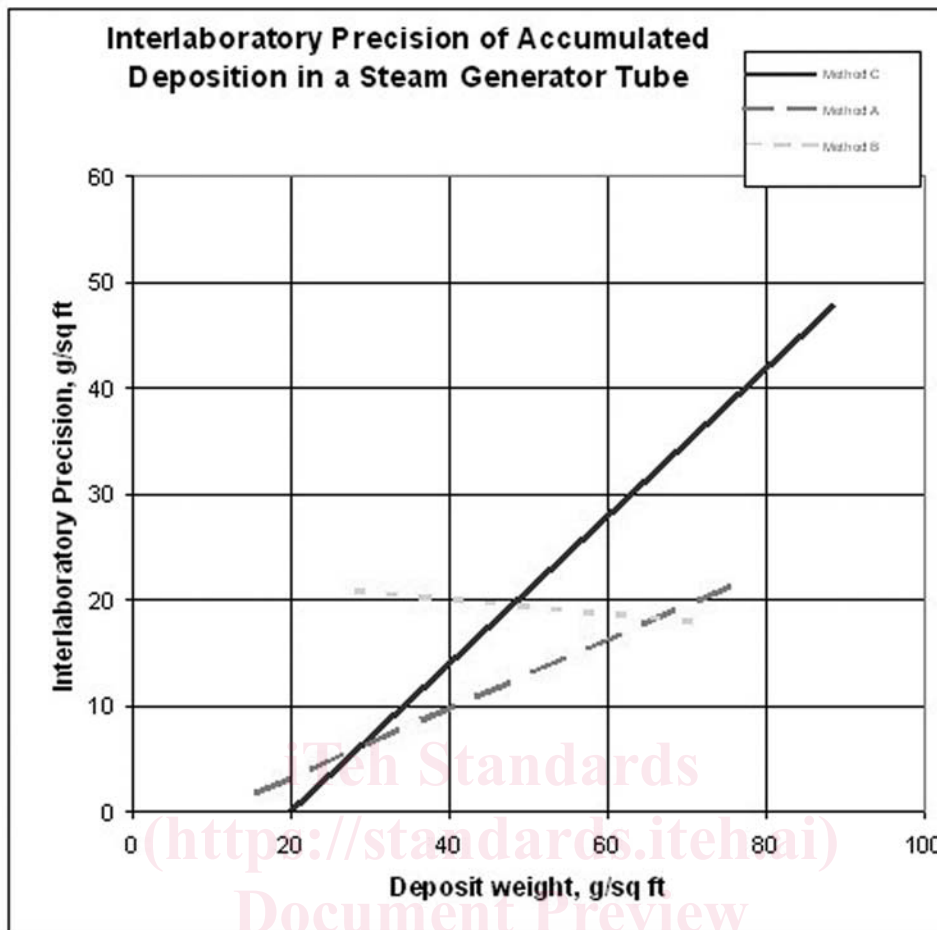


FIG. 1 Interlaboratory Precision of Accumulated Deposition in a Steam Generator Tube

15.3 Calibration and Calibration Verification: [ASTM D3483-05\(2009\)](http://standards.iteh.ai/ASTM-D3483-05(2009))

15.3.1 Analytical Balance—Follow the balance manufacturer’s recommendations for calibration procedure and frequency. Check the balance with a class S weight in the range of the expected deposit sample weight on the day of use. Recalibrate, as needed.

16. Keywords

16.1 boiler; deposit; deposition; rifled; steam generator tube

**TEST METHOD B—CHEMICAL REMOVAL BY SOLVENT**

17. Scope

17.1 This test method covers the determination of accumulated deposition in a steam generator tube by chemical removal of the deposit and measuring the weight change in the deposit. This solvent containing the deposit is then available for further chemical analysis, if desired. The method does not allow for discretionary removal of the deposit from the tube in areas of the most interest.

18. Summary of Test Method

18.1 The deposit that has accumulated in the selected boiler tube specimen is determined by measuring the weight loss of the tube sample after deposit removal with inhibited hydrochloric acid. In the event copper plates out on the tube sample during the cleaning operation, an ammonium persulfate solution is used to remove the copper prior to final weighing. The required machining of the outside surface of the selected tube sample to a wall thickness of approximately 1 mm (1/16 in.) will increase the sensitivity of the measurement and eliminate interference from external deposits.

14.

19. Interferences

19.1 Loss of base metal by the solvent, incomplete cleaning of external surface followed by loss of external material, incomplete removal of deposit.