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Standard Test Methods for Analysis of Soda Ash (Sodium Carbonate)¹

This standard is issued under the fixed designation E359; 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.

This standard has been approved for use by agencies of the Department of Defense.

^{ε1}NOTE— Editorial changes were made in June 2005.

1. Scope*

- 1.1 These test methods cover the analyses usually required on commercial soda ash (sodium carbonate).
- 1.2 The analytical procedures appear in the following sections:

	Sections
Total Alkalinity, Titrimetric	8-15
Sodium Bicarbonate, Titrimetric	16-23
Loss on Heating, Gravimetric	24-30
Moisture, Calculation	31-35
Sodium Chloride, Titrimetric	36-42
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~~1.3 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.~~

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 Review the current Materials Safety Data Sheets (MSDS) for detailed information concerning toxicity, first aid procedures, handling and safety precautions.

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. Specific hazards statements are given in Section 6.*

2. Referenced Documents

2.1 ASTM Standards:²

- C429 Test Method for Sieve Analysis of Raw Materials for Glass Manufacture
- D1193 Specification for Reagent Water
- E11 Specification for Woven Wire Test Sieve Cloth and Test Sieves
- E60 Practice for Analysis of Metals, Ores, and Related Materials by Molecular Absorption Spectrometry
- E70 Test Method for pH of Aqueous Solutions With the Glass Electrode
- E145 Specification for Gravity-Convection and Forced-Ventilation Ovens
- E180 Practice for Determining the Precision of ASTM Methods for Analysis and Testing of Industrial and Specialty Chemicals
- E200 Practice for Preparation, Standardization, and Storage of Standard and Reagent Solutions for Chemical Analysis
- E300 Practice for Sampling Industrial Chemicals

3. Significance and Use

3.1 Soda ash is used in a number of manufacturing processes. The procedures listed in 1.2 are suitable for specification acceptance and manufacturing control of commercial soda ash.

¹ These test methods are under the jurisdiction of ASTM Committee E15 on Industrial and Specialty Chemicals and are the direct responsibility of Subcommittee E15.02 on Product Standards.

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² For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard.

4. Apparatus

4.1 *Photometers and Photometric Practice*—Photometers and photometric practice used in these test methods shall conform to Practice E60.

4.2 *pH Meters*—pH meters and their use shall conform to Test Method E70.

4.3 *Buret*—A calibrated 50-mL buret, or any standard 50-mL buret calibrated by either the National Institute of Standards and Technology or by the user. Alternatively, a 100-mL calibrated buret with a 50-mL bulb at the top and a 50-mL stem below may be used.

5. Purity of Reagents and Water

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, where such specifications are available.³ 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 Unless otherwise indicated, references to water shall be understood to mean Type II or Type III reagent water conforming to Specification D1193.

6. Hazards

6.1 Soda ash is a primary skin irritant. Dusts or mists are moderately irritating to the mucous membrane of the nose and eyes. The irritation is temporary and symptoms usually disappear shortly after contact is ended.

7. Sampling

7.1 The general principles for sampling solids are covered in Practice E300. The following aspects of soda ash sampling must be considered:

7.2 General:

7.2.1 The selection of a representative sample is a necessary prerequisite for any accurate analysis, and this is particularly important with the alkalis, since they are susceptible to rapid contamination by moisture and carbon dioxide upon exposure to air. Also, some of them are not uniform in particle size and tend to segregate on handling.

7.2.2 The characteristics of soda ash that make proper sampling difficult at times are its tendency to absorb moisture and carbon dioxide from the air through any commercial container in which it is generally shipped, and the susceptibility of dense ash in bulk to segregate in relation to particle size as the result of normal transit vibrations.

7.2.3 Details of good sampling depend on: (1) the type of shipment, whether in containers or in bulk; (2) the type of product, whether light or dense soda ash; and (3) the type of analysis desired, whether chemical or physical.

7.3 Bulk Shipments:

7.3.1 Although bulk shipments are normally in transit a relatively short time, there is likely to be some absorption of moisture and carbon dioxide in exposed surface areas. If physical tests such as screen analysis are to be included, it is particularly important to avoid segregation that occurs on surface areas.

7.3.2 To sample boxcar shipments, brush aside the surface layer to a depth of 12 in. (305 mm) and take portions systematically from the newly exposed area to the bottom of the car by means of a sample thief.

7.3.3 Hopper cars and trucks are more difficult to sample adequately. Samples can be taken through the hatches with a sample thief, as for boxcar sampling. Preferably, samples should be taken during the unloading operation at the point of discharge to the bin, or from any open section of the conveyor.

7.4 Bag Shipments:

7.4.1 Packaged soda ash that has been in storage for some time can be sampled satisfactorily only by emptying the whole package and mixing thoroughly before taking the sample. Even such a portion is likely to represent only the package sampled rather than the stock of packages as a whole. The reason is that a bag or other container taken from an outer layer of the storage pile is subject to more air contact and consequently more moisture and carbon dioxide absorption than are packages buried farther back in the stock.

7.4.2 To get an idea of the quality of the soda ash as packed, it is the usual practice to take the sample from somewhere near the center of the package. This may be done by removing the top 6 or 8 in. (150 or 200 mm) of soda ash from the package, then removing the sample from the center of the remaining portion. Such a sample carefully taken will generally be found representative except in cases of long storage or unusually damp storage conditions.

7.5 Sample Preparation:

7.5.1 Thoroughly mix the total sample taken. Then quarter or riffle the entire sample to obtain the required size sample for analysis. Minimize exposure to moisture and carbon dioxide.

³ *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. Pharmacopeial Convention, Inc. (USPC), Rockville, MD.

7.5.2 Store the sample for analysis in a glass or other suitable container that will not contaminate the sample and that can be sealed to prevent exposure of the sample to moisture or carbon dioxide.

TOTAL ALKALINITY

8. Scope

8.1 This test method covers the titrimetric determination of the total alkalinity of soda ash. This alkalinity is normally expressed as percent sodium oxide (Na₂O).

9. Summary of Test Method

9.1 Total alkalinity is determined by titration with standard hydrochloric (or sulfuric) acid using methyl orange or modified methyl orange indicator solution.

10. Interferences

10.1 Alkalies other than soda ash (sodium carbonate) and compounds that consume acid will affect the accuracy of this test method.

11. Reagents

11.1 *Hydrochloric (or Sulfuric) Acid (1.0 N (1.0 meq/mL))*—Prepare in accordance with Practice E200 (record temperature of solution when standardized).

11.2 *Modified Methyl Orange Indicator Solution or Methyl Orange Indicator Solution*—See Practice E200.

11.3 *Water*, carbon dioxide-free (freshly boiled and cooled).

12. Procedure

12.1 Weigh, to the nearest 0.1 mg, 4.4 ± 0.1 g (Note 1) of the sample and transfer to a 500-mL conical flask. Add 100 mL of water and swirl to dissolve the sample.

NOTE 1—Use of the specified weight of sample requires a 100-mL buret for titration and is recommended. If a 50-mL buret is used, the sample weight should be halved.

12.2 Add 3 drops of modified methyl orange indicator solution (Note 2). Titrate this solution with standard 1.0 N meq/mL acid to a gray end point (Note 3). Record the volume to the nearest 0.02 mL and temperature of the acid used. Correct the acid normality for any difference from the standardization temperature by use of the factor $\Delta N/^\circ\text{C} = 0.00035$ between 20 and 30°C. Add the correction when the temperature of use is below and subtract when above the temperature of standardization (see Practice E200).

NOTE 2—If desired, 0.1 % methyl orange indicator solution may be used.

NOTE 3—The analyst should end the titration at the same shade of color as was used for the end point in the standardization of the acid.

13. Calculation

13.1 Calculate the total alkalinity as percent sodium oxide (Na₂O) as follows:

$$(1) \text{—sodium oxide, \% mass (m/m)} = (A \times B \times 0.030990) \times 100 \text{ } W$$

$$(1) \text{—sodium oxide, \% mass (m/m)} = (A \times B \times 0.030990) \times 100 \text{ } W$$

where:

A = acid required for titration of the sample, mL,

B = corrected normality meq/mL of the acid, and

W = sample used, g.

13.2 Alternatively, calculate the alkalinity as sodium carbonate as follows:

$$(2) \text{—sodium carbonate, \% mass (m/m)} = 1.7101 \times \text{Na}_2\text{O, wt \%}$$

$$(2) \text{—sodium carbonate, \% mass (m/m)} = 1.7101 \times \text{Na}_2\text{O, wt \%}$$

13.3 If actual sodium carbonate content is desired, the sodium bicarbonate content must be determined separately as described in Sections 16 and 23. Then:

$$(3) \text{ sodium carbonate (actual), \%} = A - (B \times 0.6308) \text{ }$$

where:

A = Na₂CO₃, % (see 13.2), and

B = NaHCO₃, % (see 21.1).

14. Report

14.1 Report the percentage of sodium oxide to the nearest 0.01 %.

15. Precision and Bias

15.1 *Precision*—The following criteria should be used for judging the acceptability of results (Note 4):

15.1.1 *Repeatability (Single Analyst)*—The standard deviation for a single determination has been estimated to be 0.032 % absolute at 52 DF. The 95 % limit for the difference between two such runs is 0.09 % absolute.

15.1.2 *Laboratory Precision (Within-Laboratory, Between-Days Variability)*—The standard deviation of results (each the average of duplicates), obtained by the same analyst on different days, has been estimated to be 0.038 % absolute at 26 DF. The 95 % limit for the difference between two such averages is 0.11 % absolute.

15.1.3 *Reproducibility (Multilaboratory)* —The standard deviation of results (each the average of duplicates), obtained by analysts in different laboratories, has been estimated to be 0.154 % absolute at 8 DF. The 95 % limit for the difference between two such averages is 0.43 % absolute.

NOTE 4—These precision estimates are based on an interlaboratory study of analyses performed in 1967 on three samples of soda ash covering the range from 58.190 to 58.385 % sodium oxide. Ten laboratories analyzed the three samples, with one analyst in each laboratory performing duplicate determinations and repeating 1 day later.⁴ Practice E180 was used for developing these precision estimates.

15.2 *Bias*—The bias of this test method has not been determined because of the lack of acceptable reference material.

SODIUM BICARBONATE

16. Scope

16.1 This test method describes the titrimetric determination of sodium bicarbonate in soda ash. The lower limit of determination is 0.02 % sodium bicarbonate.

17. Summary of Test Method

17.1 Bicarbonate is determined titrimetrically by adding a sample to an excess of standard sodium hydroxide solution (thus converting bicarbonate to carbonate), precipitating the carbonate with barium chloride solutions and back-titrating the excess sodium hydroxide with standard acid solution using a pH meter to determine the end point.

17.2 A primary standard is run simultaneously to correct the titration for adsorption or occlusion of sodium hydroxide on the barium carbonate.

18. Apparatus

18.1 *pH Meter*, with glass and calomel electrodes. Standardize the pH meter with commercially available pH 10 buffer solution.

18.2 *Magnetic Stirrer*, with TFE-fluorocarbon-covered stirring bar.

19. Reagents

19.1 *Barium Chloride Solution (120 g/L)*—See Practice E200.

19.2 *Hydrochloric Acid, Standard (0.1 N(0.1 meq/mL))*—See Practice E200.

19.3 *Sodium Carbonate, Primary Standard Na₂CO₃*—Dry about 10 g of anhydrous primary standard sodium carbonate (Na₂CO₃) in a platinum dish or low-form weighing bottle (70-mm diameter) for 4 h at 250°C (minimum) but do not exceed 300°C. Cool in a desiccator. Prepare fresh for use.

19.4 *Sodium Hydroxide, Standard Solution (0.1 N(0.1 meq/mL))*—See Practice E200.

19.5 *Water*, carbon dioxide-free (freshly boiled and cooled).

20. Procedure

20.1 Perform the following steps of the procedure on equal weights/mass of both the sample and the primary standard sodium carbonate (Na₂CO₃) (Note 5). Make duplicate determinations.

NOTE 5—To compensate for the adsorption or occlusion of NaOH by the precipitated BaCO₃ (20.5), the use of primary standard Na₂CO₃ as a blank is required.

20.2 Place 200 mL of BaCl₂ solution in a 400-mL beaker. Using a pH meter, adjust the solution to pH 8.8 by addition of 0.1 Nmeq/mL NaOH solution (or HCl) as required.

20.3 Into a 600-mL beaker place 150 mL of CO₂-free water. Add by pipet 5.0 mL of 0.1 Nmeq/mL NaOH solution.

NOTE 6—If, in 20.6, the pH of the sample solution is below 8.8 before titrating with 0.1 Nmeq/mL HCl, repeat the test adding by pipet 10.0 mL of 0.1 Nmeq/mL NaOH solution to the beakers being prepared for both the sample and the primary standard Na₂CO₃.

20.4 Weigh, to the nearest 1 mg, 4.0 g of the sample (or of the primary standard) and transfer to the solution in the 600-mL beaker. Place the beaker on a magnetic stirrer, insert a stirring bar, and stir to dissolve.

NOTE 7—The subsequent operations should be completed within 5 min to minimize absorption of atmospheric CO₂.

⁴ Supporting data are available from ASTM Headquarters. Request RR:E15-0046.

20.5 While continuing to stir, add the 200 mL of neutralized BaCl₂ solution by means of a 100-mL (or 200-mL, if available) pipet, allowing the reagent to run freely into the stirring solution.

20.6 Insert the electrodes into the solution and titrate slowly with 0.1 N_{meq/mL} HCl using a 10-mL buret, stirring continuously. When pH 8.8 is reached, allow the solution to stir for 1 min. If the pH remains at 8.8, the end point has been reached. If not, continue the titration until this pH is reached. Record the volume of titrant to the nearest 0.05 mL.

21. Calculation

21.1 Calculate the percentage of sodium bicarbonate as follows:

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where:

A = acid for sample, mL,

B = acid for primary standard, mL,

N = normality_{meq/mL} of acid, and

W = sample used, g.

22. Report

22.1 Report the percentage of sodium bicarbonate to the nearest 0.01 %.

23. Precision and Bias

23.1 *Precision*—The following criteria should be used for judging the acceptability of results (Note 8):

23.1.1 *Repeatability (Single Analyst)*—The standard deviation for a single determination has been estimated to be 0.030 % absolute at 60 DF. The 95 % limit for the difference between two such runs is 0.08 % absolute.

23.1.2 *Laboratory Precision (Within-Laboratory, Between-Days Variability)*—The standard deviation of results (each the average of duplicates), obtained by the same analyst on different days, has been estimated to be 0.078 % absolute at 30 DF. The 95 % limit for the difference between two such averages is 0.22 % absolute.

23.1.3 *Reproducibility (Multilaboratory)* —The standard deviation of results (each the average of duplicates), obtained by analysts in different laboratories, has been estimated to be 0.084 % absolute at 9 DF. The 95 % limit for the difference between two such averages is 0.24 % absolute.

NOTE 8—These precision estimates are based on an interlaboratory study of analyses performed in 1967 on three samples covering the range from 0.23 to 0.98 % sodium bicarbonate. One analyst in ten laboratories performed duplicate determinations and repeated 1 day later.⁴ Practice E180 was used in developing these precision estimates.

23.2 *Bias*—The bias of this test method has not been determined because of the lack of acceptable reference material.

<https://standards.iteh.ai/catalog/standards-astm-org/astm-e359-10/4b8-babf-772e0fbffd73/astm-e359-10> **LOSS ON HEATING**

24. Scope

24.1 This test method covers the gravimetric determination of loss on heating of soda ash.

25. Summary of Test Method

25.1 Loss on heating is determined gravimetrically by heating a weighed sample under controlled conditions to expel moisture and thermally convert sodium bicarbonate to sodium carbonate by elimination of water and carbon dioxide.

26. Apparatus

26.1 *Drying Oven*, gravity-convection, Type IB. See Specification E145.

26.2 *Weighing Bottle*, 70-mm diameter, low-form, glass, with cover.

27. Procedure

27.1 Dry the weighing bottle at 250°C minimum (270°C max) for 30 min. Cool in a desiccator and weigh to the nearest 0.1 mg.

27.2 Place 5 ± 0.1 g of the sample in the weighing bottle, cover and weigh to the nearest 0.1 mg. Determine the sample weight by difference.

27.3 Dry with the cover ajar for 4 h at 250°C minimum (270°C maximum). Cool in a desiccator with the cover ajar. Weigh to the nearest 0.1 mg with the cover closed.

28. Calculation

28.1 Calculate the percentage loss in weight as follows:

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where:

- A = weightmass of bottle and sample before heating, g,
- B = weightmass of bottle and sample after heating, g, and
- W = sample used, g.

29. Report

29.1 Report the percentage loss in weightmass to the nearest 0.01 %.

30. Precision and Bias

30.1 *Precision*—The following criteria should be used for judging the acceptability of results (Note 9):

30.1.1 *Repeatability (Single Analyst)*—The standard deviation for a single determination has been estimated to be 0.016 % absolute at 54 DF. The 95 % limit for the difference between two such runs is 0.04 % absolute.

30.1.2 *Laboratory Precision (Within-Laboratory, Between-Days Variability)*—The standard deviation of results (each the average of duplicates), obtained by the same analyst on different days, has been estimated to be 0.015 % absolute at 27 DF. The 95 % limit for the difference between two such averages is 0.04 % absolute.

30.1.3 *Reproducibility (Multilaboratory)* —The standard deviation of results (each the average of duplicates), obtained by analysts in different laboratories, has been estimated to be 0.030 % absolute at 8 DF. The 95 % limit for the difference between two such averages is 0.08 % absolute.

NOTE 9—These precision estimates are based on an interlaboratory study of analyses performed in 1967 on three samples covering the range from 0.35 to 0.55 % loss on heating. One analyst in each of ten laboratories performed duplicate determinations and repeated 1 day later.⁴ Practice E180 was used in developing these precision estimates.

30.2 *Bias*—The bias of this test method has not been determined because of the lack of acceptable reference material.

MOISTURE

31. Scope

31.1 This test method covers the calculation of moisture in soda ash.

32. Summary of Test Method

32.1 Moisture is determined by calculation. The percent of volatile products resulting from decomposition of sodium bicarbonate, 21.1, is subtracted from the percent loss on heating, 28.1, and the difference is reported as moisture.

NOTE 10—The test method makes the assumption that in commercial soda ash, nonvolatile matter other than moisture and products of sodium bicarbonate decomposition will not be evolved at 250 to 270°C. [ASTM E359-10](https://standards.iteh.ai/catalog/standards/sist/48a0f4dc-8df8-44b8-babf-772e0fbffd73/astm-e359-10)

33. Calculation

33.1 Calculate the percentage of moisture as follows:

$$\text{moisture, \% mass (m/m)} = A - (B \times 0.369)$$

where:

- A = loss on heating, % (see 28.1), and
- B = sodium bicarbonate, % (see 21.1).

34. Report

34.1 Report the percentage of moisture to the nearest 0.01 %.

35. Precision and Bias

35.1 *Precision*—The following criteria should be used for judging the acceptability of results (Note 11):

35.1.1 *Repeatability (Single Analyst)*—The standard deviation for a single determination has been estimated to be 0.014 % absolute at 54 DF. The 95 % limit for the difference between two such runs is 0.04 % absolute.

35.1.2 *Laboratory Precision (Within-Laboratory, Between-Days Variability)*—The standard deviation of results (each the average of duplicates), obtained by the same analyst on different days, has been estimated to be 0.031 % absolute at 27 DF. The 95 % limit for the difference between two such averages is 0.09 % absolute.

35.1.3 *Reproducibility (Multilaboratory)* —The standard deviation of results (each the average of duplicates), obtained by analysts in different laboratories, has been estimated to be 0.044 % absolute at 8 DF. The 95 % limit for the difference between two such averages is 0.12 % absolute.

NOTE 11—These precision estimates are based on an interlaboratory study of analyses performed in 1967 on three samples covering the range from 0.18 to 0.34 % moisture in soda ash. One analyst in each of ten laboratories performed duplicate determinations and repeated 1 day later.⁴ Practice E180 was used in developing these precision estimates.