Designation: C 1226 – 93 (Reapproved 2006)

Standard Test Method for Soluble Chlorides in Asbestos[1]

This standard is issued under the fixed designation C 1226; 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 test method covers the leaching out of the soluble chlorides in asbestos and the volumetric determination of chloride ion in the leachate.

1.2 **Warning**—Breathing of asbestos dust is hazardous. Asbestos and asbestos products present demonstrated health risks for users and for those with whom they come into contact. In addition to other precautions, when working with asbestos-cement products, minimize the dust that results. For information on the safe use of chrysoltile asbestos, refer to "Safe Use of Chrysotile Asbestos: A Manual on Preventive and Control Measures."[2]

1.3 *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.* See 1.2 for a specific hazard warning.

2. Referenced Documents

2.1 *ASTM Standards:* [3]

D 1193 Specification for Reagent Water

D 2590 Test Method for Sampling Chrysotile Asbestos

D 2946 Terminology for Asbestos and Asbestos–Cement Products

D 3879 Test Method for Sampling Amphibole Asbestos

E 177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

2.2 *QAMA Standards:*

A-2-72 Definitions of Terms Relating to Asbestos[4]

G-5-74 Soluble Chlorides[4]

2.3 *ACS Standards:*

Specifications of the Committee on Analytical Reagents [5]

3. Terminology

3.1 Refer to Terminology D 2946 and QAMA Standard A-2-72.

4. Summary of Test Method

4.1 The asbestos is leached with water in a Soxhlet extractor for 3 h.

4.2 Dilute mercuric nitrate solution is added to an acidified specimen of leachate in the presence of mixed diphenylcarbazone bromphenol blue indicator. The end point of the titration is the formation of the blue-violet mercury diphenylcarbazone complex (see Note 5).

4.3 An alternative titration by means of an automatic titrator is presented in Annex A1.

4.4 An alternative simplified titration, suitable for non-referee internal quality control, is presented in Annex A2.

5. Significance and Use

5.1 This test method provides an evaluation of the water-soluble chlorides in asbestos. It is used to determine the suitability of asbestos for use in products, such as gaskets, that may be in contact with metals under hydrothermal conditions that foster chloride ion corrosion.

6. Interferences

6.1 Zinc, lead, nickel, ferrous, and chromous ions affect the solubility of the chloride ion and the end point color, but they do not reduce the accuracy of the titration when present in concentrations up to 100 ppm.

6.2 Copper is tolerable up to 50 ppm.

6.3 Titration in the presence of chromate ion requires an indicator with intensified background color, such as alphazurine, and prior reduction for concentrations above 100 ppm.

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[1] This test method is under the jurisdiction of ASTM Committee C17 on Fiber-Reinforced Cement Products and is the direct responsibility of Subcommittee C17.03 on Asbestos-Cement Sheet Products and Accessories.

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[2] Available from The Asbestos Institute, http://www.chrysotile.com/en/sr_use/manual.htm.

[3] 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.

[4] Published in the *Chrysotile Asbestos Test Manual*. Available from the Asbestos Institute, 1002 Sherbrooke St. W., Suite 1750, Montreal, QC, Canada H3A 3L6.

[5] *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.

6.4 Ferric ion above 10 ppm must be reduced before titration, and sulphite ion must be oxidized.

6.5 A part of any bromide and fluoride ion that is present will also be titrated with the chloride ion.

6.6 Quaternary ammonium salts also interfere, if present in significant concentrations (1 to 2 ppm).

6.7 Deep coloration of the leachate may also interfere.

7. Apparatus

7.1 *Microburet*, 1 or 5-cm^3 capacity, with 0.01-cm^3 graduation intervals (see Note 5).

7.2 *Soxhlet Extraction Apparatus*, including:

7.2.1 Flask, 500 cm^3, with a 24/40 glass joint, flask to tube.

7.2.2 *Extraction Tube*, with a 43-mm diameter by 123-mm length thimble, with a 55/50 glass joint, tube to condenser.

7.2.3 *Condenser*, with a 55/50 glass joint to tube.

7.2.4 *Porous Thimble Specimen Holders*.

7.3 *Desiccator*.

7.4 *Tweezers*.

7.5 Refer also to A1.1.

8. Reagents and Materials (see Note 5)

8.1 *Purity of Reagents*—Reagent grade chemicals shall be used in all tests. All reagents shall conform to the American Chemical Society specifications. Other grades may be used, provided it is first ascertained that the reagents are of sufficiently high purity to permit their use without decreasing the accuracy of the determination.

8.2 *Purity of Water*—Unless otherwise indicated, references to water shall be understood to mean reagent water as defined by Type III of Specification D 1193.

8.2.1 In addition, reagent water shall be free of chloride ion.

8.3 *Bromophenol Blue*, (3′, 3″, 5′, 5″ tetrabromophenolsulphonphthalein), powder.

8.4 *Diphenylcarbazone* ($C_6H_5NHNHCON: NC_6H_5 \cdot C_6H_5NHNHCONHNHC_6H_5$), crystalline.

8.5 *Ethanol* (CH_3CH_2OH (ethyl alcohol), 95 %.

8.6 *Hydrogen Peroxide (H_2O_2)*— 30 % solution.

8.7 *Hydroquinone ($C_6H_6O_2$)*—10 g/dm^3.

8.7.1 Dissolve 1 g of purified hydroquinone in water and dilute to 100 cm^3.

8.8 *Mercuric Nitrate Solution*—($Hg(NO_3)_2 \cdot H_2O$), 0.025 *N*.

8.8.1 Acidify 50 cm^3 of water with 0.5 cm^3 of nitric acid, HNO_3, sp gr 1.42.

8.8.2 Dissolve 4.2830 g of $Hg(NO_3)_2 \cdot H_2O$ in the acidified water.

8.8.3 Dilute to 1 dm^3.

8.8.4 Filter, if necessary.

8.8.5 Standardize against the standard NaCl solution, using the procedure in 12.13.

NOTE 1—The end point, while sharp, can be improved somewhat for certain types of leachates by adding to the titration specimen several drops of a 0.05-g/cm^3 solution of xylene cyanole FF or alphazurine blue-green dye (color index 714). These chemicals can be mixed with the indicator in the same proportions.

8.9 *Mercuric Nitrate Solution*—($Hg(NO_3)_2 \cdot H_2O$), 0.0141 *N*.

8.9.1 Acidify 25 cm^3 of water with 0.25 cm^3 of nitric acid, HNO_3 sp gr 1.42.

8.9.2 Weigh out 2.5200 g of $Hg(NO_3)_2 \cdot H_2O$.

8.9.3 Dissolve this $Hg(NO_3)_2 \cdot H_2O$ in the acidified water (8.8.1) and dilute to 1 dm^3.

8.9.4 Filter, if necessary.

8.9.5 Standardize against the standard NaCl solution, using the procedure in 12.13 (see Note 2).

8.10 *Mixed Indicator*.

8.10.1 Dissolve 0.5 g of crystalline diphenylcarbazone and 0.05 g of bromophenol blue powder in 75 cm^3 of ethanol 95 % (Note 2), and dilute to 100 cm^3 with the ethanol.

NOTE 2—Denatured alcohol is not suitable. Methanol or isopropanol may be used if the 95 % ethanol is not available.

8.10.2 Store the mixed indicator in a brown bottle and discard after six months (Note 3).

NOTE 3—The indicator solution generally deteriorates to the point that it yields no end point color after 12 to 18 months. Temperatures above 38°C (100°F) and exposure to bright light may shorten its useful life. A dry powder mixture of the two indicator ingredients is stable for much longer periods. Both the powder mixture (capsule form) and the liquid indicator are available commercially.

8.11 *Nitric Acid* (HNO_3), sp gr 1.42.

8.12 *Nitric Acid Solution* (HNO_3), (3 + 997).

8.12.1 Dissolve 3 cm^3 of HNO_3 sp gr 1.42 in water and dilute to 1 dm^3.

8.13 *pH Indicating Paper*, long-range type, covering a pH range from 1 to 11.

8.14 *Sodium Chloride Standard Solution* (NaCl) (0.025 *N*).

8.14.1 Dry 1.5 g of NaCl for 1 h at 600°C.

8.14.2 Cool in a desiccator.

8.14.3 Weigh out 1.4613 ± 0.0002 g of the dried NaCl.

8.14.4 Dissolve in water and dilute with water at 20°C to 1 dm^3 in a volumetric flask.

NOTE 4—Drying for 2 h at 105°C is adequate for practically all analytical requirements. If ultimate accuracy of standardization is desired, fuse the NaCl prior to cooling it in a desiccator.

8.15 *Sodium Hydroxide Solution* (NaOH), 2 g of NaOH per dm^3.

8.15.1 Dissolve 2 g of NaOH in water and dilute to 1 dm^3.

8.16 *Xylene Cyanole FF*—($OSO_2(NaOSO_2)(HO)C_6H_2C$ [$C_6H_3(CH_3)NHC_2H_5$], CAS)—No. 2650-17-1, or alphazurine blue green dye (color index 714).

8.17 See also A1.2 and A2.1.

9. Hazards

9.1 Most of the reagents in Section 8 are toxic and some are corrosive. Wear protective clothing, gloves, and goggles.

9.2 **Warning**—see 1.2.

10. Sampling, Test Specimens, and Test Units

10.1 *Sampling*:

10.1.1 Sample chrysotile asbestos in accordance with Test Method D 2590.

10.1.2 Sample amphibole asbestos in accordance with Test Method D 3879.

10.2 *Test Specimens*:

10.2.1 The 25-g test specimens shall be derived from the laboratory test sample. Wear gloves to prevent contact of the asbestos with sweat on the skin.

10.2.2 Quarter this sample down to approximately 0.5 kg (1 lb).

10.2.3 Divide the 0.5-kg (1-lb) sample into ten approximately equal portions.

10.2.4 Subdivide these portions into halves.

10.2.5 Combine a half of each of the ten portions and mix thoroughly.

10.2.6 Repeat the operation (10.2.4 and 10.2.5) until the sample mass is reduced to approximately 150 g.

10.2.7 On the smooth clean surface, spread the 150-g sample into a thin layer over an area of approximately 500 by 500 mm in such a manner that homogeneous pinches may be taken from all parts.

10.2.8 Use tweezers to extract twenty bundles of the longer fibers free from rock, grit, dust, or contaminants, each weighing about 2.5 g, and spread these into a thin layer.

10.2.9 Use tweezers to extract at least five bundles of the longer fiber from different areas of the thin layer, of such size that when combined and dried to constant mass at 110°C, the test specimen will have a mass of 25 ± 0.2 g.

11. Conditioning

11.1 Place each test specimen in a tared porcelain crucible and dry to constant mass at 110°C.

11.2 Cool in a desiccator.

11.3 Weigh each specimen and crucible to 0.0001 g. This mass minus the tare mass is the specimen mass, *S*.

12. Procedure

12.1 Place the conditioned specimen in the porous extraction thimble.

12.2 Place the thimble in the extraction tube.

12.3 Add 300 cm^3 of water to the extraction flask.

12.4 Assemble the Soxhlet extraction apparatus.

12.5 Heat the extraction flask to boiling, and continue boiling for 3 h.

12.6 Allow the extraction flask to cool.

12.7 Pour the leachate into a 500-cm^3 volumetric flask.

12.8 Rinse out the extraction flask and pour the rinsings into the volumetric flask.

12.9 Add water to bring the volume of leachate to the 500-cm^3 mark.

12.10 Mix thoroughly.

12.11 Take an aliquot portion from the 500 cm^3 of leachate of such volume that it will not contain more than 20 mg of chloride ion, diluting this aliquot with water to 50 cm^3, if necessary.

12.11.1 If the volume of the aliquot taken differs from 50 cm^3, measure and note this volume, V_3.

12.11.2 If the 500-cm^3 volume of leachate contains less than 2.5 mg of chloride ion, make the final titration as described in 12.12, with 0.0141 *N* $Hg(NO_3)_2$ solution, using a 1 or 5-cm^3 microburet (Note 5).

12.11.2.1 In this latter case, determine an indicator blank on 50 cm^3 of water, applying the same procedure followed for the test specimen.

12.11.2.2 If the specimen contains less than 0.1 ppm of chloride ion, concentrate this to an appropriate volume of 50 cm^3.

NOTE 5—An automatic titration apparatus may be used to advantage provided that a double junction reference electrode is used. For this alternative procedure, the microburet and reagents required for the end point indicator are not required.

12.12 Add 5 to 10 drops of mixed indicator, and shake or swirl the flask. If a blue-violet or red color develops, add HNO_3 (3 + 997) dropwise until the color changes to yellow.

12.12.1 Add 1 cm^3 excess acid.

12.12.2 If a yellow or orange color forms immediately on addition of the mixed indicator, add NaOH solution (2 g/dm^3) dropwise until the color changes to blue-violet.

12.12.2.1 Add NHO_3 (3 + 997) dropwise until the color changes to yellow.

12.12.2.2 Add 1 cm^3 excess acid (Note 6).

NOTE 6—The prescribed acidification provides a satisfactory pH range from 3.0 to 3.5. Acidified specimens on which electrometric pH measurements have been made shall not be used for chloride determinations because the use of the calomel reference electrode may introduce error due to chloride contamination. Instrumental pH measurements may be made on an aliquot of the specimen, the chloride content determined on the balance of the specimen being corrected accordingly.

12.13 Titrate the solution with 0.025 *N* $Hg(NO_3)_2$ until a blue-violet color, as viewed in transmitted light, persists throughout the solution (Note 7).

12.13.1 Record the volume of $Hg(NO_3)_2$ titrated.

12.14 If chromate ion is present in the absence of iron and in concentration less than 100 ppm, use the alphazurine modified mixed indicator (Note 2) and acidify the specimen as described in 12.12 to 12.12.2.2, but to pH 3 as indicated by pH indicating paper.

12.14.1 Titrate the leachate as described in 12.13 and 12.13.1, but to an olive-purple end point.

NOTE 7—The use of indicator modifications and the presence of heavy metal ions can change solution colors without affecting accuracy of the determination. For example, solutions containing alphazurine may be bright blue when neutral, greyish purple when basic, blue-green when acidic, and blue-violet at the chloride end-point. When applying this test method to samples that contain colored ions or that require modified indicator, it is recommended that the operator familiarize himself with the specific color changes involved by experimenting with solutions prepared as standards for comparison of color effects.

12.15 If chromate ion is present in the absence of iron and in a concentration greater than 100 ppm add two cm^3 of fresh hydroquinone solution and proceed as described in 12.13.

12.16 If ferric ion is present in the absence or presence of chromate ion, use a sample of such volume as to contain no more than 2.5 mg of ferric ion or of ferric ion plus chromate ion. Add 2 cm^3 of fresh hydroquinone solution, and proceed as described in 12.11 to 12.13.

12.17 If sulphite ion is present, add 0.5 cm^3 of H_2O_2 to 50 cm^3 of the sample in the Erlenmeyer flask and mix for 1 min. Then proceed as described in 12.11 to 12.13.

12.18 For titration with an automatic titrator, refer to A1.3 and A1.4.

13. Calculation

13.1 Calculate the chloride ion concentration, in parts per million (ppm), in the original test specimen as follows:

$$\text{Chloride, ppm} = 35500\, N\, V_3(V_1 - V_2)/S\, V_4 \quad (1)$$

where:

V_1 = volume of standard $Hg(NO_3)_2$ solution consumed by the titration, cm^3,
V_2 = volume of standard $Hg(NO_3)_2$ solution consumed by the blank titration, cm^3,
V_3 = volume of aliquot in accordance with 12.11.1, cm^3,
V_4 = total volume of leachate, cm^3,
N = normality of the standard $Hg(NO_3)_2$ solution, and
S = mass of specimen, g.

14. Precision and Bias

14.1 *Precision*:

14.1.1 *Repeatability*:

14.1.1.1 The single-sample, multiple-operator intralaboratory repeatability, (2*S*) as defined in Practice E 177, is ±0.1 ppm or ±2 % of the chloride ion content, whichever is greater.

14.1.2 *Reproducibility*:

14.1.2.1 Based upon the QAMA Standard G-5-74, from which this test method was derived, the following statement on interlaboratory reproducibility is quoted directly: "The precision of this method is 0.1 ppm or two percent of the chloride ion content, whichever is greater. The accuracy is approximately equal to precision in the absence of interferences."

14.1.2.2 *Refer also to* Note 8.

NOTE 8—The repeatability obtained by this test method on concrete specimens has been reported[6] as follows for determinations on 69 specimens with an average chloride content of 0.0568 %: "An average absolute error of ±0.0008 % characterizes the accuracy level of the proposed test method. The precision, as expressed by the spread (difference between the minimum and maximum readings), for the 69 runs equals 0.013 % chloride. A better measure of the precision, the standard deviation *s* for the 69 runs amounts to 0.0026 % chloride. A stem-leaf plot and a histogram for the data show a nearly normal distribution of the measurements (a perfect normal distribution is expected only for an infinite number of measurements). According to the laws of statistics for normal distributions, virtually all (99.7 %) of the readings fall at the mean ±3*s*, or 0.0568 %± 3 × 0.0026, that is, between 0.0490 and 0.646 % chloride. All the individual data fall within these limits.

14.2 *Bias*:

14.2.1 Based upon multiple-sample, multiple-operator intralaboratory trials using asbestos samples spiked with known additions of chloride ion, zero bias was detected by this test method, in the absence of interferences.

15. Keywords

15.1 asbestos; chloride; chloride ion; soluble; soluble chloride ion; test

[6] Bishava, S. W., "Title No. 88-M32" *American Chemical Institute Materials Journal*, Vol 88, No. 3, May–June 1991, pp. 265–270.

ANNEXES

(Mandatory Information)

A1. ALTERNATIVE TITRATION USING AN AUTOMATIC TITRATOR

A1.1 *Apparatus:*

A1.1.1 *Double Junction Reference Electrode*.

A1.1.1.1 The inner unit shall be a single junction reference electrode containing an Ag/AgCl reference element in a glass body with a porous ceramic junction and a fill of 4 *M* KCl saturated with AgCl.

A1.1.1.2 The glass outer body shall be fitted with a porous ceramic sleeve and cracked-bead junctions. Alternatively, a rugged polymer body with a porous ceramic junction may be used.

A1.2 *Reagents and Materials:*

A1.2.1 *Potassium Chloride Solution* (KCl), 4 *M*, saturated with silver chloride, AgCl.

A1.2.2 *Potassium Nitrate Solution* (KNO_3), 1.0 *M*.

A1.2.2.1 Add 10.11 g KNO_3 into a 100-cm ^{3} volumetric flask and fill to the mark with water.

A1.2.3 *Silver Chloride* (AgCl), crystals.

A1.3 *Preparation of Apparatus:*

A1.3.1 The complete electrode unit comes assembled, but dry. The two bodies must be separately filled with the appropriate solutions.

A1.3.2 A snug-fitting O-ring seal in the cap assembly holds the bodies together. To separate them, grasp the lower section of the cap with one hand and, with the other hand, pull outward on the upper lip. Fill the inner body as follows:

A1.3.2.1 Prepare the filling solution bottle (4 *M* KCl, saturated with AgCl) by replacing the cap with the supplied dispenser spout. (**Warning—**Never use saturated KCl solution to fill the inner body.)

A1.3.2.2 With the dispensing spout inserted loosely into the fill hole, fill the inner body with the solution to a level of about 6 mm below the fill hole.

A1.3.2.3 With the dispensing spout inserted snugly into the fill hole, tilt the bottle back and squeeze it momentarily to apply air pressure within the inner body. This helps initiate electrolyte flow at the junction.

A1.3.2.4 Reassemble the two bodies, positioning the inner body fill hole 180° away from the outer body fill hole.

A1.3.3 Fill the outer body as follows:

A1.3.3.1 Prepare a filling solution bottle containing the outer body electrolyte (for example, 1.0 *M* KNO $_3$) by replacing the cap with a dispenser spout.

A1.3.3.2 With the dispensing spout inserted loosely into the fill hole, fill the outer body with the prepared electrolyte to a level of about 6 mm below the fill hole.

A1.3.3.3 Depending on junction type, initiate electrolyte flow as follows:

(a) Ceramic or Cracked-Bead Junction—With dispensing spout inserted snugly into the fill hole, tilt bottle back and squeeze it momentarily to apply air pressure within the outer body.

(b) Sleeve Junction—Loosen sleeve by turning, and then firmly seat the sleeve.

A1.4 *Procedure:*

A1.4.1 Mount the prepared electrode in a suitable holder, and insert the cable pin plug into the pH meter reference or automatic titrator jack. Observing the following guidelines will produce optimum results with the electrode.

A1.4.1.1 Maintain inner body electrolyte level so that the reference element is always covered. To prevent backflow, inner body electrolyte level should always be several millimetres higher than outer body electrolyte level.

A1.4.1.2 Maintain outer body electrolyte level several millimetres higher than sample solution level to prevent backflow.

A2. ALTERNATIVE TITRATION USING A SIMPLIFIED METHOD (FOR NON-REFEREE TESTING)

A2.1 *Reagents:*

A2.1.1 *Bromophenol Blue* (3′, 3″, 5′, 5″ tetrabromophenolsulphonphthalein), powder, as 0.2 % solution in ethanol.

A2.1.2 *Diphenylcarbazone* ($C_6H_5NHNHCON$: $NC_6H_5 \cdot C_6H_5NHNHCONHNHC_6H_5$), crystalline as 0.2 % solution in ethanol.

A2.1.3 *Mercuric Nitrate*—($Hg(NO_3)_2 \cdot H_2O_3$)—0.0400 *N* solution.

A2.1.3.1 Dissolve 3.4262 g of $Hg(NO_3)_2 \cdot H_2O$ in 500 cm^3 of 0.005 *N* HNO_3.

A2.1.3.2 To a 500-cm^3 conical flask, add the following:

(a) Add 10 cm^3 of the 0.0300 *N* NaCl.

(b) Add 90 cm^3 of water.

(c) Add 2.0 cm^3 of 0.1 *N* HNO_3.

(d) Add five drops of diphenylcarbazone solution.

A2.1.3.3 Titrate as described in A2.2.

A2.1.4 *Nitric Acid (HNO_3)*—0.05 *N* solution.

A2.1.5 *Nitric Acid (HNO_3)*—0.1 *N* solution.

A2.1.6 *Sodium Chloride (NaCl)*—0.0300 *N* solution.

A2.2 *Procedure:*

A2.2.1 To the 500 cm^3 of cooled leachate, add five drops of bromophenol blue.

A2.2.2 Acidify using 5 cm^3 of 0.1 *N* HNO^3.

A2.2.3 Carefully add 0.05 *N* HNO_3 until the yellow color of bromophenol blue appears.

A2.2.4 Add 10 cm^3 more of the 0.05 *N* HNO_3 to bring the pH to about 3.0.

A2.2.5 Add five drops of diphenylcarbazone solution.

A2.2.6 Titrate slowly against $Hg(NO_3)_2$, 0.0400 *N* solution at a rate of five to eight drops per minute. The endpoint is characterized by a color change from very faint yellow to the first appearance of pink; the latter should last more than 60 s.

A2.2.7 In cases where the soluble chloride concentration of the specimen is low, the possibility of not attaining the desired accuracy, because of the small volume of $Hg(NO_3)_2$ solution consumed by the titration, may be excluded by adding a precisely known aliquot (such as 2 cm^3) of the standard NaCl solution to the analyte prior to titration.

A2.2.8 Conduct a blank titration under identical conditions. The blank may be expected to consume 0.5 cm^3 of 0.04 *N* $Hg(NO_3)_2$ solution.

A2.3 *Calculation:*

A2.3.1 *Mass of Soluble Chloride*:

$$g = (N_1V_1 - N_2V_2)35.453/1000 \quad \text{(A2.1)}$$

where:

N_1 = normality of the $Hg(NO_3)_2$ solution,
V_1 = titer of the $Hg(NO_3)_2$ solution, cm^3,
N_2 = normality of the NaCl solution, and
V_2 = volume of NaCl solution added, cm^3.

A2.3.2 *Chloride Ion*:

$$\% = (N_1V_1 - N_2V_2)3.5453/W \quad \text{(A2.2)}$$

where:

W = mass of specimen, g.