



Designation: A630 – 16

# Standard Test Methods for Determination of Tin Coating Weights for Electrolytic Tin Plate<sup>1</sup>

This standard is issued under the fixed designation A630; 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.

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

## INTRODUCTION

Four test methods for determination of tin coating weights are described. These are typical methods and represent those most commonly used in the tin plate industry. Publication of these test methods is not intended to preclude the use of any other methods such as X-ray fluorescence measurement systems for control purposes by the consumer or supplier. However, in case of dispute, the referee method is to be used to determine conformance to Specification A624/A624M and Specification A626/A626M.

Sampling procedures for tin coating-weight testing and applicable standards for the specific class designation are outlined in Specification A624/A624M and Specification A626/A626M.

### 1. Scope

1.1 These test methods include four methods for the determination of tin coating weights for electrolytic tin plate as follows:

| Test Method   | Sections |
|---|----------|
| A—Bendix Test Method  | 3 to 9   |
| B—Constant-Current, Electrolytic Test Method (Referee Method) | 10 to 18 |
| C—Sellar's Test Method  | 19 to 28 |
| D—Titration Test Method                                       | 29 to 37 |

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

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.*

<sup>1</sup> These test methods are under the jurisdiction of ASTM Committee A01 on Steel, Stainless Steel and Related Alloys and are the direct responsibility of Subcommittee A01.20 on Tin Mill Products.

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### 2. Referenced Documents

#### 2.1 ASTM Standards:<sup>2</sup>

- A624/A624M Specification for Tin Mill Products, Electrolytic Tin Plate, Single Reduced
- A626/A626M Specification for Tin Mill Products, Electrolytic Tin Plate, Double Reduced
- D1125 Test Methods for Electrical Conductivity and Resistivity of Water

## METHOD A—DETERMINATION OF THE TIN COATING WEIGHTS BY THE BENDIX TEST METHOD

### 3. Scope

3.1 This test method covers the determination of tin coating weights on steel plate.

### 4. Summary of Test Method

4.1 The procedure involves dissolution of tin from a tin plate anode in a dilute hydrochloric acid solution containing a

<sup>2</sup> 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

measured excess of standard potassium iodate-potassium iodide solution. Excess iodine from the iodate-iodide solution is back titrated with standard sodium thiosulfate using a starch indicator.

## 5. Apparatus<sup>3</sup>

5.1 The detinning cell consists essentially of two cathodes of carbon rod, the sample that serves as an anode, and a beaker of dilute hydrochloric acid electrolyte. The carbon rods (6 by 0.25 in. or 152 by 6.35 mm, encased in porous porcelain thimbles) are suspended from a suitable frame about 1 in. (25 mm) apart. A small glass-enclosed magnet is attached to the frame in such a manner that it will hold the sample suspended midway between the two cathodes. A movable platform permits the beaker of electrolyte to be brought up around the assembly so that the sample will be completely immersed.

5.2 A source of direct current that can be regulated to supply up to 3 A at 3 to 5 V through the deplater is required.

5.3 Although regular laboratory glassware can be used, it is advisable to use automatic dispensing pipets or burets, a motor-driven stirrer for titrations, and a timing switch when large numbers of determinations are to be made.

5.4 *Precautions*—The apparatus must be kept in continuous operation to prevent iron in the solution adhering to the porous cells from oxidizing and subsequently liberating iodine from the potassium iodate-potassium iodide solution. If the instrument has been idle for some time, it is necessary to remove the ferric iron by running a disk of tinplate through the regular procedure before test samples are run.

## 6. Reagents

6.1 *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.<sup>4</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.

6.2 *Water*—Deionized or distilled water having a volume resistivity greater than 1 MΩ·cm at 25°C as determined by Nonreferee Method of Test Methods **D1125**.

6.3 *Hydrochloric Acid* (1.7 to 2.0 *N*)—Add 1 part of concentrated hydrochloric acid (HCl, sp gr 1.19, 36.5 to 38.0%) to 5 parts of water and mix well.

<sup>3</sup> Complete details and drawings of the apparatus are contained in U. S. Patent No. 2,455,726 entitled "Method for Electrolytic Stripping and Determination of Plating Metals." A suitable commercial supplier of the apparatus has been found to be the Wilkens-Anderson Company of Chicago.

<sup>4</sup> *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.

6.4 *Potassium Iodate-Potassium Iodide, Standard Solution* (0.0975 *N*)—Dissolve 3.48 g of KIO<sub>3</sub>, 21.74 g of KI, and 1.21 g of NaOH in 1 L of distilled water. Standardize as follows: Transfer 0.2700 g of National Bureau of Standards tin to a 500-mL Erlenmeyer flask. Add 200 mL of HCl (1+1). Connect the flask to a carbon dioxide (CO<sub>2</sub>) system and displace the air in the flask with CO<sub>2</sub>. While continuing the flow of CO<sub>2</sub>, heat the flask but do not boil violently. After the tin has dissolved add 0.5 g of antimony and 2 g of high-purity aluminum. Heat until the aluminum is completely dissolved and digest for an additional 10 min. Cool the flask to room temperature in running water while maintaining an atmosphere of CO<sub>2</sub>. Disconnect from the CO<sub>2</sub> system and titrate with the KIO<sub>3</sub>-KI solution using starch as an indicator. Calculate the tin titer, *T*, as follows:

$$T = A/B$$

where:

*A* = tin used (0.2700 g),

*B* = KIO<sub>3</sub>-KI solution used for titration, mL, and

*T* = tin titer for above KIO<sub>3</sub>-KI solution, (grams of tin/mL),

*T* = 17.28 = lb/base box (bb)/mL, for a 4-in.<sup>2</sup> (25.81-cm<sup>2</sup>) sample.

6.5 *Sodium Thiosulfate, Standard Solution (for coatings over 0.50 lb/bb)*—Dissolve 15.11 g of Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>·5 H<sub>2</sub>O and 1.11 g of NaOH in 1 litre of distilled water in a light-proof bottle. Allow this solution to age for 72 h, remix, and standardize as follows: Connect the bottle to the Bendix apparatus and titrate 20 mL of the standardized KIO<sub>3</sub>-KI solution with the thiosulfate solution using the same procedure as is used for making weight of coating determinations, but ignore the stripping unit. The tin equivalent of the Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> solution in pounds per base box is equal to: 20/*A* × *T* × 17.28, where *A* = millilitres of sodium thiosulfate solution used in titrating 20 mL of standard KIO<sub>3</sub>-KI solution. A chart can be prepared showing lb/bb/mL of thiosulfate.

6.6 *Sodium Thiosulfate, Standard Solution (for coatings 0.50 lb/bb and under)*—Dissolve 6.57 g of Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub>·5 H<sub>2</sub>O and 2.78 g of NaOH in 1 litre of distilled water in a light-proof bottle. Larger quantities in the same proportions may be prepared if desired. Allow that solution to age for 72 h, remix, and standardize by the same procedure used for the stronger Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> solution but use only 10 mL of potassium iodate-potassium iodide solution.

6.7 *Starch Solution*—Heat 200 mL of distilled water to boiling in a Florence flask and slowly add 2.5 g of soluble starch paste while the solution is agitated. Add the hot starch solution to 500 mL of distilled water containing 2.5 g of NaOH. Dilute to 1 L and thoroughly mix.

## 7. Test Sample

7.1 Tin plate samples for coating weight determinations are obtained by stamping disks 2.257 ± 0.001 in. (57.33 ± 0.02 mm) in diameter which is equivalent to 4 in.<sup>2</sup> (25.81 cm<sup>2</sup>) of area (8 in.<sup>2</sup> (52 cm<sup>2</sup>) of surface area). Recommended methods of obtaining representative samples are described in the Tin

Mill Products sections of the American Iron and Steel Institute's Steel Products Manual.<sup>5</sup>

## 8. Procedure

8.1 Make required electrical connections.

8.2 Add HCl (1+1) to the porous tubes containing the carbon cathodes.

8.3 Suspend the sample disk of tin plate from the magnetic holder.

NOTE 1—If it is desired to strip on one side only, mask the opposite side and reduce the current to half its normal value. If a heavy oxide film has developed on the tin plate during storage, the plate must be cathodically cleaned prior to testing.

8.4 Place a measured quantity of standardized KIO<sub>3</sub>-KI solution into a 400-mL beaker (see 8.10). Simultaneously add 250 mL of dilute HCl and mix thoroughly.

8.5 Raise the beaker so that the sample and porous cells are immersed.

8.6 Turn on d-c current and adjust to give 0.5 A/in.<sup>2</sup> of sample.

8.7 Time for complete removal of tin (see 8.10).

8.8 Remove the beaker and add approximately 5 mL of starch indicator solution.

8.9 Titrate with standardized Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> solution to the disappearance of the blue color.

8.10 The stripping times and amounts of KIO<sub>3</sub>-KI solution to use are as follows:

| Product          | Stripping Time, s | Amount of KIO <sub>3</sub> -KI Solution, mL |
|------------------|-------------------|---|
| Electrolytic 100 | 90                | 20  |
| Electrolytic 75  | 75                | 20  |
| Electrolytic 50  | 60                | 10  |
| Electrolytic 25  | 60                | 10  |
| Electrolytic 10  | 45                | 10  |

Stripping time should not be longer than is required to remove all of the tin. Results will be high by approximately 0.01 lb/bb for each minute of over-stripping.

## 9. Reproducibility of Results

9.1 Arbitrary maximum spreads in intermill check tests show the reproducibility of test results by the Bendix Method to be as follows: ±0.02 lb/bb for 0.25-lb coatings, ±0.03 lb/bb for 0.75-lb coatings, and ±0.04 lb/bb for 1.25-lb coatings. Data have not been developed for 0.10-lb coatings.

<sup>5</sup> Available from American Iron and Steel Institute (AISI), 1140 Connecticut Ave., NW, Suite 705, Washington, DC 20036, <http://www.steel.org>.

## METHOD B—DETERMINATION OF THE TIN COATING WEIGHTS BY THE CONSTANT CURRENT, ELECTROLYTIC METHOD (REFEREE METHOD)

### 10. Scope

10.1 This test method<sup>6</sup> may be used to determine not only the total tin coating weight but also to determine that part of the tin coating which is present as free tin and that part which is present in the alloyed form.

### 11. Summary of Test Method

11.1 In this test method, the tin is stripped from a sample of tin-plate anodically at constant current in an electrolyte of the hydrochloric acid. The potential difference developed between the sample and a reference electrode is plotted against time on a strip chart recorder or an electric digital readout. The time required for stripping the free tin and alloyed tin, respectively, are read from the resulting chart (see Fig. 1) or a digital readout. Since the stripping current has been preset, the free-tin and alloy-tin coating weights are calculated by employing Faraday's law of electrolysis.

### 12. Calibration and Standardization

12.1 Determine the weight loss of pure tin specimens electrolyzed for a given time interval, expressing the results as milligrams or pounds of tin per base box per second.

12.2 The test specimen should be a 4-in.<sup>2</sup> disk of pure tin approximately 0.20 in. (5.1 mm) thick.

12.3 The milliammeter should be frequently checked using a precision milliammeter.

### 13. Available Constant Current Procedures

13.1 There are two commercially available constant current, electrolytic units that are in common use. Either of the following, or equivalent equipment, can be used as an acceptable referee method:

13.1.1 *Willey & Kunze Coulometric Test Method*—Supplier will provide set up, start up and running procedures.<sup>7</sup>

13.1.2 *The Stannomatic Test Method*—Supplier will provide set up, start up and running procedures.<sup>8</sup>

### 14. Willey & Kunze Coulometric Test Method

14.1 In this test method, the tin is electrolytically removed from a 4 in.<sup>2</sup> (25.807 cm<sup>2</sup>) circular sample of tinplate anodically at constant current in an electrolyte of 1.0 N hydrochloric

<sup>6</sup> See Kunze, C. T., and Willey, A. R., "Electrolytic Determination of Tin and Tin-Iron Alloy Coating Weights on Tin Plate," *Journal, Electrochemical Society*, Vol 99, No. 9, September 1952, pp. 354-359; and "Methods for Determination of Coating Weights of Tin Plate," American Iron and Steel Institute, December 1959, pp. 19-26.

<sup>7</sup> Available from Coulometric Systems, Bergholtz, OH.

<sup>8</sup> Available from Products Distribution Service Division, Wilkens Anderson Co., 4525 West Division St., Chicago, IL 60651.

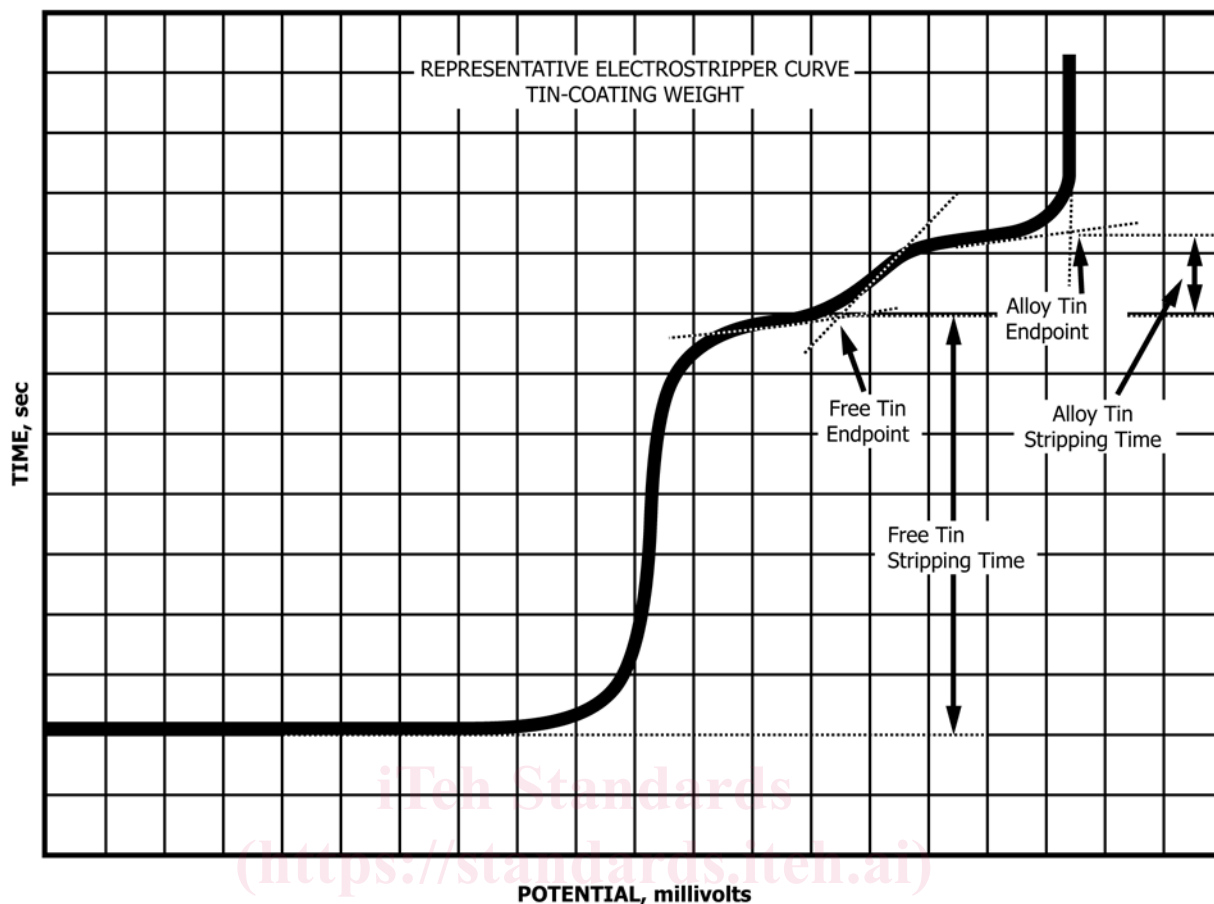


FIG. 1 Representative Electrostripper Curve

acid. The potential difference developed between the sample and a glass calomel reference electrode is plotted against time on a strip chart recorder. The time required for stripping the free tin and alloy tin, respectively are read from the resulting chart (see Fig. 1) or on an electronic digital readout. Since the stripping current is constant and preset, the free tin and alloy tin coating weights are calculated by employing Faraday's law of electrolysis.

14.2 Significance and Use:

14.2.1 The amount of tin coating is directly associated with the economics of producing tinplate and the performance of the container or part for which such plate is used. Therefore, the test method was developed for accuracy and as a control. The amount of tin combined in the alloy layer is also essential as the continuity and amount plays an important part in its functional properties. This test method is so designed that the tin coating is determined on only one side of the specimen at a time. This is useful when determining tin coatings on differential tinplate.

14.3 Apparatus:

14.3.1 This instrument (Model 8014) consists of an ammeter, volt meter, constant current source and strip recorder. A cell and sample holder are provided.

14.4 Reagents:

14.4.1 Electrolyte—1.0 N hydrochloric acid (HCl).

14.5 Sample Size:

14.5.1 Tinplate samples for coating weight determinations are obtained by stamping discs  $2.257 \pm 0.001$  in. ( $57.33 \pm 0.02$  mm) in diameter. This is equivalent to  $4 \text{ in.}^2$  ( $25.81 \text{ cm}^2$ ) of area of one side. Sampling procedures for tin coating weight testing and applicable standards for the specific class designation are outlined in Specifications, A624, A624M, A626, and A626M.

14.6 Interferences:

14.6.1 The distance of the cathode from the sample is important and should be  $0.75 \pm 0.25$  in. ( $1.90 \pm 0.64$  cm). Also, it is important that the cathode be approximately the same shape as the sample so that all parts of the anode are equidistant from the cathode.

15. The Stannomatic Test Method

15.1 Principle of Equipment Operation:

15.1.1 The free tin and the alloy tin covering the surface of the tin plate to be examined are dissolved electrolytically. The test size is exactly defined on both sides of the sample by two precision gaskets. The free tin and iron-tin alloy results are a function of the amount of current (Coulombs) used for stripping and are displayed on a numeric readout.

15.2 Apparatus: