



# Standard Test Method for Measurement of Impedance of Anodic Coatings on Aluminum<sup>1</sup>

This standard is issued under the fixed designation B 457; 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 describes the conditions and equipment for measuring the impedance of anodic coatings on aluminum. Such measurements have been used to evaluate the quality of seal of an anodic coating. The test method does not prescribe the procedure for producing the anodic coating, nor the postanodizing treatment usually described as “sealing.”

1.2 This test method is applicable to the rapid, nondestructive testing of anodic coatings. The interpretation of results and correlation of data with service experience and other tests are not within the scope of this test method.

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.*

## 2. Nature of Test

2.1 Impedance is an electrical characteristic described as the total opposition of all circuit elements to the flow of alternating current. Inductive effects of anodic coatings are negligible and the impedance is presumed to be made up of resistance and capacitive reactance according to the following relationships:

$$Z = \sqrt{R^2 + X_c^2} \quad (1)$$

and

$$X_c = 1/2 \pi f C \quad (2)$$

where:

- Z = impedance,
- R = resistance,
- X<sub>c</sub> = capacitive reactance,
- f = frequency, and
- C = capacitance.

2.2 Both resistance and capacitance are associated with a material constant and a geometric factor:

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee B08 on Metallic and Inorganic Coatings and is the direct responsibility of Subcommittee B08.07 on Chromate Conversion Coatings.

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$$R = r(l/A) \quad (3)$$

where:

- R = resistance,
- r = specific resistance,
- l = length of conductor, and
- A = area of cross section of conductor.

$$C = e(A/l) \quad (4)$$

where:

- C = capacitance,
- e = dielectric constant,
- A = area of opposing plates of capacitor, and
- l = distance between plates.

2.3 For measuring impedance of anodic coatings, the material constants are partly associated with the anodic coating and partly with the electrolyte employed in the test cell. For simplification these constants are assumed not to vary. The variations in measured impedance then depend directly on geometric factors.<sup>2</sup>

## 3. Apparatus

3.1 *Impedance Bridges*—Commercially available a-c impedance bridges with the following characteristics are satisfactory:<sup>3</sup>

3.1.1 *Range*—1 μF (1000 nF) to 0.0001 μF (0.1 nF) full scale with a dissipation factor of 0 to 2.

3.1.2 *Frequency*—1000 Hz.

3.1.3 *Accuracy*—1 %.

3.1.4 *Voltage*—Adjustable so as to be not greater than 0.5 V as applied to the test specimen.

<sup>2</sup> The Alcoa Impedance Test for Anodic Coatings (AZTAC) evaluates a 0.129-cm<sup>2</sup> (0.02-in.<sup>2</sup>) test area and expresses impedance in kilohms. Instructions are available from Alcoa Process Development Laboratories, P.O. Box 2970, Pittsburgh, PA 15230.

<sup>3</sup> The Z-Scope, formerly manufactured by Twin City Testing Corp., Tonawanda, NY was designed to measure the impedance of anodic coatings on aluminum. AZTAC values (the impedance of a 0.129-cm<sup>2</sup> (0.02-in.<sup>2</sup>) test area) can be read directly in kilohms with this instrument.

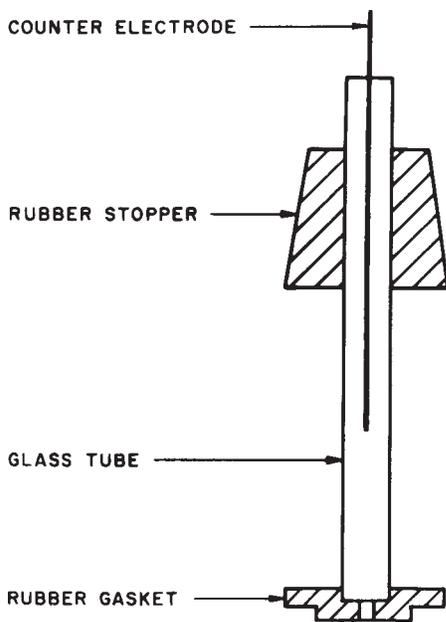


FIG. 1 Diagram of Test Cell Construction

3.2 Cell (Fig. 1) for containing the electrolyte during test. It may be constructed from the following components:<sup>4</sup>

3.2.1 Glass Tube, 9 mm (0.35 in.) in outside diameter by 9 cm (3.54 in.).

3.2.2 Rubber Gasket or Seal.<sup>5</sup>

3.2.3 Rubber Stopper—Any convenient size with a hole in center to accommodate the glass tube.

3.2.4 Platinum or Type 300 Stainless Steel Counter Electrode, 9 cm (3.54 in.) long by 0.75 to 1.0 mm (0.030 to 0.040 in.) diameter wire.

3.3 Wire Leads, two, insulated, approximately 1 m (40 in.) long complete with C-clamps or alligator clips shall be used for making connections to the test specimen and cell electrode.

3.4 Support Strand, complete with a utility clamp to hold the electrolytic test cell.

3.5 Glass or Stainless Steel Tank containing pure boiling water is required for conditioning the test specimen.

3.6 Container for Cell Standardization—A 150 to 500-mL Type 300 stainless steel beaker or standard 1-in.<sup>2</sup> test cell<sup>6</sup> may be used.

#### 4. Electrolyte

4.1 The electrolyte shall be a 3½ % solution of sodium chloride prepared by dissolving 36 g of the salt in 1 L of distilled or deionized water.

#### 5. Test Specimen

5.1 The area to be tested should be sufficiently large to accommodate the test cell, sufficiently flat to prevent leakage

of the solution from the probe, and free from mechanical defects such as scratches. After an anodic coating has been sealed, moisture is lost from the coating thus producing an increase in impedance. The rate at which moisture is lost increases as the relative humidity decreases; therefore, the relative humidity of the testing environment should be controlled and never below 25 %. Specimens should be tested within 1 h after the anodic coating has been sealed. If this cannot be done or if the part has been subjected to an elevated temperature drying treatment, the test area should be conditioned as follows:

5.1.1 Wipe the test area with acetone, methylethylketone, trichloroethylene, or similar solvent.

5.1.2 Immerse the test area in pure boiling water for 30 s.

5.1.3 Rinse in cold water.

5.1.4 Blot dry and test without further delay.

#### 6. Procedure

6.1 Penetrate the anodic coating in a small area with a sharp instrument and connect the lead from the low-impedance terminal of the bridge to the exposed aluminum substrate.

6.2 Connect the other lead from the bridge to the counter electrode of the test cell. Be certain the lead wires are not twisted around each other. Turn on the bridge and allow it to warm up.

6.3 Place the test cell on the area to be tested and apply enough pressure, 490 to 1230 MPa (71 to 178 psi) to prevent leakage of the electrolyte (the cell is spring-loaded to ensure sufficient and constant pressure). Make certain the bottom of the gasket on the test cell is level with the test surface.

6.4 Fill the test cell at least half full with electrolyte and commence a 2-min soak period. The counter electrode should not contact the test specimen.

6.5 Turn on and obtain a preliminary “balance” of the bridge in accordance with the manufacturer’s instructions (not necessary if a direct-reading instrument is used).

6.6 After the electrolyte has been in contact with the test surface for a period of 2 min, obtain a final balance of the bridge and record the dissipation factor ( $\tan \delta$ ). Next, record the capacitance (in nanofarads) as indicated by either the balancing series component ( $C_S$ ) or the balancing parallel component ( $C_P$ ).

6.7 Calculate the impedance,  $Z$ , in kilohms, as follows:<sup>7</sup>

$$Z = 159/C_s \cos \delta \quad (5)$$

$$C_s = C_p [1 + (\tan \delta)^2]$$

6.8 Different locations should be measured until at least two values are within 10 %. These are then averaged and multiplied by the correlation factor (See Section 7).

#### 7. Cell Standardization

7.1 Impedance is inversely proportional to the test area. The apparatus described herein tests an area of 0.129 cm<sup>2</sup> (0.02 in.<sup>2</sup>). Use of this relatively small test area facilitates the measurement of small parts and curved surfaces. It may be

<sup>4</sup> Another test cell satisfactory for use with this method is the one used with the Kocour Electronic Thickness Tester Model 995 available from Kocour Co., 4800 S. St. Louis Ave., Chicago, IL.

<sup>5</sup> Type A seal available from Kocour Co. or Twin City Testing Corp., 2440 Franklin Ave., St. Paul, MN, has been found satisfactory.

<sup>6</sup> Available from Twin City Testing Corp.

<sup>7</sup> Direct-reading instruments, such as the Z-Scope, are available, and the use of such equipment obviates mathematical computations (see 3.1).

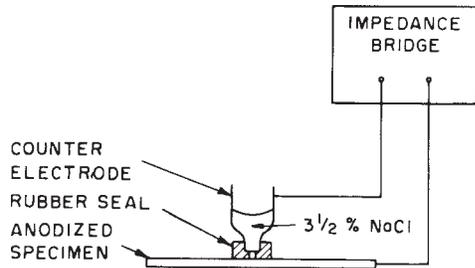


FIG. 2 Diagram of Test Set-Up

desirable to modify this apparatus so that larger areas can be measured. Because this area may vary owing to variations in cell gasket size and wear during use, the cell should be standardized daily.

7.2 Cell standardization is accomplished by measuring the impedance on a 6.45-cm<sup>2</sup> (1-in.<sup>2</sup>) surface and comparing this measurement with results obtained with the cell. The 6.45-cm<sup>2</sup> (1-in.<sup>2</sup>) test surface must be free from surface scratches. The required area may be obtained by appropriately masking a larger anodized specimen using wax or lacquer. Several applications of the masking material will ensure against uncoated areas, especially at edges. Standard 1-in.<sup>2</sup> test cells are available and may be used as an alternative way of arriving at a 1-in.<sup>2</sup> area. If this type cell is used beaker immersion is not required.

7.3 Immerse the specimen with the 6.45-cm<sup>2</sup> (1-in.<sup>2</sup>) area of exposed anodic coating in a stainless steel beaker containing the 3 1/2 % sodium chloride electrolyte. Connect one lead from the impedance bridge to the beaker, the other to an area of exposed aluminum on the test specimen.

7.4 Measure the impedance as outlined in Section 6, and record as A.

7.5 Using the test cell, make at least two impedance measurements and average on this same area of the specimen used for standardization. Record this as B. If the two measurements are not within 10 %, an additional measurement should be made and the two values within 10 % averaged.

7.6 Obtain the correction factor as follows:

$$\text{Correction factor} = 50A/B \quad (6)$$

## 8. Temperature Correction

8.1 Impedance decreases with increasing temperature. If measurements are made at widely varying temperatures, they should be adjusted to a constant, that is, 25°C (77°F).

Example:

$$Z_{77\text{ F}} = Z_T/[1 - 0.011(T - 77)] \quad (7)$$

where:

- $Z_T$  = impedance value recorded at ambient,
- $T$  = ambient temperature, °F, and
- $Z_{77\text{ F}}$  = corrected reading.

## 9. Interpretation of Results

9.1 The relationship between impedance value and quality of the anodic coating shall be as agreed by the manufacturer and the purchaser. A minimum acceptable value can be established for any anodic coating thickness being used. Generally, higher values should be obtained with thicker anodic coatings. However, an increase in coating thickness does not compensate for a poor seal. Low values will be obtained regardless of coating thickness when the quality of seal is poor.

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