Designation: B 490 – 92 (Reapproved 2003)

# Standard Practice for
# Micrometer Bend Test for Ductility of Electrodeposits[1]

This standard is issued under the fixed designation B 490; 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.*

## 1. Scope

1.1 This practice describes a procedure for measuring the ductility of electrodeposited foils.[2]

1.2 This practice is suitable only for the evaluation of electrodeposits having low ductility.

1.3 The obtained ductility values must only be considered semi-quantitative because this test has a significant operator dependence.

1.4 This practice is best used for in-house process control where measurements are always made by the same operator. A change in ductility value can be used as an indication of possible changes in the electroplating solution.

1.5 *This standard does not purport to address the safety problems, 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. Referenced Documents

2.1 *ASTM Standards:* [3]

B 177 Guide for Engineering Chromium Electroplating

## 3. Summary of Practice

3.1 This practice consists of measuring the bend of a foil held between the jaws of a micrometer; these are closed until fracture or cracks appear.

## 4. Significance and Use

4.1 This practice is useful as one method of controlling some electroplating solutions. It serves to indicate the presence of contamination or some other adverse condition.

4.2 Ductility measurements are of particular value when electroplated parts are to be subjected to moderate stress such as that involved in bolting an electroplated bumper to an automobile.

NOTE 1—The foils used in this practice are typically 25 to 40 µm thick. Foils in this thickness range do not have the same properties as bulk metal. For example, a nickel electrodeposit 0.5 mm thick, prepared in purified bright nickel electroplating solutions for which this test is being used, had less than 3 % elongation in a tension test, and could not be bent to a 90° angle without complete fracture. However, foils 25 to 40 µm thick, electroplated at the same time, had micrometer ductility values in the 10 to 25 % range.

## 5. Apparatus

5.1 *Micrometer*, 25-mm with flat jaws to measure the thickness and to compress the foil.

5.2 *Hand or Power Shear*, grinding wheel, or hack saw, to trim the edges of the electroplated panel and to separate the foil from the basis metal.

5.3 *Pair of Sharp Scissors* to cut the test specimens.

## 6. Test Specimens

6.1 An electrodeposit shall be prepared using a basis metal with a smooth surface from which the electrodeposit can be readily separated. A stainless steel or nickel electroplated steel panel may be used for this purpose, prepared as in 6.2.

6.2 A piece of cold-rolled steel, of any convenient size, such as 100 by 150 mm, shall be properly cleaned, acid dipped, and electroplated with approximately 7.5 µm of nickel. After rinsing, the specimen shall be cleaned anodically for 15 s in a hot alkaline cleaner, rinsed, acid dipped in about 1 *N* sulfuric acid (about 27 mL of concentrated sulfuric acid added to about 900 mL of cold water, mixed, and diluted with cold water to 1 L), and immediately placed in the electroplating solution of the metal to be tested. An electrodeposit 25 to 40 µm thick shall be electroplated on the prepared surface. The deposit shall be plated at an average current density and under conditions (agitation, temperature, etc.) approximating those used on parts plated in the solution being tested.

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[1] This practice is under the jurisdiction of ASTM Committee B08 on Metallic and Inorganic Coatings and is the direct responsibility of Subcommittee B08.10 on Test Methods.

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[2] For a discussion of this test see Mohrnheim, A. F., "The Bend Test for Measuring the Strain Limit of Surfaces," *Plating*, Vol 50, 1963, pp. 1094–1099.

[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.

6.3 The volume of the plating solution used to produce the test specimen shall be sufficient so that the concentration of the additives do not drop below 90 % of original additive concentration. Additions to the test solution shall not be made since they can alter the original composition.

NOTE 2—The ductility of nickel, with or without chromium, will vary depending upon plating conditions, contamination, and the additive system used. If electroplated with chromium, the foil may require heating or aging to overcome temporary hydrogen embrittlement. A procedure to overcome hydrogen embrittlement is covered in 8.2 of Guide B 177.

6.4 Proper preparation of the surface from which the foil must be separated undamaged is critical. Buffed nickel or buffed stainless steel, which may require anodic treatment, in a hot alkaline cleaner as defined in 6.2, can be used as the basis metal. Steel or nickel dipped in a chromating solution, such as used for chromating zinc, can be used as the basis metal. Copper or brass, masked on one side, can be used as the basis metal, and can be subsequently dissolved from the coating to be tested. Because the dissolving step can embrittle the test deposit, the test deposit must be aged as stipulated in Note 2.

6.5 Cut off the edges of the panel with a power or hand shear, or by any convenient method that permits ready separation of the foil from the basis metal.

6.6 Using a pair of sharp scissors, cut two or more test specimens, about 5 to 75 mm from the center of the foil.

## 7. Procedure

7.1 Measure the thickness of the test foil with the micrometer at the point of bending. Bend the test foil in the shape of a "U" with the side of the foil that was against the basis metal facing inward in the "U". Place the bent foil between the jaws of the micrometer so that as the jaws are closed, the bend remains between the jaws. Close the micrometer jaws slowly until the foil cracks (Note 3). Use an average of two or more foil tests. Record the micrometer reading as $2R$ and the thickness of the foil as determined by the micrometer as $T$.

7.2 At times, no single crack may develop over the convex surface. If jagged cracks or a series of shorter cracks develop (excluding edges), they signify failure. If no cracks develop, the maximum ductility values are obtained.

## 8. Calculation

8.1 Two standard formulas are used to compute ductility:

$$\text{Ductility, percent} = 100T/(2R-T) \tag{1}$$

Maximum value is 100 %. (1)

$$\text{Ductility, ratio} = T/2R \tag{2}$$

Maximum value is 0.5. (2)

8.1.1 Either formula can be used but they give different values for the same ductility. It is important that the formula be consistently used for purpose of comparison. When reporting ductility values, the formula must be indicated.

8.2 It should be understood that this value bears no simple relation to the percentage elongation obtained through tension or other tests. The ductility of this type of low-ductility electrodeposit varies with the thickness. Usually the greater the thickness, the lower is the percentage ductility for these foils. (Note 2).

NOTE 3—With foils of a ductility of 70 % or greater using formula $100T/(2R - T)$ or 0.4, using formula $T/2R$ (see 8.1). It is helpful to examine the foil at low magnification (10×) while it is still in the micrometer.