Introduction

Coatings are tested to confirm compliance with specifications, to monitor the operation of a coating process, and to evaluate coatings for various services. The ability of a coating to perform as intended usually depends on several characteristics, and the testing of a coating usually involves several different tests. At first glance the nature of a characteristic that is being tested may seem clear and the results of a test may seem to be unambiguous, however, the nature of a characteristic may be more complex than realized and the ability of a test to measure the characteristic may be less than expected. The Members of ASTM Committee B-8 on Metallic and Inorganic Coatings felt it was desirable to organize a symposium on the testing of metallic and inorganic coatings so as to bring these problems to the attention of practitioners. This publication is based on the symposium, which was presented in Chicago on April 14 and 15, 1986.

Committee B-8's scope encompasses metallic and inorganic coatings of all types applied to products. The committee was organized in 1941 with the title Committee on Electrodeposited Coatings, and its early work was in this field. Over the years, its scope has expanded because many of the members have become interested in coatings in general, not just those produced by electroplating. For these historical reasons, electroplated coatings are still a major activity of the committee, but there is significant activity in other areas such as anodic coatings, chemical conversion coatings, mechanically applied metallic coatings, coatings applied by vacuum processes, porcelain enamel and ceramic coatings, coatings produced by thermal spray, and coatings produced by chemical vapor deposition.

Committee B-8 has issued over 120 specifications, test methods, guides, practices, and definitions, which are published in Vol. 02.05 of the *Annual Book of ASTM Standards*. The importance that the committee attaches to the testing of coatings is indicated by the fact that nearly half of the 120 documents are test methods. The testing of coatings presents special problems because coatings are thin and usually adherently bonded to relatively massive objects made of some other material. It is seldom practical or even possible to separate the coating from the coated product to allow it to be tested directly. In some cases, even if a coating can be removed, it is brittle or has internal stresses that prevent the fabrication of a suitable test specimen, and when the coating can be isolated and formed into a test specimen,

its thinness often so influences the test that the results are of questionable value. Certain kinds of coatings, produced in special ways and in greater than typical thickness, can be separated from their substrates and subjected to tests. This approach is used to measure mechanical properties, usually ductility and tensile strength. There is a lack of consensus on the methods of performing these tests, as is illustrated by the first six papers of this publication in which four different approaches are described.

Partly for the reasons discussed in the preceding paragraph, coatings are almost always tested in situ—on the product to which it is applied. There are other reasons for this. For one, the performance of a coating in service can be a function of both the properties of the coating and of the substrate to which it is applied, for example, corrosion resistance. In other instances, use is made of the properties of both the substrate and the coating, as in many thickness tests where a characteristic that is influenced by both, electrical conductivity for example, is measured and related to coating thickness.

Two kinds of tests are used in evaluating coatings, performance tests and the direct measurement of characteristics. Performance tests must be used with care, because the tests usually simulate, and only approximately, the service environment to which the coated product will be subjected. This problem is pointed out by Dean in the paper on corrosion testing. Corrosion resistant coatings generally are expected to have service lives measured in years. Obviously, performance in service cannot be used as an acceptance test of a coating. Resort is made to accelerated tests in which the coated product is exposed to highly corrosive artificial environments for hours or days. The results cannot be used to predict performance, and they cannot be used to rank different kinds of coatings because the tests and service environments are so different. The tests are useful in detecting defects in coatings that affect service life. Still, long-term tests of coated products and specimens are run to verify the expectations of service performance. Kain and Baker report on the performance of coatings that have been under test since 1951.

Even apparently straightforward direct measurement of a coating characteristic itself can mislead the unwary. Horner illustrates this with his report of the results of a round-robin program that studied the reproducibility of the microhardness test. He found such a wide variation in the measurements made at the participating laboratories that he questions the usefulness of specifying the hardness of a coating. In another context, Ogburn points out that even such an apparently simple concept as the thickness of a coating can have unexpected complexity.

Problems like these prompted Committee B-8 to organize the symposium. The primary purpose was for specialists to discuss various characteristics for which coatings are tested. They were asked to explain in detail in each case just what the characteristic is that is being tested, what its

significance is to the function of a coating, what actually is being measured, and what the ability is of the available tests to accurately measure the characteristic. These papers are by Di Bari (mechanical properties), Ogburn (thickness), Dean (corrosion), and Bhushan (friction and wear). Lacay and Sonino review the testing of anodic coatings on aluminum.

In addition to these overview papers, there are papers devoted to particular test methods and papers that illustrate the usefulness of certain tests by reporting applications of the tests to particular problems. Moreover, Mittal has provided a brief introduction and an extensive bibliography on the adhesion of coatings to their substrates and testing of the adhesion.

By presenting this symposium and publishing this STP, the members of ASTM Committee B-8 hope to promote the meaningful testing of metallic and inorganic coatings, to bring to the attention of practitioners the tests that are available, to encourage prudence in the use of tests and in the interpretation of their results, and to stimulate the refinement of present tests and the development of new tests.

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