Plastics engineers frequently are required to evaluate the physical and other characteristics of objects made from plastics. The purpose may be control of quality in production, acceptance testing against specifications, establishment of data for engineering and design, or other economically important activities.

Whatever the purpose, the question of the reliability of the evaluation cannot be avoided; and when the economic importance of the evaluation is great, the reliability of the evaluation must be in proportion to it. Neither the authority of the engineer nor the computations performed on his or her data can produce reliable predictions from unreliable data; there is no substitute for a valid testing method, which must be selected before evaluation begins.

Plastics, perhaps more than most other classes of materials, require specialized testing methods. The characteristics of the resins and compounds, and of the production processes used to manufacture the articles economically, interact to determine the final properties of fabricated articles. An engineer who tests an object made from plastic tests not only its material, but also the way the object was made. There are inherent variations in the articles, from lot to lot, and within each lot, and also from place to place within each individual article. This place-to-place variation establishes the rule that the characteristics of each article made from a plastic are governed not only by the material of which it is made, but also by its shape and dimensions, that is, its design. These variations are rooted in the nature of the production process itself.

The very word "plastic," implying the ability to be shaped, suggests the economic basis of the processes of fabrication. The manufacture of articles from plastics must be a repetitive process of maximum rapidity, involving rapid changes in temperature and in pressure, and hence necessarily abrupt transitions between fluid (or plastic) and solid conditions. The quality of the finished product is notably sensitive to any irregularity in temperature, pressure, or time in the production cycle. Hence, the uniformity of performance of a finished product, from lot to lot, and even within a lot, depends not only upon the uniformity of the plastic used but also very considerably upon the uniformity of the operation of manufacturing the article, that is, upon precision of control of all factors in the operation.

To establish the degree of uniformity that can be expected, or to determine the reproducibility of a method of test, it may be necessary to test all, or a large percentage, of the articles in a lot.

But, particularly because many performance tests are destructive, considerations of cost usually restrict testing, for control purposes, to a very small number of samples from a lot. In this connection, it must be emphasized that the results of testing only a few samples from a lot
can be reliable only when the lot as a whole has been manufactured under constant conditions—uninterrupted production, with effective instrument control over all variables.

Performance tests, realistically pertinent to the conditions and hazards of service of the article, may become a very potent tool for:

1. Choosing the kind, and specific grade, of plastic for the job, or an acceptable alternative material.
2. Establishing, at the start, the proper operating conditions for production (preferably at the time when samples are made for approval).
3. Proving the soundness of design of the product.
4. Checking the uniformity of the material, and of the article as made.
5. Checking the effects of subsequent changes in tooling or machinery or operating conditions (e.g., enlarging of gates; change to a larger machine; change in any factor in the cycle of manufacture).

There is a great deal of useful literature on test methods for measuring the physical and other characteristics of the various plastics as materials. Almost without exception, these methods utilize specimens of standard dimensions and shapes, prepared specifically for the purpose. The resulting data are valuable in identifying and determining the uniformity of the materials themselves, but usually the published standard data derived from such test specimens are not reliably and directly applicable to design calculations.

Hence it is difficult to predict from such standard test data the performance of a specific article, made from a specific plastic, when it is subjected to the stresses and exposures that it is expected to withstand in service.

Few commercial articles will resemble, even remotely, in shape or dimensions, the standard test specimens. And even when it is feasible to cut specimens of standard dimensions from the larger object that is to be evaluated, the results of tests on such specimens rarely resemble those obtained on standard molded specimens; nor can such results be relied upon to indicate precisely the probable performance of the whole object itself.

The plastics engineer, then—recognizing the difficulty of evaluating with reliability the probable performance of the article, on the basis of either the standard test data on the material or tests of standard-sized specimens cut from the article itself—must arrive at a method of test that is adaptable to the specific case at hand, and may have to design one. Prime consideration must be given to the relevance of the test to service conditions of the article. Ideally, the result of the performance test should correlate perfectly with the actual performance of the article in service.

The literature on methods of testing objects of nonstandard shapes and dimensions is not—nor, by definition, can it ever be—anything like the orderly and compact, yet comprehensive, set of guides covering the testing of plastics simply as materials. Not only are there as many or more properties to be measured, but there is an infinity of possible different shapes and, for each possible shape, a wide range of possible dimensions. Given the nature of the material used, and the process by which the article is made, each article is likely to have its own unique set of characteristics. Hence, in the testing of articles made from plastics there can be no complete codification of methods, apparatus, or acceptable levels of performance.

This chapter represents an attempt to describe tests and equipment, in several categories, that have been effectively used for testing specific articles, and for measuring certain important characteristics of plastics in the form of finished articles. Although the methods outlined may not meet the requirements of any given case, it is suggested that the general principles set forth herein be used in devising variations or new methods that will be suited to the particular article to be tested.

**PERFORMANCE TESTING***

One test may measure a single property or several properties at once. In every case the test

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