

Recommendations for

The presentation of plastics design data —

Part 1: Mechanical Properties —

Section 1.2 Impact behaviour

IMPORTANT NOTE. Before reading this Section it is **essential** to read the General Introduction to this series of recommendations, issued separately.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 15 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Amendments issued since publication

Amd. No.	Date	Comments

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Introduction

Choosing a plastics material for a particular application involves the consideration of a number of properties. Of these the ability of the end product to resist the inevitable knocks and drops it will experience in use is generally of great importance.

The prime aim of impact data on plastics materials is to give a reliable guide to this practical performance. Impact behaviour depends however on product design, method of manufacture and conditions of use, in addition to the basic properties of the material; it is therefore not surprising that a single impact test figure for each material is insufficient for satisfactory comparisons to be made.

Because of the many interacting variables, it has not yet been possible to develop formulae for use in the rational design of plastics products with regard to impact behaviour. That is to say, the impact performance of a plastics article cannot yet be calculated from a result obtained on a specimen of the material having given dimensions, processed in a given way, and tested under some standard impact test conditions.

It is however possible to list the main factors controlling impact performance, and to investigate these by the careful selection of a range of test specimens and test conditions in a particular type of impact test. The uniform presentation of such multi-point data greatly improves the comparison of materials and assists their logical selection for specific applications and designs. Such data also highlight the points that need to be considered to ensure optimum impact performance from the point of view of manufacture and service conditions.

Since the quantitative prediction of the impact performance of a plastics article is still not possible, even on the basis of such multi-point data, drop impact tests to simulate service conditions more closely are frequently used. Such tests often highlight the weak points in a design; they may also serve as control tests for maintaining quality on production. Reliable comparisons require care in the method of testing and in the presentation and interpretation of results.

For the reasons stated above, this Section describes two experimental approaches. Subsection 1.2.1 deals with the general modes of impact failure observed with plastics materials and the main factors that lead to changes from one mode of failure to another. A test programme is then described which provides multi-point data for comparing in detail the overall impact behaviour of different materials or grades of material. Such data provide the basis for initial selection of a suitable material. They also give information about processing conditions and design features, which must be considered in order to ensure the optimum impact performance of the plastics article.

Subsection 1.2.2 is concerned with the procedures for the presentation and interpretation of results from drop impact tests, and gives the essential requirements for obtaining reliable results from such tests.

It is believed that by considering, on the one hand, the use of multi-point data for initial material selection and, on the other hand, drop impact tests on specific finished products, a truer perspective will be obtained of these two aspects of impact testing applied to engineering design.

1.2.1 Basic properties and presentation of multi-point data for material selection

1 General

Because many factors affect the impact behaviour of a plastics article in service, multi-point data are essential for comparing and selecting plastics materials. If such multi-point data are to be used and interpreted correctly, it is essential that they have a sound basis which is clearly understood.

Hence it is considered necessary at the outset to discuss in some detail the general modes of failure exhibited by plastics under impact conditions. The importance of the transition from tough to brittle behaviour has also been clearly emphasised. This is because this change from tough to brittle behaviour and the factors which can promote brittleness are considered the basic elements that need highlighting in any presentation of multi-point impact data. Thus the test procedures described and the recommendations made on the presentation of data have been chosen with these points in mind.

It is realised that even upon the basis of such multi-point data it is not yet possible to predict quantitatively the impact strength of a plastics article in service. With specific components confirmatory tests that more closely simulate service conditions may still be necessary. It is for this reason that drop impact tests are considered in Subsection 1.2.2.

However, the provision of multi-point data in the form recommended should considerably improve the comparison of materials and greatly assist their logical selection for specific applications. It also serves to highlight the processing and design factors that must be considered if optimum impact performance is to be achieved in service.

Hence, this uniform presentation of multi-point data is considered the main requirement for initial material selection and the general comparison of plastics materials.

2 The importance of the mode of failure in impact behaviour

2.1 The simplest classification of the mode of failure, observed under impact conditions with plastics, would result in a division into two broad types: those that are typically brittle and those that are typically ductile. If during any destructive impact a load-deformation curve were obtained, these two types of failure would be typified by the curves given in Figure 1. With brittle type failure a crack initiates and propagates prior to any bulk yielding of the specimen and hence the point of failure lies on the initial rising portion of the load-deformation curve. In the case of ductile failure, at least in the region of failure, considerable yielding takes place and the failure occurs well after the maximum on the load-deformation curve. As the area under the curve is a measure of the fracture energy it can be seen that brittle failures are associated with very low absorbed energies compared with ductile failures. In practice intermediate type failures often occur. In such instances limited amounts of yielding occur in the region of failure prior to or during the propagation of a crack. The failure point will thus lie adjacent to, but after, the maximum on the load-deformation curve. The energy to failure will thus be variable and intermediate between that of typically brittle and typically ductile failures. These three failure types are illustrated in Figure 1.

2.2 The appearance of the fractured surfaces can often be correlated with the type of failure.

The fractured surface of specimens giving brittle failure may be smooth and glassy or somewhat splintered and irregular.

In specimens giving ductile failure, deformation and yielding occur to an appreciable depth over the whole fracture surface, often accompanied by stress whitening. The texture of the surface may range from fairly smooth to rough, depending on the structure of the material.

In specimens giving intermediate failures, there may be a transition from the first type of fracture surface to the second as the crack progresses across the specimen.

2.3 In practice many complaints arise regarding unsatisfactory impact performance because of the sporadic brittle failure of components produced from a material which normally exhibits ductile behaviour. In such applications, satisfactory performance necessitates the avoidance of areas of brittle behaviour and the most satisfactory material is that which behaves in a ductile manner over the widest range of conditions whilst still satisfying the associated rigidity and other requirements.

In other instances other properties may be of prime importance (e.g. clarity or rigidity) and materials will be deliberately used in their brittle region. Here the actual energy to break in brittle failure of the material will be of importance.

In the context of resistance to impact, ductile behaviour in itself is considered to be a criterion of satisfactory performance and hence the actual magnitude of the energy to break in ductile failure is of limited significance. Within the ductile range it is likely that other properties such as rigidity and ease of processing will be of more relevance in governing the choice of materials.

The ductile-brittle transition temperature and the factors that can cause significant shifts in this transition are important criteria in comparing the impact behaviour of materials.