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Paper and board — Determination of fracture toughness — Constant rate of elongation method (1,7 mm/s)

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National foreword

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Paper and board — Determination of fracture toughness — Constant rate of elongation method (1,7 mm/s)

Papier et carton — Détermination de la résistance à la rupture — Méthode à gradient d'allongement constant (1,7 mm/s)

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Foreword

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The committee responsible for this document is ISO/TC 6, *Paper, board and pulps*, Subcommittee SC 2, *Test methods and quality specifications for paper and board*.

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Introduction

The essence of fracture mechanics theory is that the material parameter fracture toughness is determined by controlled laboratory testing before it is used to predict the fracture properties of structures or structural components containing defects. This Technical Specification describes a laboratory test method for determination of the fracture toughness of paper materials and a numerical method to predict the fracture strength and fracture strain of notched paper webs for a given reference paper web geometry called ISO paper web geometry. The specified methods are based on nonlinear fracture mechanics theory (J-integral theory).[1] [2] [3]

The experimental procedure for determining the fracture toughness of this Technical Specification consists of two material tests: tensile testing and fracture toughness testing. Both these tests are performed following ISO 1924-3, with the exception that 50 mm wide test pieces containing 20 mm-wide centre notches are used in the fracture toughness test.

For material ranking and material development purposes, it is advantageous to define a notched reference geometry for predictions of fracture strength (stress at break) and fracture strain (strain at break). Such notched reference geometry makes it easier to compare fracture properties of different paper materials and to communicate results in reports and articles. The main application of fracture mechanics to paper materials is related to breaks in continuous web handling operations, such as in manufacture, winding, and printing. The characteristic dimensions of paper webs in such operations generally are in the order of metres, while defects in the paper webs commonly have a characteristic size in the order of millimetres. Furthermore, the most severe defects from a web break perspective are located in the region of the edges of the paper web. In this Technical Specification, a 2 m long and 1 m wide paper web, containing a 10 mm edge notch, is used as the notched ISO paper web geometry for predicting and ranking of the fracture properties of paper materials. The terms ISO fracture strength and ISO fracture strain are used to indicate that the fracture properties are determined for this particular notched ISO paper web geometry following this Technical Specification. A successful experimental validation of the procedure for determining the fracture properties for the assigned ISO web geometry has been performed.[1] [2] [3]

NOTE 1 The determined fracture toughness may also be utilized to predict fracture properties of paper webs and paper products that have different dimensions and shapes than the introduced ISO paper web geometry. The procedure for such predictions is given in References [1], [2], and [3].

NOTE 2 The fracture toughness alone does not constitute sufficient information to determine the fracture behaviour of structures or structural components. Consider the stress/strain curves for two materials, A and B, obtained by tensile testing of notched test pieces (see Figure 1). The exemplified materials have *equal fracture toughness* but *different fracture strengths and fracture strains*. Materials A and B, which have different stress/strain behaviours, could for instance originate from machine direction (MD) and cross-machine direction (CD) of a particular paper grade or could be two papers of different origin. Clearly, materials A and B are expected to behave very differently in converting operations, although they have equal fracture toughness. This example illustrates that the fracture toughness cannot be used to rank the fracture properties of papers that show different stress/strain behaviour. However, the ISO fracture strength and ISO fracture strain, according to this Technical Specification, can be used to accurately rank the fracture properties of materials A and B.

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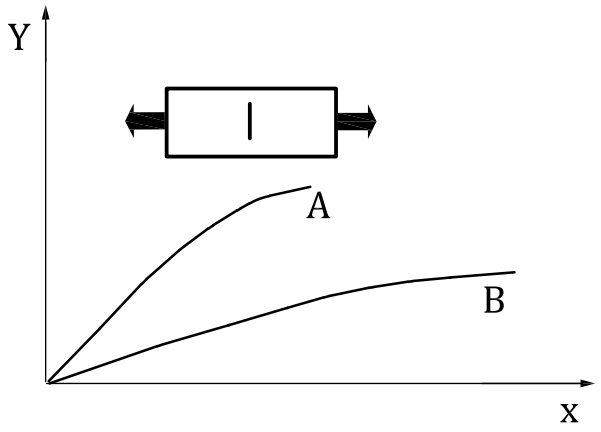

Figure 1 — Stress/strain curves for two materials, A and B, obtained by tensile testing of notched test pieces

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Paper and board — Determination of fracture toughness — Constant rate of elongation method (1,7 mm/s)

1 Scope

This Technical Specification describes a method for determining the fracture toughness of paper and board using a tensile testing machine operated with a constant rate of elongation. This Technical Specification also describes the determination of the fracture strength and fracture strain of a notched paper web with an assigned standard web geometry. This information is used to rank the fracture properties of paper materials.

This Technical Specification is applicable to all kinds of paper and paperboard, except for certain special grades, such as creped paper and other paper materials that significantly deviate from exhibiting monotonically decreasing tangential stiffness during tensile testing. This Technical Specification does not apply to corrugated fibreboard.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 186, *Paper and board — Sampling to determine average quality*

ISO 187, *Paper, board and pulps — Standard atmosphere for conditioning and testing and procedure for monitoring the atmosphere and conditioning of samples*

ISO 536, *Paper and board — Determination of grammage*

ISO 1924-3, *Paper and board — Determination of tensile properties — Part 3: Constant rate of elongation method (100 mm/min)*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1
tensile stiffness
E^b
maximum slope of the curve obtained when tensile force per unit width is plotted versus strain

[SOURCE: ISO 1924-3:2005, definition 3.8]

3.2
tensile strength
σ_T^b
maximum tensile force per unit width that paper and board will withstand before breaking under the conditions defined in this Technical Specification

[SOURCE: ISO 1924-3:2005, definition 3.1]

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