INTERNATIONAL STANDARD

ISO 21181

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2013-02-15

Light conveyor belts — Determination of the relaxed elastic modulus

Courroies transporteuses légères — Détermination du module d'élasticité relaxé

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

ISO 21181 was prepared by Technical Committee ISO/TC 41, *Pulleys and belts (including veebelts)*, Subcommittee SC 3, *Conveyor belts*.

This International Standard is based on EN 1723:1999, prepared by CEN/TC 188.

This second edition cancels and replaces the first edition (ISO 21181:2005), of which it constitutes a minor revision.

Introduction

Many applications for light conveyor belts require that the belt is initially tensioned and there is no subsequent change in belt length by adjustment of any rollers. In such cases, the tensioning force in the belt changes throughout the life of the belt because of two effects: permanent stretch and relaxation of the belt, both of which change its real elastic modulus. It is vital to have a means of establishing the way in which the tensioning forces change; and this test applies a cyclic stretching between two defined states of elongation over a large number of cycles. It has been found experimentally that the tensioning force drops in an exponential way. It is possible to measure the tensioning force and then to calculate what is defined in this International Standard as the “relaxed elastic modulus”. It is important to note that this is not a true elastic modulus, because it includes an element of permanent stretch; but, except in cases where the permanent stretch is relatively large, it is a measure of great practical value in determining final tensioning forces. This International Standard is designed to meet the requirements for such applications.

Light conveyor belts — Determination of the relaxed elastic modulus

1 Scope

This International Standard specifies a test method for the determination of the relaxed elastic modulus of light conveyor belts according to ISO 21183-1 or other conveyor belts where ISO 9856 is not applicable.

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 7500-1, *Metallic materials — Verification of static uniaxial testing machines — Part 1: Tension/compression testing machines — Verification and calibration of the force-measuring system*

ISO 9856, *Conveyor belts — Determination of elastic and permanent elongation and calculation of elastic modulus*

ISO 18573, *Conveyor belts — Test atmospheres and conditioning periods*

ISO 21183-1, *Light conveyor belts — Part 1: Principal characteristics and applications*

3 Terms and definitions

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

3.1
elastic modulus
<conveyor belt technology> force per unit of width of a conveyor belt

Note 1 to entry: It is expressed in newtons per millimetre width of belt and is represented in ISO 9856 by the symbol *M*.

Note 2 to entry: This definition of the term deviates from that normally used in engineering, which is expressed in units of stress, i.e. a force per unit of cross-section, and represented by the symbol *E* (see, for example, ISO 527-4).

3.2
elastic modulus
<light conveyor belt technology> force in newtons per unit of width required to extend a representative test piece of light conveyor belting by 1 % of its original length

Note 1 to entry: The force is represented by the symbol k and, consequently, the elastic modulus is represented by the symbol $k_{1\%}$. This value is also called the “tensile force for 1 % elongation per unit of width” or “$k_{1\%}$ value”. It is expressed in newtons per millimetre.

Note 2 to entry: In EN 10002-1:2001, the symbol k is used to represent the coefficient of proportionality.

3.3
relaxed elastic modulus
<light conveyor belt technology> elastic modulus of a light conveyor belt after being cycled between predetermined limits of extension for 500 cycles

Note 1 to entry: The $k_{1\%}$ value of a new conveyor belt is higher than that of a used conveyor belt in which relaxation has taken place in service. The relaxation takes place following an exponential function.

4 Symbols

For the purposes of this document, the following symbols apply.

F_A, F_B are the maximum and minimum tensile forces, respectively, in the test piece, in newtons;

F'_A, F'_B are the specific values of F_A, F_B referred to the width of the test piece, in newtons per millimetre;

a is the value, in newtons per millimetre, of $k_{1\%}$ for $z = 1$;

b is the manufactured width of conveyor belt, in millimetres;

r is the correlation coefficient;

x is the variable in equation of straight line;

y is the value of equation of straight line;

z is the number of cyclic elongations.

5 Principle

A test piece is exposed to a cyclic elongation between two defined limits and the tensile force recorded as a function of the number of cycles. From that graph, the relaxed elastic modulus is determined by calculation through a logarithmic regression.

6 Apparatus

6.1 Tensile testing machine, capable of applying a load suitable for the strength of the test piece and with a force measuring system in accordance with ISO 7500-1:2004, class of machine 3 or better (e.g. class of machine 2), and also capable of applying the load in displacement-controlled cycles of ±5 mm and with a frequency of 0,5 Hz (this frequency being realizable also with older, mechanically controlled dynamometers).

7 Test pieces

7.1 Shape, dimensions, number and selection

Cut from the full thickness of the conveyor belt in the longitudinal direction five rectangular test pieces each (50 ± 0,5) mm wide and having a length of 500 mm plus twice the length necessary for clamping in the jaws. Select the test pieces from the conveyor belt in accordance with Figure 1. The test piece shall not be tested sooner than five days after manufacture.

Dimensions in millimetres

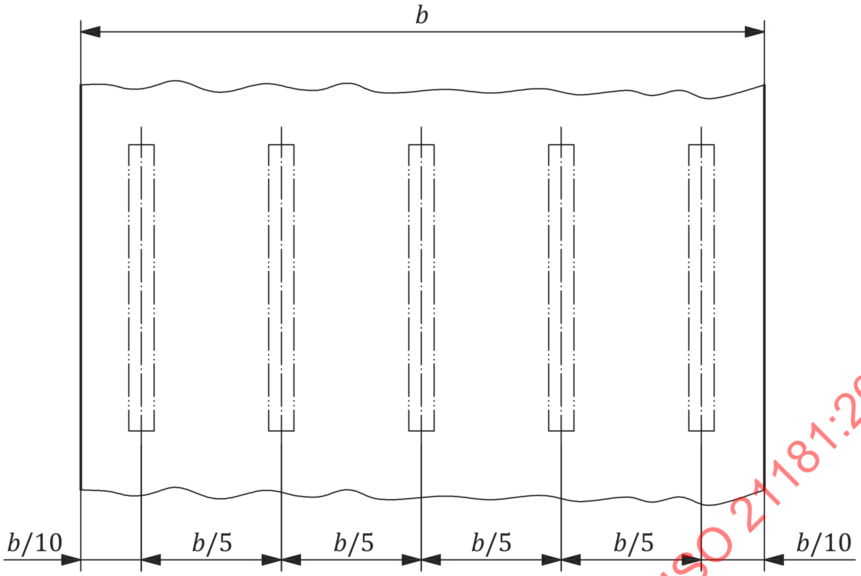


Figure 1 — Distribution of test piece selection

7.2 Conditioning

Before testing, condition the test pieces in accordance with ISO 18573, Atmosphere B, for 24 h, except that, if the light conveyor belt (as specified in ISO 21183-1) consists of materials with a high absorption of moisture, e.g. cotton or polyamide, condition the test piece for 48 h.

8 Procedure

Place the ends of the test piece between the jaws of the tensile testing machine (6.1) such that the test piece is straight without using force. Ensure that the free length between the jaws is 500 mm ± 1 mm and that there is no slippage of the test piece in the jaws during the test.

Slippage can be minimized by rubbing rosin on the portion of the test piece that will be in the jaws, removing any excess rosin and enclosing both sides of the rosin-coated test piece with coarse emery cloth. The emery cloth should be folded over the ends of the test piece with the coarse side of the cloth next to the rosin-coated surfaces.

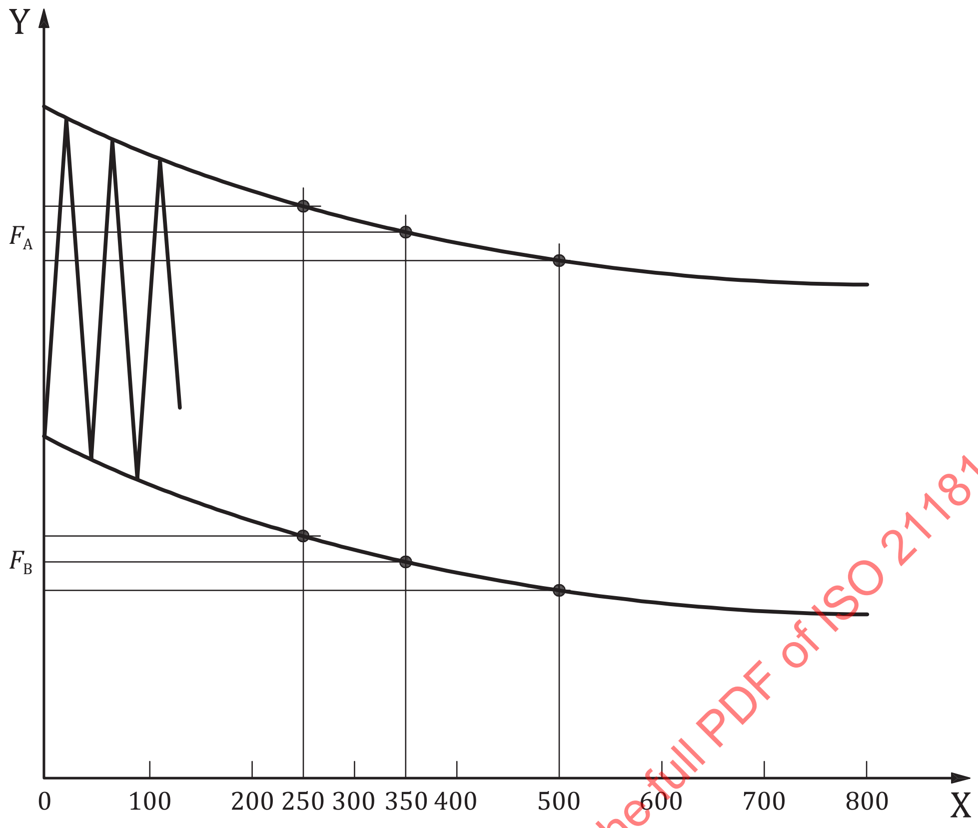
Elongate the test piece cyclically, either

a) between 1 % and 2 % (5 mm and 10 mm) at a frequency of 0,5 Hz, or

b) if the conveyor belt contains reinforcing elements with a high elastic modulus (e.g. with reinforcing elements of aramid threads), between 0,5 % and 1 % (2,5 mm and 5 mm) at the same frequency of 0,5 Hz.

NOTE For a), the same effect will be realized if the test piece is given an initial elongation of 1,5 %, corresponding to 7,5 mm, and a cyclic alteration of the elongation of ± 0,5 %, corresponding to ± 2,5 mm, is superposed at the same frequency. The average speed of deformation in the test piece will be 5 mm/s (= 300 mm/min).

Record the tensile force during 500 cyclic elongations as a function of the number of cycles. At the end of the test, measure the permanent elongation by reducing the tensioning force to zero and measuring the distance between the jaws. If this elongation is equal to or exceeds 1 % of the initial length, this indicates that the method is unsuitable for such a belt type; in which case, use the method according to ISO 9856 instead.



Key

X number of cycles, *z*

Y tensile force, *F*, N

Figure 2 — Tensile force as function of number of cyclic elongations

9 Calculation and expression of results

Read the forces F_A and F_B for the number of cyclic elongations $z = 250$, $z = 350$, and $z = 500$ from the graph shown in Figure 2.

Divide all of these forces by belt width (50 mm) to give the elastic moduli, as follows:

$$F'_A = \frac{F_A}{50} \text{ N/mm} \quad (1a)$$

$$F'_B = \frac{F_B}{50} \text{ N/mm} \tag{1b}$$

If a cyclic elongation between 1 % and 2 % has been applied, calculate the elastic modulus from the following formula:

$$k_{1\%} = \frac{F'_A + F'_B}{2 \times 1{,}5} \text{ N/mm} \tag{2}$$

If a cyclic elongation between 0,5 % and 1 % has been applied, calculate the elastic modulus from the following formula:

$$k_{1\%} = \frac{F'_A + F'_B}{2 \times 0{,}75} \text{ N/mm} \tag{3}$$

From the three calculated $k_{1\%}$ values and the corresponding number of cyclic elongations, determine the equation of a straight line of the form:

$$y = a + cx \tag{4}$$

and subsequently carry out a logarithmic regression.

For that, use a calculator which provides statistical functions. The x-values of the number couples to enter are the numbers of cyclic elongations given as natural logarithms (ln z). The y-values are the corresponding calculated $k_{1\%}$ values.

Therefore, Formula (4) becomes:

$$k_{1\%} = a + (c \times \ln z) \tag{5}$$

where

c is the slope of the straight line;

a is $k_{1\%}$ for $z = 1$.

Determine both values and the correlation coefficient, r, by calculator.

The correlation coefficient r of the straight line should be as high as possible. Ideally, it would be 1,0, although values between 0,8 and 1,0 are sufficiently high. If $r < 0{,}7$, the test should be repeated and the calculation carried out with larger numbers of cyclic elongations, z.

By means of the found values for a and c and with Formula (5), calculate the relaxed $k_{1\%}$ value by putting in a value for z of 43 200 cyclic elongations, corresponding to a testing time of 24 h at a frequency of 0,5 Hz (see Figure 3). (Numerically, ln 43 200 = 10,67.)

Calculate the individual relaxed $k_{1\%}$ values for all five test pieces and determine the arithmetic mean of the five values.