
**Belt drives — V-ribbed belts for the
automotive industry — Fatigue test**

*Transmissions par courroies — Courroies striées pour la construction
automobile — Essai de fatigue*

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had not received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 41, *Pulleys and belts (including veebelts)*, Subcommittee SC 1, *Friction*.

This third edition cancels and replaces the second edition (ISO 11749:2014), which has been technically revised.

The main changes are as follows:

- addition of [Table 1](#) with symbols;
- addition of the test condition with constant belt tensioning force in [8.1.2](#) and [8.2.1.3](#);
- change in pulley surface roughness R_a to $< 3,2 \mu\text{m}$;
- revision of test pulley dimensions ([Table 2](#)).

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Belt drives — V-ribbed belts for the automotive industry — Fatigue test

1 Scope

This document specifies a dynamic test method for the quality control of V-ribbed belts (PK profile) which are used predominantly for accessory drive applications in the automotive industry.

The dimensional characteristics of the belts and of corresponding pulleys are the subject of ISO 9981.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

No terms and definitions are listed in this document.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

4 Symbols

For the purpose of this document, the symbols given in Table 1 apply.

Table 1 — Symbols

Symbols	Designation	Unit
b_e	effective line differential	mm
d_B	checking ball or rod diameter	mm
d_e	effective diameter	mm
d_{e1}	effective diameter of driving and driven pulleys	mm
d_{e2}	effective diameter of idler pulley	mm
d_p	pitch diameter	mm
d_{r3}	outside diameter of reverse bending idler pulley	mm
e	groove pitch	mm
f	lateral distance	mm
F	belt tensioning force	N
g	additional slip	%
i_f	rotational frequency ratio at measurement of the additional slip	—
i_o	rotational frequency ratio at the initial	—
k	standard value to calculate belt tensioning force	N/kW
K	diameter over balls or rods	mm
M	torque load	Nm
^a Rotations per minute.		

Table 1 (continued)

Symbols	Designation	Unit
n	number of grooves	—
n_f	final rotational speed of the driven shaft	r/min ^a
n_o	initial rotational speed of the driven shaft	r/min ^a
N	driver speed	r/min ^a
N_f	final rotational speed of the driving shaft	r/min ^a
N_o	initial rotational speed of the driving shaft	r/min ^a
P_s	specified power	kW
r_b	radius at the groove root	mm
r_t	radius at the groove tip	mm
R_a	surface roughness	µm
$2x$	position of the ball or rod to groove tip	mm
α	groove angle	°
^a Rotations per minute.		

5 Principle

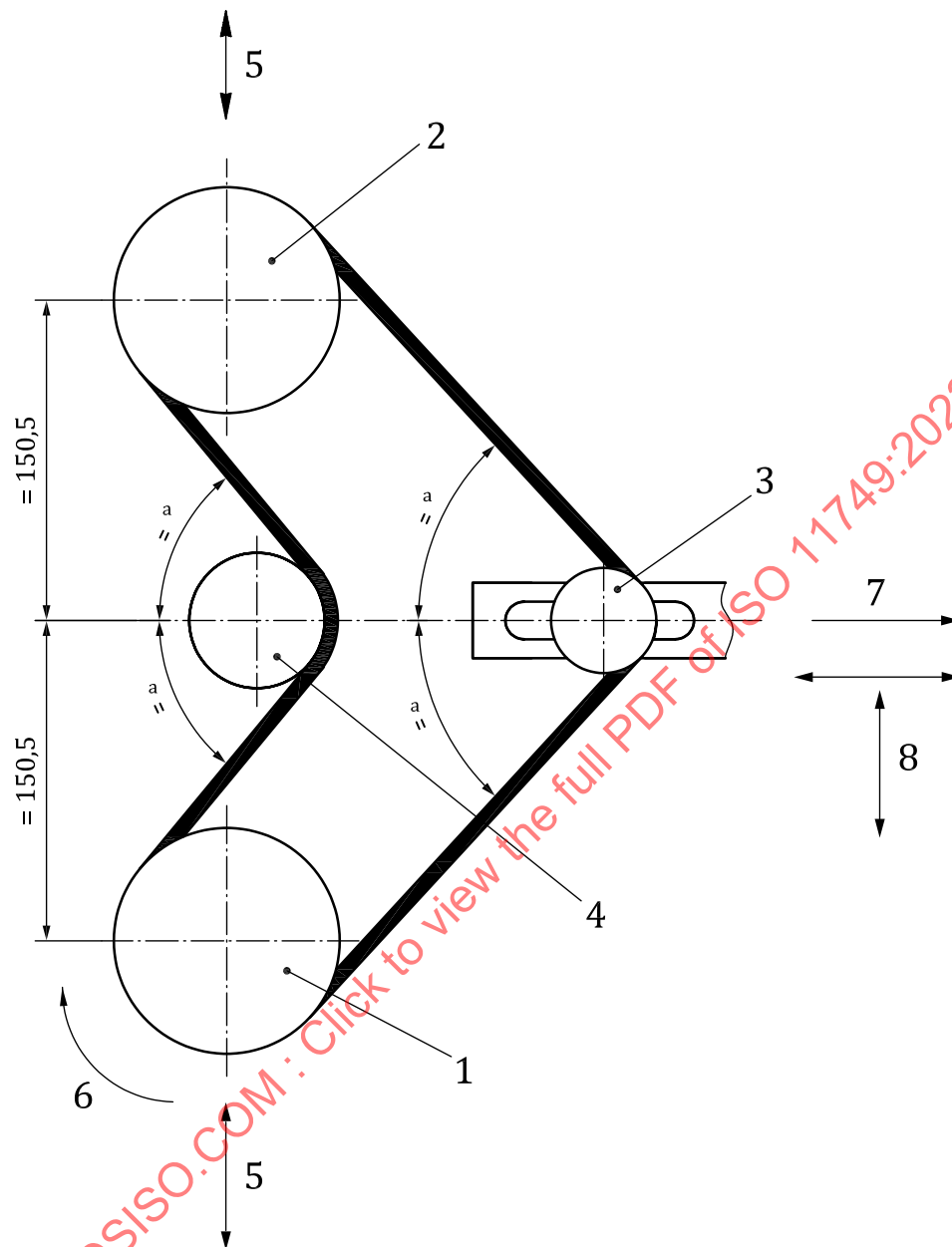
Determination of the performance of a belt under specified conditions on a two-, three-, or four-pulley test machine is as described in [Clause 6](#).

The shortest V-ribbed belt which can be tested on the four-pulley test machine (see [Figures 1](#) and [2](#)) is approximately 1 000 mm. Belts with lengths between 800 mm and 1 000 mm inclusive can be tested on the three-pulley test machine (see [Figure 3](#)). Shorter belts should be tested on the two-pulley test machine (see [Figure 4](#)) as described in [8.2.1.2](#).

A number of conditions with fixed belt tensioning force shall be agreed between the manufacturer and user, including the power to be transmitted and the number of times the belt can be retensioned.

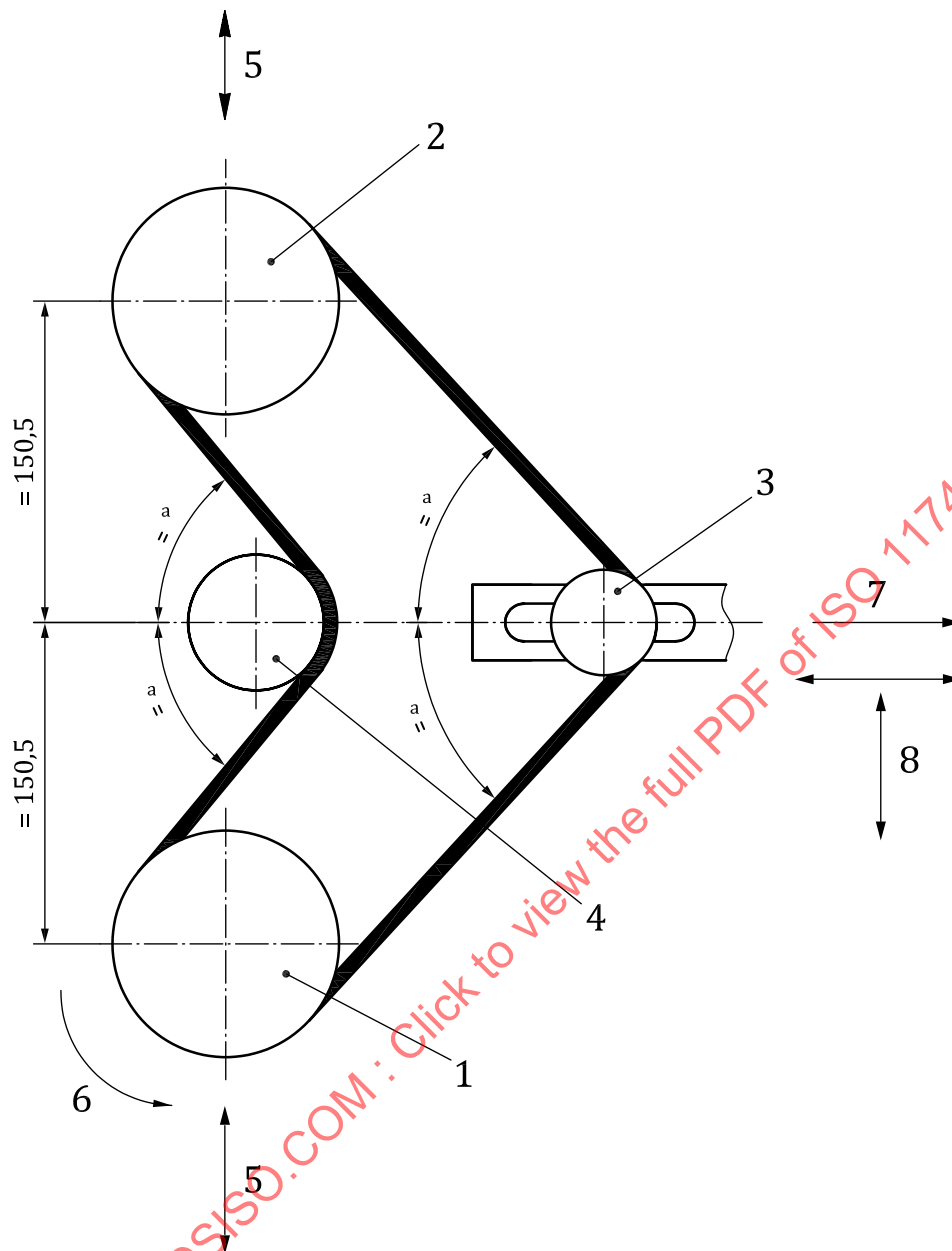
The minimum acceptable life, in hours, shall be agreed between the manufacturer and users.

Belt failure occurs when the belt no longer satisfies the agreed conditions.

**Key**

- 1 driving pulley
- 2 driven pulley (power-absorption unit)
- 3 idler pulley, set in slide
- 4 reverse bending idler pulley
- 5 direction of adjustment of driving and driven pulley
- 6 direction of rotation with fixed belt tensioning force
- 7 belt tensioning force applied to the idler pulley
- 8 direction of adjustment of idler pulley assembly and its support
- a Equal (=), the angle as shown by [Figure 1](#) is specified for the initial test layout and may change slightly with retensioning during the course of the test.

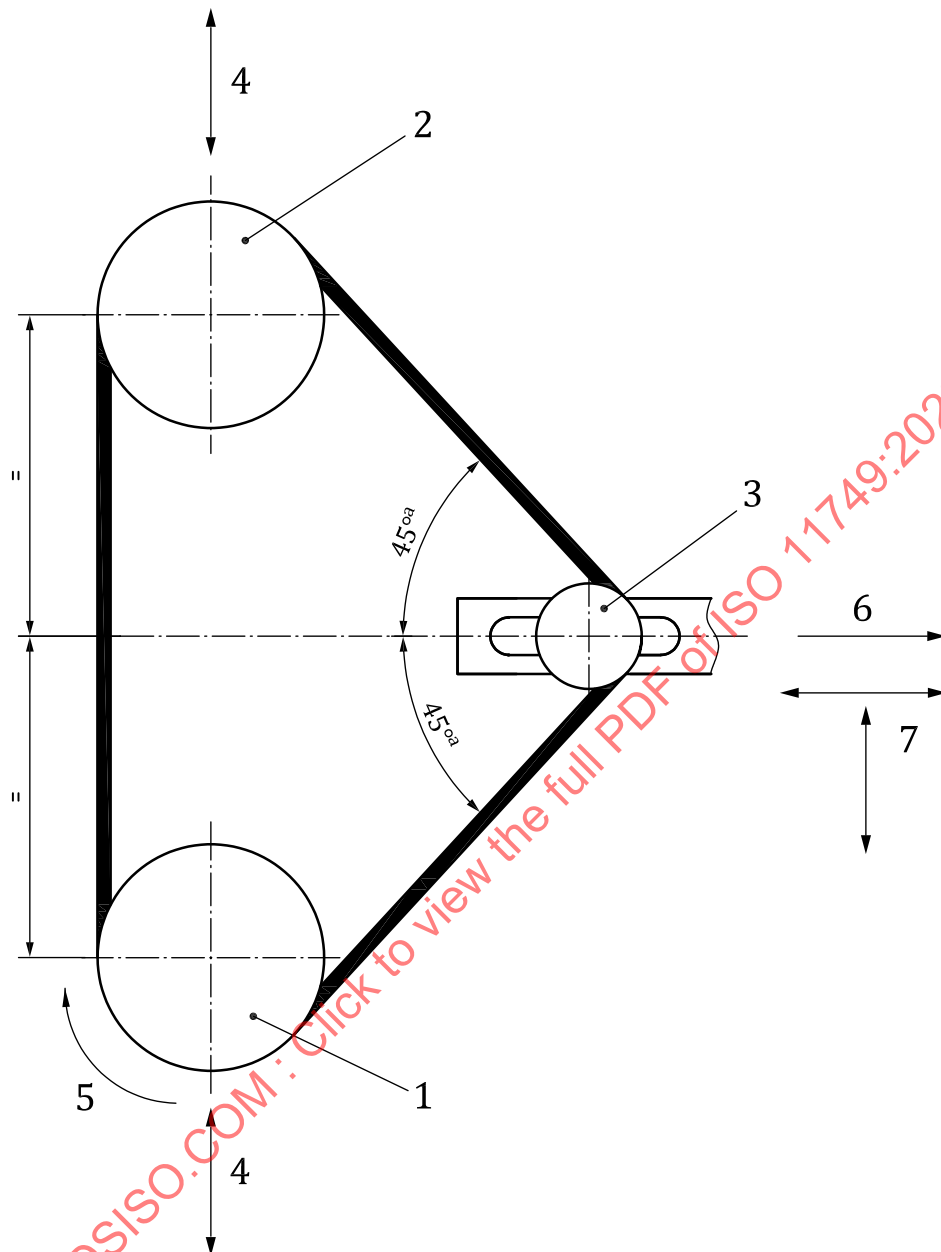
Figure 1 — Four-pulley test machine layout (fixed belt tensioning force)



Key

- 1 driving pulley
- 2 driven pulley (power-absorption unit)
- 3 idler pulley, set in slide
- 4 reverse bending idler pulley
- 5 direction of adjustment of driving and driven pulley
- 6 direction of rotation with constant belt tensioning force
- 7 belt tensioning force applied to the idler pulley
- 8 direction of adjustment of idler pulley assembly and its support
- a Equal (=), the angle as shown by [Figure 2](#) is specified for the initial test layout and may change slightly with retensioning during the course of the test.

Figure 2 — Four-pulley test machine layout (constant belt tensioning force)

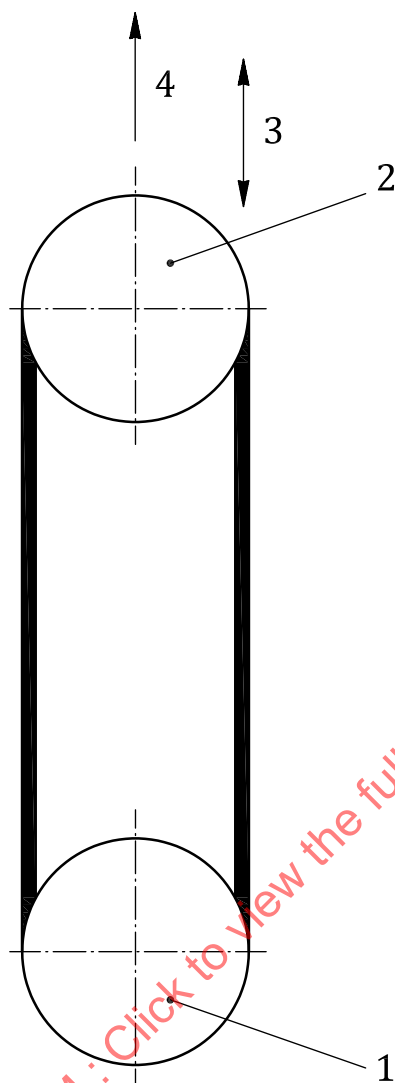
**Key**

- 1 driving pulley
- 2 driven pulley (power-absorption unit)
- 3 idler pulley, set in slide
- 4 direction of adjustment of driving and driven pulley
- 5 direction of rotation
- 6 belt tensioning force applied to the idler pulley
- 7 direction of adjustment of idler pulley assembly and its support

The belt, mounted on the test pulleys shall be aligned to within $\pm 0,25^\circ$ in relation to the plane through the centre of each pulley.

^a 45° is specified for the initial test layout and may change slightly with retensioning during the course of the test.

Figure 3 — Three-pulley test machine layout

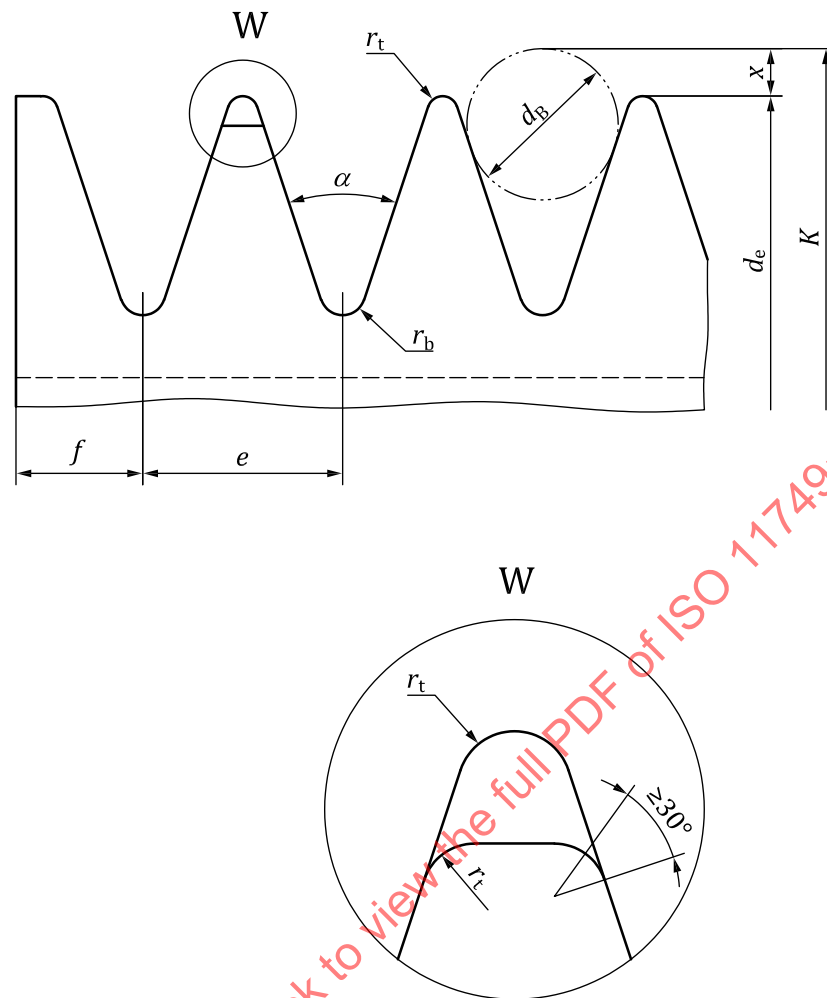


Key

- 1 driving pulley
- 2 driven pulley (power-absorption unit)
- 3 direction of adjustment of the movable pulley (method of locking in place)
- 4 belt tensioning force applied to the movable pulley

The belt, mounted on the test pulleys, can be aligned to within $\pm 0,25^\circ$ in relation to the plane through the centre of each pulley.

Figure 4 — Two-pulley test machine layout



The actual configuration of the tip profile can lie anywhere between the maximum and minimum indicated. Any configuration shall have a transitional radius, r_t , corresponding to a 30° minimum arc tangent to the groove side wall (in accordance with ISO 9981).

Figure 5 — Cross-section of pulley grooves

Radial and axial circular runouts shall not exceed 0,25 mm total indicator reading (TIR). The runout in the two directions is measured separately with a ball mounted under spring pressure to ensure contact with the grooves as the pulley is rotated.

The pulley groove shall have a surface roughness $R_a < 3,2 \mu\text{m}$ (the value of $3,2 \mu\text{m}$ for R_a has been fixed because in this case it is a question of testing pulleys). See ISO 254 for definitions and measurement method.

6 Apparatus

6.1 Dynamic test machine, of robust design so that all components withstand, with virtually no deflection, the stress to which they are subjected.

The test machine shall consist of the following (see [Figures 1, 2, 3, and 4](#)).

6.1.1 Driving pulley, and suitable mechanism for driving it.

6.1.2 Driven pulley, to which a suitable power-absorption unit ([6.1.3](#)) is connected.

6.1.3 Power-absorption unit, accurate and capable of calibration.

6.1.4 Temperature control system.

6.1.5 Reverse bending idler pulley, only for four-pulley test machine (see [Figures 1](#) and [2](#)).

6.1.6 Device through which tension may be applied to the belt:

- a) in the case of the three- or four-pulley test machine layout, an idler and tensioner pulley (see [Figures 1](#), [2](#), and [3](#)); or
- b) in the case of the two-pulley test machine layout, a movable pulley (see [Figure 4](#)).

6.1.7 Means of determining belt slip, to an accuracy of $\pm 0,1$ %. The layout of the pulley and the direction of rotation are shown in [Figures 1](#), [2](#), [3](#), and [4](#).

In order to accommodate different lengths, the position of relevant driving and driven members, the position of the idler pulley and its support (in the case of the three-pulley test machine), and the position of the reverse bending idler pulley (in the case of the four-pulley test machine) shall be adjustable so that the test layout of the pulleys is attainable for each belt length.

So that the tension can be satisfactorily applied to the belt, and in order to allow for belt stretch, the idler pulley and its bearing assembly shall be free to slide, as necessary, in the support bracket along the line of application of the tensioning force.

For the four-pulley test machine, the line of action of the tensioning force shall bisect the belt layout at the idler pulley and at the reverse bending idler pulley and shall lie in the plane through the centre of the pulleys (see [Figures 1](#) and [2](#)).

For the three-pulley test machine, the line of action of the tensioning force shall bisect the belt layout at the idler pulley, shall pass through the axis centre of the idler pulley and shall lie in the plane through the centre of the idler pulley (see [Figure 3](#)).

The two-pulley test machine shall be constructed so that one of the units (driven or driving) can be moved to accommodate belt lengths of up to 800 mm. A method of locking the movable unit in position for a given tension in the belt shall be provided. For the tension to be satisfactorily applied to the belt, and in order to allow for belt stretch, the line of action of the tensioning force shall pass through the axis centre of the driven and driving pulleys and shall lie in the plane through the centre of the same pulleys (see [Figure 4](#)).

6.2 Test pulleys, made from steel, as defined in ISO 683-1, with a surface hardness of 55 HRC, conforming to ISO 6508-1. The pulley groove shall have a surface roughness such that the arithmetical mean deviation of the profile R_a is lower than $3,2 \mu\text{m}$.

The characteristics of the test pulleys are given in [Figure 5](#). The dimensions of test pulleys are given in [Table 2](#).

Table 2 — Dimensions of test pulleys

Parameter		Symbol	Dimension	Tolerance
Number of grooves		n	5	—
Groove pitch		e	3,56 mm	$\pm 0,05$ ^{ab}
Groove angle ^c		α	40°	$\pm 0,5^\circ$
Radius at the groove root		r_b	< 0,5 mm	—
Radius at the groove tip		r_t	0,25 mm	+0,18 0
Effective diameter	Driving and driven pulleys ^d	d_{e1}	120,6 mm	—
	Idler pulley ^d	d_{e2}	60 mm ^e	—
	Driving and driven pulleys ^f	d_{e1}	63 mm	—
Outside diameter of reverse bending idler pulley ^g		d_{r3}	76,2 mm ^h	$\pm 0,15$
Pitch diameter ⁱ		d_p	$d_p = d_e + 2b_e$	—
Effective line differential		b_e	2 mm	nominal value
Diameter over balls or rods	Driving and driven pulleys	K	$K = d_e + 2x$	$\pm 0,25$
	Idler pulley			$\pm 0,15$
Position of the ball or rod to groove tip		$2x$	0,99 mm	nominal value
Checking ball or rod diameter		d_B	2,5 mm	$\pm 0,01$
Lateral distance		f	>2,5 mm	—
^a The tolerance on e applies to the distance between the axis of two consecutive grooves. ^b The sum of all deviations from the nominal value e for all grooves in any one pulley shall not exceed $\pm 0,3$ mm. ^c The centreline of the groove shall make an angle of $90^\circ \pm 0,5^\circ$ with the axis of the pulley. ^d In the case of the three- or four-pulley test machine. ^e The value of 45 mm is the minimum recommended to better represent actual design practice in ISO 9981 and may be used for testing. The value of 55 mm may be selected to better represent actual design practice. ^f In the case of the two-pulley test machine. ^g In the case of the four-pulley test machine. ^h No minimum reverse bend diameter is standardized. The value of 60 mm may be used for testing but should not be considered for production drives. ⁱ The true pitch diameter of a V-ribbed pulley is slightly larger than the effective diameter, and its exact value is determined with the particular belt being used. A nominal value of the effective line differential b_e of 2 mm may be used to calculate the speed ratio. If more precision is required, the belt manufacturer should be consulted.				

7 Test room conditions

The test temperature shall be:

- in a test room, an ambient temperature between 18 °C and 32 °C (the mean ambient temperature for the duration of the test shall be given with the test result, and the atmosphere in the vicinity of the test drive shall be free of draughts from sources other than the belt drive itself); or
- in a thermostatically controlled enclosure, a high temperature of (120 ± 5) °C; or
- in a thermostatically controlled enclosure, a high temperature of (85 ± 5) °C.

8 Test method

8.1 Test conditions

8.1.1 Test with fixed belt tensioning force

The rotational frequency of the driving pulley shall be $4\,900\text{ min}^{-1}$ to within $\pm 2\%$. The power transmitted is fixed, in kilowatts, for a belt with three to five ribs, and shall be agreed between the manufacturer and user.

The driver pulley speed, in revolutions per minute, shall be used in the torque load calculation, and the torque load shall be kept constant without compensation for loss of driven pulley speed resulting from belt slippage.

The torque load, M , is given by [Formula \(1\)](#).

$$M = \frac{P_s}{N} \times 9\,549 \quad (1)$$

where

M is the torque load, in newton metres (Nm);

P_s is the specified power, in kilowatts (kW);

N is the driver speed, in rotations per minute (r/min).

The test equipment shall be maintained so as to minimize parasitic loads due to bearing losses, lubricants, etc.

In the case of the three- or four-pulley test machine, the belt tensioning force, F , in newtons, applied to the idler pulley, and in the case of the two-pulley test machine that applied to the driven unit, shall be such that

$$F = k \times P_s \quad (2)$$

where

k = 60 N/kW, in the case of the three- or four-pulley test machine;

= 110 N/kW, in the case of the two-pulley test machine.

EXAMPLE For 10,3 kW, $F = 618\text{ N}$: for one belt with six ribs = 105 N/rib (in the case of the three- or four-pulley test).

8.1.2 Test with constant belt tensioning force

The rotational frequency of the driving pulley shall be $4\,900\text{ min}^{-1}$ to within $\pm 2\%$. The power transmitted is fixed, in kilowatts, for a belt with three to five ribs, and shall be agreed between the manufacture and user.

The driver pulley speed, in revolutions per minute, shall be used in the torque load calculation, and the torque load shall be kept constant without compensation for loss of driven pulley speed resulting from belt slippage.

The specified power, P_s , is 10,3 kW, the torque load, M , is given by [Formula \(3\)](#).

$$M = \frac{P_s}{N} \times 9\,549 \quad (3)$$

where

- M is the torque load, in newton metres (Nm);
- P_s is the specified power, in kilowatts (kW);
- N is the driver speed, in rotations per minute (r/min).

The test equipment shall be maintained so as to minimize parasitic loads due to bearing losses, lubricants, etc.

In the case of the four-pulley test machine with constant belt tension, the belt tensioning force, F , is 464 N, applied to the idler pulley.

8.2 Procedure

8.2.1 Preparation

8.2.1.1 Three- or four-pulley test machine with fixed belt tensioning force

Method A: after mounting the belt on the pulleys, apply the specified belt tensioning force (see 8.1.1) to the idler pulley and, leaving the idler pulley support bracket free to move in its slide, bring the drive up to the specified rotational frequency (see 8.1.1). Then apply the relevant load to the driven pulley as quickly as possible. Run the drive under these conditions for $5 \text{ min} \pm 15 \text{ s}$, not including the starting and stopping time. Stop the machine and leave it to stand for at least 10 min.

Then turn the drive manually for several revolutions of the belt and immediately lock the idler pulley support bracket in position.

Method B: after mounting the belt on the pulleys, apply the specified belt tensioning force (see 8.1.1) to the idler pulley, leaving the idler pulley support bracket free to move in its slide. Then turn the drive manually for several revolutions of the belt and immediately lock the idler pulley support bracket in position.

8.2.1.2 Two-pulley test machine

Use the same procedure as in 8.2.1.1 with the movable unit taking the place of the idler pulley support.

8.2.1.3 Four-pulley test machine with constant belt tensioning force

After mounting the belt on the pulleys, apply the specified belt tensioning force (see 8.1.2) to the idler pulley and, leaving the idler pulley support bracket free to move in its slide without lock it, bring the drive up to the specified rotational frequency (see 8.1.2).

8.2.2 Test

Start (restart in the case of method A) the machine, bring the drive up to the specified rotational frequency, apply the test load to the driven pulley, and measure the slip between the driving and driven pulleys.

The drive shall run continuously under these conditions until:

- in all test conditions: the belt fails; or
- in the test with fixed belt tensioning force: the additional slip g exceeds by 4 % the slip measured initially.

The additional slip, g , expressed as a percentage, is given by [Formula \(4\)](#):

$$g = \frac{(i_o - i_f)}{i_o} \times 100 \quad (4)$$

where

$$i_o = \frac{n_o}{N_o} \quad (5)$$

and

$$i_f = \frac{n_f}{N_f} \quad (6)$$

where

- n_o is the initial rotational speed of the driven shaft;
- n_f is the final rotational speed of the driven shaft;
- N_o is the initial rotational speed of the driving shaft;
- N_f is the final rotational speed of the driving shaft.

All rotational speeds shall be measured under the test load.

8.2.3 Retensioning

In case of two-, three- or four-pulley test machine with fixed belt tensioning force, if the additional belt slip reaches 4 % before belt failure, stop the machine and leave it to stand for at least 20 min. After unlocking the idler support bracket of the three- or four-pulley test machine, apply the test tension to the belt, turn the drive manually for two or three revolutions of the belt, relock the idler support bracket in position as described in [8.2.1.1](#), and repeat the test specified in [8.2.2](#). In the case of the two-pulley test machine, unlock the movable unit, apply the test tension to the belt, then relock the movable unit as described in [8.2.1.2](#), and repeat the test specified in [8.2.2](#).

Repeat this procedure whenever the additional slip reaches 4 % before failure, until the belt fails.

9 Test report

The test report shall include at least the following information:

- a) a reference to this document (i.e. ISO 11749);
- b) the identification of the belt tested;
- c) the type of machine used (if necessary, the effective diameter of the idler pulley or the outside diameter of the reverse bending idler pulley);
- d) the method used (A or B);
- e) the number of running hours under test to satisfy the agreed conditions;
- f) the transmitted power and the number of ribs;
- g) the number of times and the running hours at which the belt was retensioned in the test condition with fixed belt tensioning force;
- h) the mean ambient temperature during the test;