

# Castors and wheels — Test methods and apparatus

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ICS 21.180; 53.060;

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## Summary of pages

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English version

## Castors and wheels — Test methods and apparatus

Roues et roulettes — Méthodes  
et appareillages d'essai

Räder und Rollen — Prüfverfahren und -geräte

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**CEN**

European Committee for Standardization  
Comité Européen de Normalisation  
Europäisches Komitee für Normung

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Ref. No. EN 12527:1998 E

## Foreword

This European Standard has been prepared by Technical Committee CEN/TC 324, Castors and wheels, the Secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by March 1999, and conflicting national standards shall be withdrawn at the latest by March 1999.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

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## Introduction

Castors and wheels are used in many applications and environments.

For many of these specific requirements are needed. Thus the need for a standard on testing of castors and wheels suitable for users, original equipment manufacturers and testing houses.

## 1 Scope

This European Standard specifies the test methods and apparatus to be used to check the performance of the castors and wheels.

The test to be used and the acceptance criteria, values and applicability relevant to each type of castor and wheel are covered by the specific standards.

## 2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply only to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 12526:1998, *Castors and wheels — Vocabulary, recommended symbols and multilingual dictionary*.  
ISO 2878, *Rubber vulcanized — Antistatic and conductive products — Determination of electrical resistance limits*.

## 3 Definitions and symbols

For the purposes of this European Standard, definitions given in EN 12526:1998 apply and the meaning of the symbols is listed in Table 1 and in the individual tests.

**Table 1 — Symbols and meaning of the symbols**

Symbol	Unit	Meaning of the symbols
<i>A</i>	mm	dimensions of top plate
<i>a</i>	mm	bolt hole spacing
<i>B</i>	mm	dimensions of top plate
<i>b</i>	mm	bolt hole spacing
<i>c</i>	m	distance between obstacles
<i>D</i>	mm	wheel diameter
<i>d</i>	mm	bore diameters
<i>E</i> <sub>1</sub>	—	number of locking actions
<i>E</i> <sub>2</sub>	cycles per minute	frequency of locking actions
<i>e</i>	mm	wheel spacing
<i>F</i>	mm	offset
<i>f</i>	mm	fork width
<i>G</i>	mm	fixing bolt diameter
<i>g</i>	mm	minimum distance of slotted hole centres
<i>H</i>	mm	overall height
<i>h</i> <sub>1</sub>	mm	height of obstacles
<i>h</i> <sub>2</sub>	mm	drop height
<i>K</i> <sub>1</sub>	N	horizontal tractive force
<i>K</i> <sub>2</sub>	N	horizontal tractive force
<i>L</i> <sub>1</sub>	N	load capacity
<i>L</i> <sub>2</sub>	N	test load
<i>L</i> <sub>3</sub>	N	test load

Table 1 — Symbols and meaning of the symbols (continued)

Symbol	Unit	Meaning of the symbols
$L_4$	N	test load
$L_5$	kg	free falling mass
$L_6$	N	test load
$L_7$	N	test load
$L_8$	N	test load
$L_9$	N	test load
$L_{10}$	N	pull-out force
$L_{17}$	N	test load
$M$	mm	hub diameter
$m$	mm	swept radius
$n$	—	number of obstacles
$P$	mm	stem diameter
$Q$	mm	stem length
$R$	$\Omega$	electrical resistance
$r_1$	—	number of wheel revolutions
$r_2$	—	number of cycles
$r_3$	mm	external corner radius
$r_4$	mm	internal corner radius
$r_5$	mm	tread curvature
$S_1$	mm	maximum initial swivel play
$S_2$	mm	maximum swivel wear play
$s$	mm	bearing seat dimensions
$T$	mm	wheel width
$T_1$	mm	hub width
$T_2$	mm	tyre width
$T_3$	mm	tread width
$t$	mm	bearing seat dimensions
$v_1$	m/s	average speed of running period
$v_2$	m/s	speed at impact with obstacles
$v_3$	mm/s	travel speed
$W_1$	mm	maximum initial wheel play
$W_2$	mm	maximum wheel wear play
$w_1$	N	minimum rolling resistance (type H)
$w_2$	N	minimum rolling resistance (type W)
$w_3$	N	horizontal tractive force
$w_4$	N	swivel resistance
$y_1$	value	load factor
$y_2$	h	time of application of the load
$y_3$	h	elapsed time prior to inspection (for furniture and swivel chair castors only)
$z_1$	min	running period
$z_2$	min	pause
$z_3$	—	speed (cycles per min)
$\beta$	degrees	angle of inclination

## 4 Test methods

### 4.1 General requirements

#### 4.1.1 Test sequence

Tests shall be carried out in a pre-defined sequence to allow repeatability of testing conditions.

#### 4.1.2 Test sample

All tests within the sequence shall be made with the same castor(s) or wheel(s), unless otherwise specified in the appropriate standard. Castors and wheels shall not be artificially cooled during testing.

#### 4.1.3 Application of test load

The test load shall always be applied directly so that its centre of gravity lies central to the mounting plane of the castor(s), or the centre of the test frame — where required — on which the sample(s) under test are mounted (see Figures 3 and 7). Unless otherwise specified the test load shall be a real weight.

#### 4.1.4 Test report

Actual readings and test results of each test and indication if the test is passed or failed shall be clearly given in the test report, including the following information:

- reference to the relevant European Standard;
- type of the test machine which was used;
- details of any deviation to this European Standard;
- main features of the test sample;
- name and address of location where the test was carried out;
- date of the test.

### 4.2 Wheel play test

#### 4.2.1 Objectives

This test is to determine the initial wheel play — at the commencement of the test sequence — and the final wheel play — at the end of the test sequence.

#### 4.2.2 Symbols

The following symbols are to be used:

Symbol	Meaning of the symbol
$W_1$	maximum initial wheel play
$W_2$	maximum wheel wear play

#### 4.2.3 Apparatus

The test apparatus is a device to clamp the fork with the fitted wheel under test.

#### 4.2.4 Procedure

The measurements shall be taken with the wheel and axle bush assembled as during test (original product). The fork of the castor is rigidly clamped in a vertical position ensuring that the fork width is maintained and the movement of the wheel is not impaired. The wheel play shall not include any side movement of the wheel on the axle. Wheel play shall be in mm and measured as in Figure 1. To determine the wear play subtract the initial wheel play from the final wheel play.

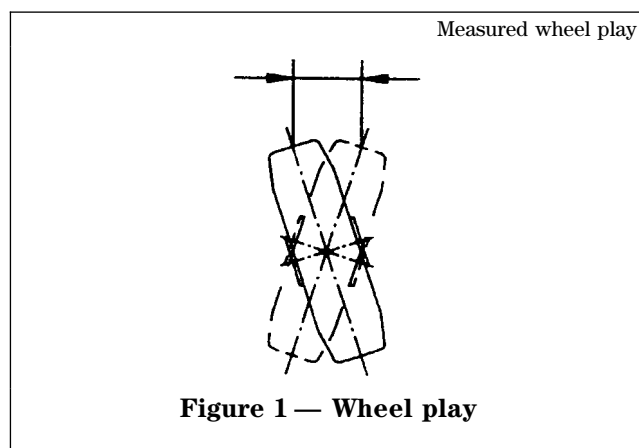


Figure 1 — Wheel play

### 4.3 Swivel play test

#### 4.3.1 Objectives

This test is to determine the initial swivel play — at the commencement of the test sequence — and the final swivel play — at the end of the test sequence.

#### 4.3.2 Symbols

The following symbols are to be used:

Symbol	Meaning of the symbol
$S_1$	maximum initial swivel play
$S_2$	maximum swivel wear play

#### 4.3.3 Apparatus

The test apparatus is a lever of at least 200 mm in length suitable to be rigidly fixed to the mounting plane of the castor under test as in Figure 2.

#### 4.3.4 Procedure

The measurements shall be taken with the wheel and axle bush assembled as during test (original product). The fork of the castor is rigidly clamped in a vertical position ensuring that the fork width is maintained and the movement of the swivel is not impaired. A mark shall be made on the fixed and swivelling parts of the castor. The swivel play shall be measured at 200 mm from the swivel axis of the castor when:

- the marks are aligned;
- the mounting plane is rotated through 90°.

Swivel play shall be in mm and measured as in Figure 2. The larger of these two values shall be taken. To determine the swivel play subtract the initial swivel play from the final swivel play.

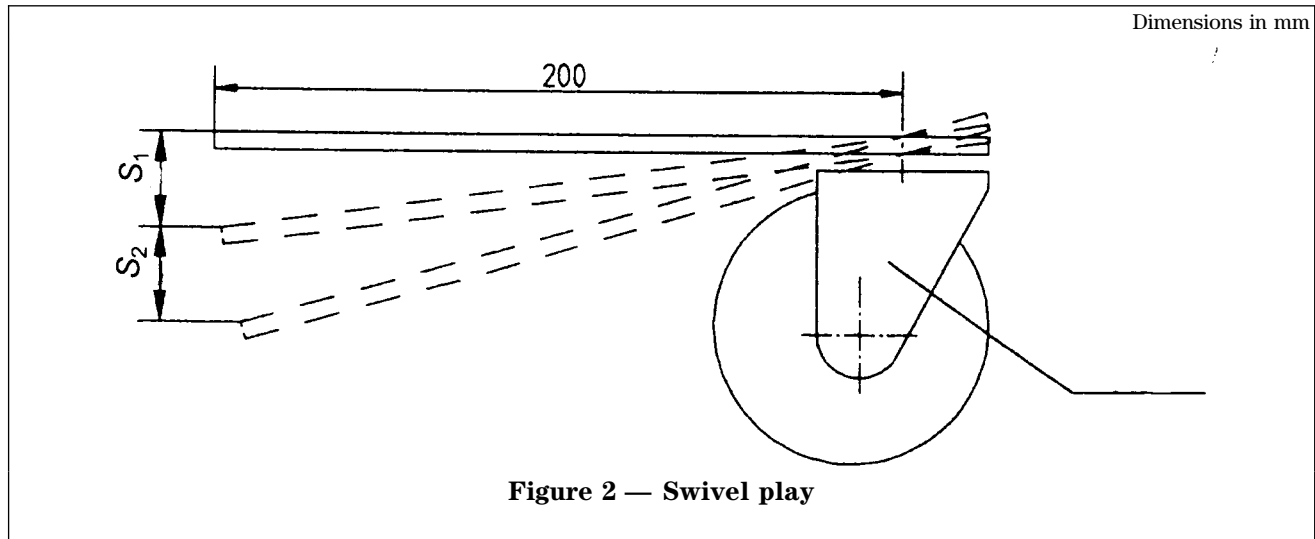


Figure 2 — Swivel play

#### 4.4 Electrical resistance test

##### 4.4.1 Objectives

This test is to measure the electrical resistivity of the sample (according to ISO 2878). The wheel(s) shall be perfectly clean and dry.

##### 4.4.2 Symbols

The following symbols are to be used:

Symbol	Meaning of the symbol
$L_{17}$	test load
$R$	measured resistance

##### 4.4.3 Apparatus

The test apparatus is *an instrument having a nominal open circuit voltage of 500 V d.c.*, preferably an insulation tester (ohm meter), or any suitable instrument known to give comparable results.

The instrument shall be sufficiently accurate to determine the resistance within 10 % and shall not dissipate more than 3 W in the product.

The resistance values obtained will vary with the applied voltage, and errors may occur when low test voltages are involved. In case of dispute, the voltage applied to the product shall be not less than 40 V, except where this conflicts with the requirement not to dissipate more than 3 W in the test piece.

##### 4.4.4 Procedure

Place the castor and/or wheel on a metal plate that is insulated from the floor. Between the metal plate and the castor a piece of wet blotting paper of the size of the contact area can be added if furniture castors or swivel chair castors are tested. Keep the tread in contact with the metal plate by applying with a load of 5 % to 10 % of the nominal load on the castor or wheel as given in 4.1.3. Using the insulation tester measure the resistance between the mounting plane of the castor or axle of the wheel and the metal plate. It is necessary to take three readings each with a different part of the tread in contact with the metal plate.

#### 4.5 Fatigue test for braking and/or locking device

##### 4.5.1 Objectives

This test is to determine if there is any wear and/or permanent deformation, that would adversely affect the performance of the braking and/or locking device. This test is not applicable to braking and/or locking devices based on a threaded mechanism.

##### 4.5.2 Symbols

The following symbols are to be used:

Symbol	Meaning of the symbol
$E_1$	number of locking actions
$E_2$	frequency of locking actions in cycles per minute
$L_3$	load

##### 4.5.3 Apparatus

The test apparatus shall simulate as effectively as possible what happens when the braking and/or locking device is operated and released with the castor stationary.

##### 4.5.4 Procedure

The castor loaded with  $L_3$  is placed in the apparatus and the braking/locking actions are carried out in accordance with  $E_1$  and  $E_2$ .

#### 4.6 Efficiency check of wheel braking and/or locking device

##### 4.6.1 Objectives

This test is to determine the performance of the wheel braking and/or locking device. It is recommended that this test should follow the test in 4.5, where applicable.



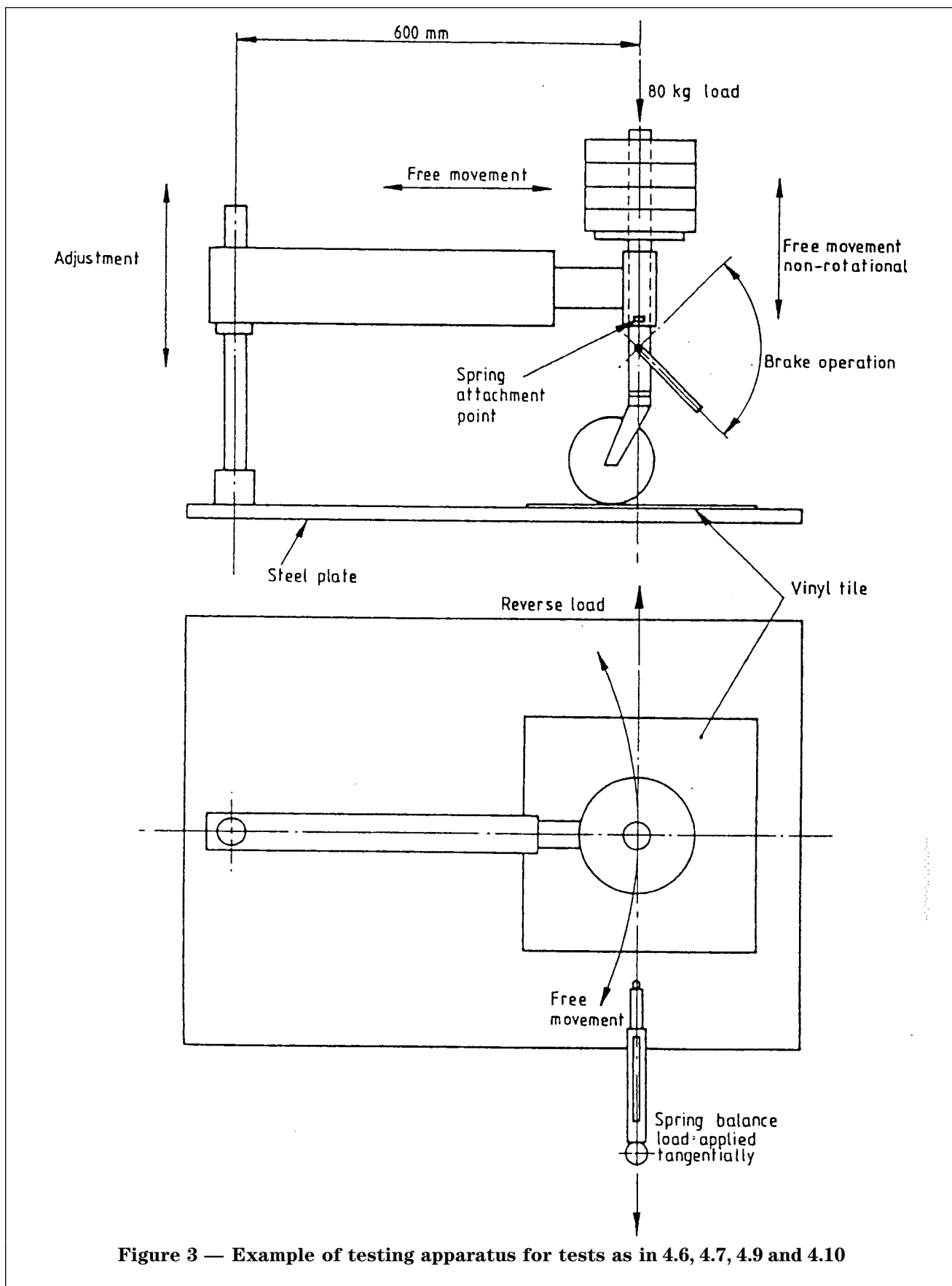


Figure 3 — Example of testing apparatus for tests as in 4.6, 4.7, 4.9 and 4.10

#### 4.6.2 Symbols

The following symbols are to be used:

Symbol	Meaning of the symbol
$L_1$	load capacity
$K_1$	horizontal tractive force

#### 4.6.3 Apparatus

The test apparatus is:

- a low friction device that allows either a:
  - a) linear movement;
  - b) circular movement;
- a force measuring device;
- a pulling device to pull force equal to  $K_1$ ;
- a time measuring instrument.

#### 4.6.4 Procedure

The castor is placed on a horizontal smooth steel surface, clean from visible dirt. The braking and/or locking device is engaged. Apply to the mounting plane of the castor a load  $L_1$ . Then gradually apply a horizontal tractive force ( $K_1$ ) in line with the running direction of the wheel. The force  $K_1$  shall be applied for 10 s then released. Gradually apply the force  $K_1$  once more for 10 s and monitor if the wheel revolves around its axle. Repeat the above procedure applying the force in the opposite direction. If during the application of the force  $K_1$  the wheel skids on the floor, change the surface material to a higher grip and repeat the test.

#### 4.7 Efficiency check of swivel braking and/or locking device

##### 4.7.1 Objectives

This test is to determine the performance of the swivel braking and/or locking device. It is recommended that this test should follow the test in 4.5.

##### 4.7.2 Symbols

The following symbols are to be used:

Symbol	Meaning of the symbol
$L_1$	load capacity
$K_2$	horizontal tractive force

##### 4.7.3 Apparatus

The test apparatus is:

- a low friction device that allows either:
  - a) a linear movement;
  - b) a circular movement;
- a force measuring device;
- a pulling device to pull force equal to  $K_2$ ;
- a time measuring instrument.

##### 4.7.4 Procedure

The castor is placed on a horizontal smooth steel surface, clean from visible dirt. The braking and or locking device is engaged. Apply to the mounting plane of the castor a load  $L_1$ . Then gradually apply a horizontal tractive force ( $K_2$ ) at 90° to the running direction of the wheel. The force  $K_2$  shall be applied for 10 s then released. Gradually apply the force  $K_2$  once more for 10 s and monitor if swivelling movement is detected. Repeat the above procedure applying the force in the opposite direction. If during the application of the force  $K_2$  the wheel skids on the floor, change the surface material to a higher grip and repeat the test.

##### 4.8 Dynamic test

This test applies to:

- castors for institutional applications;
- castors for hospital beds;
- castors for applications up to 1,1 m/s (4 km/h);
- castors for applications over 1,1 m/s and up to 4,4 m/s (16 km/h).

##### 4.8.1 Objectives

This test is to verify that a load capacity, under a dynamic application, will not cause damage and/or excessive wear to be a prejudice to the performance of the castor or wheel under test.

##### 4.8.2 Symbols

The following symbols are to be used:

Symbol	Meaning of the symbol
$L_1$	load capacity
$v_1$	average speed of running cycle
$v_2$	speed at impact with the obstacles
$h_1$	height of obstacles
$c$	distance between obstacles
$n$	number of obstacles to be passed by the wheel
$r_1$	number of revolutions of the wheel
$z_1$	running period
$z_2$	pause

##### 4.8.3 Apparatus

The test apparatus is:

- A machine, which can have either a linear or a circular track in a horizontal or vertical position (see Figures 4, 5 and 6) with a smooth steel surface and shall be able to run the sample at speeds as  $v_1$  and  $v_2$  and apply a load as  $L_1$  and 4.1.3. Rectangular metal obstacles shall be placed on the track at 45° to the running direction, alternately to the right and left of it. The obstacles shall be 100 mm wide, height as per  $h_1$  and featuring rounded edges with radius of 1/3 of its height. Such radius cannot be larger than 5 mm and less than 1,5 mm. The obstacles shall be positioned as  $c$ .
- A time measuring instrument.
- Portable hardness meter.

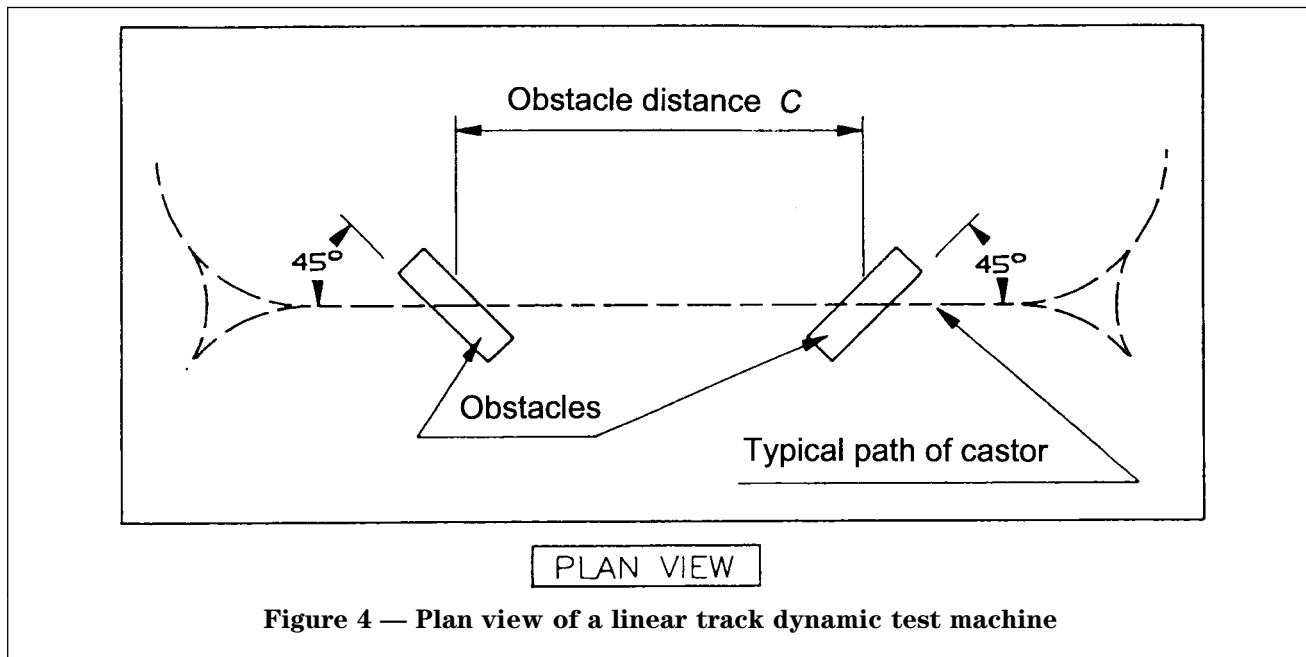


Figure 4 — Plan view of a linear track dynamic test machine

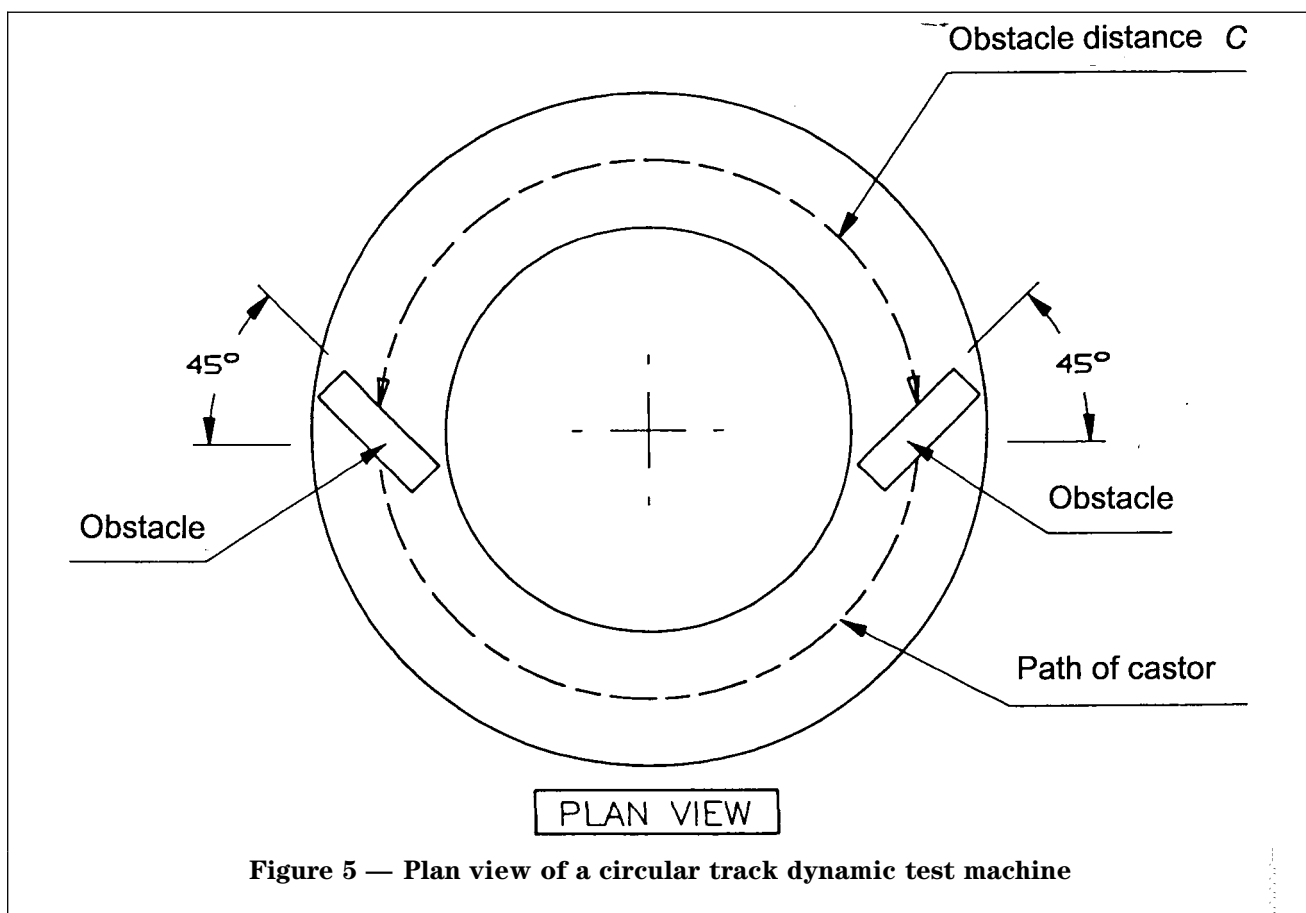


Figure 5 — Plan view of a circular track dynamic test machine

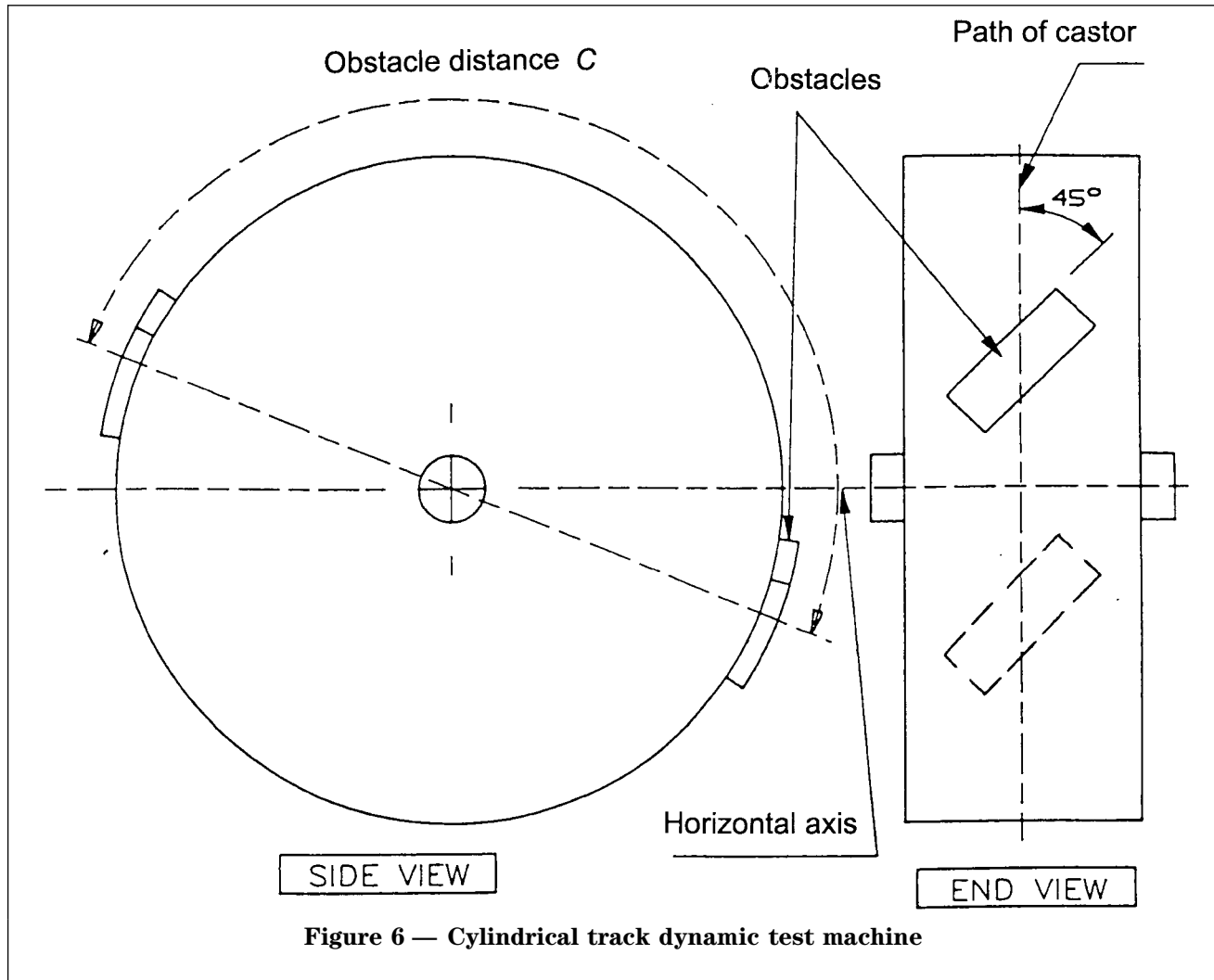


Figure 6 — Cylindrical track dynamic test machine

#### 4.8.4 Procedure

The castor or wheel is placed in the test apparatus with a correct fitting.

EXAMPLE: Fitted with all fixing bolts, and correctly tightened.

The test consists of a continuous running period with a duration of  $z_1$ , which may be followed by a pause  $z_2$ . The direction of travel must be reversed at the commencement of each new running period when either of the circular track dynamic test machines is used.

The castor shall be made to run, under load, until it has passed a number of obstacles  $n$ . When the total number of revolutions  $r_1$  specified exceed the revolutions required with obstacle contact the obstacles are removed and the test proceeds until all necessary revolutions are completed. The obstacles shall be removed in a period of time not exceeding  $z_1$ .

#### 4.9 Static test

##### 4.9.1 Objectives

This test is to determine the static performance of a castor and/or wheel.

##### 4.9.2 Symbols

The following symbols are to be used:

Symbol	Meaning of the symbol
$L_1$	load capacity
$L_6$	test load
$y_1$	load factor
$y_2$	time of application of the load
$y_3$	elapsed time prior to inspection

##### 4.9.3 Apparatus

The test apparatus is:

- a machine that applies a test load (either  $L_1$  multiplied by  $y_1$  or  $L_6$ ), as 4.1.3;
- a time measuring instrument.

##### 4.9.4 Procedure

The castor or wheel is placed in the test apparatus with a correct fitting on a horizontal smooth steel surface.

EXAMPLE: Fitted with all fixing bolts, and correctly tightened.

Apply the test load (either  $L_1$  multiplied by  $y_1$  or  $L_6$ ) as 4.1.3 for a period of time  $y_2$ .

Readings must be taken after a time  $y_3$  from when the load is removed.

#### 4.10 Contact pressure test

##### 4.10.1 Objectives

This test is to determine the contact pressure between the wheel and the floor.

##### 4.10.2 Symbols

The following symbols are to be used:

Symbol	Meaning of the symbol
$L_2$	load
$y_2$	time of application of the load

##### 4.10.3 Apparatus

A horizontal smooth steel surface is provided on which graph and carbon paper is placed.

A castor able to receive the load  $L_2$  is mounted vertically above the plate (see Figure 3).

A time measuring instrument is required.

Other methods of establishing the contact area obtained under the load  $L_2$  for a time of application of  $y_2$  are permissible provided the accuracy is not less than that of the procedure described above.

##### 4.10.4 Procedure

A horizontal smooth steel surface is provided on which graph and carbon paper are placed, so that the carbon paper will mark the graph paper when the load  $L_2$  is imposed on the castor for  $y_2$  hours. The area of the impression transferred is measured.

The contact pressure is the quotient of the load  $L_2$  and of the surface area.

$$\text{contact pressure} = \frac{L_2}{\text{surface area}}$$

#### 4.11 Chair castor brake performance test

##### 4.11.1 Objectives

This test is to determine the efficiency of the brake.

This test applies to castors type U.

##### 4.11.2 Symbols

The following symbols are to be used:

Symbol	Meaning of the symbol
$L_4$	load (including the frame)
$v_3$	travel speed
$w_1$	minimum rolling resistance (Type H)
$w_2$	minimum rolling resistance (Type W)

##### 4.11.3 Apparatus

The test apparatus is:

- a rigid three arm frame, that will not distort when the stated load is imposed (see Figure 7) on which three castors are mounted;
- a force measuring device;
- a pulling device, to pull the force equal to  $w_1$  or  $w_2$ ;
- a speed measuring instrument;
- a time measuring instrument.

For testing Type W castors: a table with a horizontal smooth steel surface shall be provided.

For testing Type H castors: a similar table shall be covered with textile having the characteristics given in Table 2.

Table 2 — Textile floor covering

Requirements for:	Characteristic
production method	tufted
upper surface	loop pile
nap count per m <sup>2</sup>	100 000 to 130 000
backing material	synthetic latex
raw material used for loop pile	100 % polyamide
yarn type	filament yarn
pile thickness of fully trimmed sample	3,5 mm
pile weight of fully trimmed sample	450 g/m <sup>2</sup>
The floor covering shall be conditioned before values are measured by running the test frame and castors five times over the area of the covering which will be used for the test.	

##### 4.11.4 Procedure

A load  $L_4$  (including the frame) is applied for the three arm frame.

A horizontal tractive force is applied in the running direction at 250 mm from the floor to the column of the frame (see Figure 7) in such a way to obtain a travel speed  $v_3$  over the test table for a distance of 250 mm.

This test shall be performed three times with each load  $L_4$ . The average value of resistance to rolling is measured between 100 mm and 250 mm of travel.

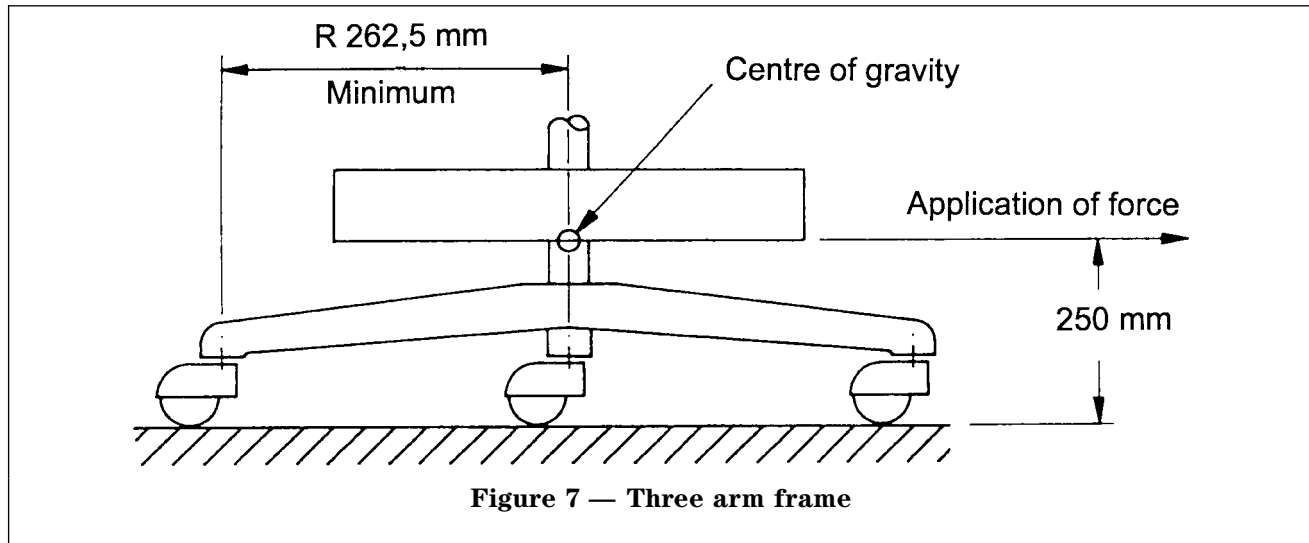


Figure 7 — Three arm frame

#### 4.12 Impact test

##### 4.12.1 Objectives

This test is to determine the resistance to impact.

##### 4.12.2 Symbols

The following symbols are to be used:

Symbol	Meaning of the symbol
$L_5$	free falling mass
$h_2$	drop height

##### 4.12.3 Apparatus

A castor is rigidly vertically mounted upside down in a test rig placed on a solid floor (see Figure 8), so that a free falling mass  $L_5$  can impact the tread of the wheel/wheels.

In the case of a twin wheel castor both wheels shall be impacted simultaneously.

##### 4.12.4 Procedure

The free falling mass  $L_5$  is caused to impact the castors ten times within a period of 10 min from the height  $h_2$ .

#### 4.13 Dynamic test for castors for furniture and swivel chairs only

This test applies to:

- castors for swivel chairs;
- castors for furniture.

##### 4.13.1 Objectives

This test is to verify that a load capacity, under a dynamic application, will not cause damage and/or excessive wear to be prejudice to the performance of the castor under test.

##### 4.13.2 Symbols

The following symbols are to be used:

Symbol	Meaning of the symbol
$L_7$	test load per castor
$h_1$	height of obstacles
$r_2$	number of cycles
$z_1$	running period
$z_2$	pause
$z_3$	cycles per min

##### 4.13.3 Apparatus

A test machine with a linear or circular motion shall be provided (see Figures 9 and 10), with a horizontal smooth steel surface, that allows one or more castors to be mounted in such a way so as to run for a distance of one metre over two metal obstacles. At the end of one metre the running direction of the castors shall be reversed.

The two metal obstacles shall be placed to be at  $90^\circ$  to the running direction of the castors.

The two metal obstacles shall be 50 mm wide and  $h_1$  mm high and long enough to ensure that the castor/castors being tested always impact the full face of the metal obstacles. The metal obstacles shall have a radius on both sides equal to their height  $h_1$ .

##### 4.13.4 Procedure

The castor is placed in the test apparatus with a correct fitting.

The test consists of a continuous sequence of cycles  $r_2$  performed at a load  $L_7$  completing  $z_3$  cycles per minute. The cycle consists of a path of one metre forward and one metre return stroke and impact with two spaced obstacles occurs in each direction. The running period is defined in  $z_1$  followed by a pause  $z_2$ .

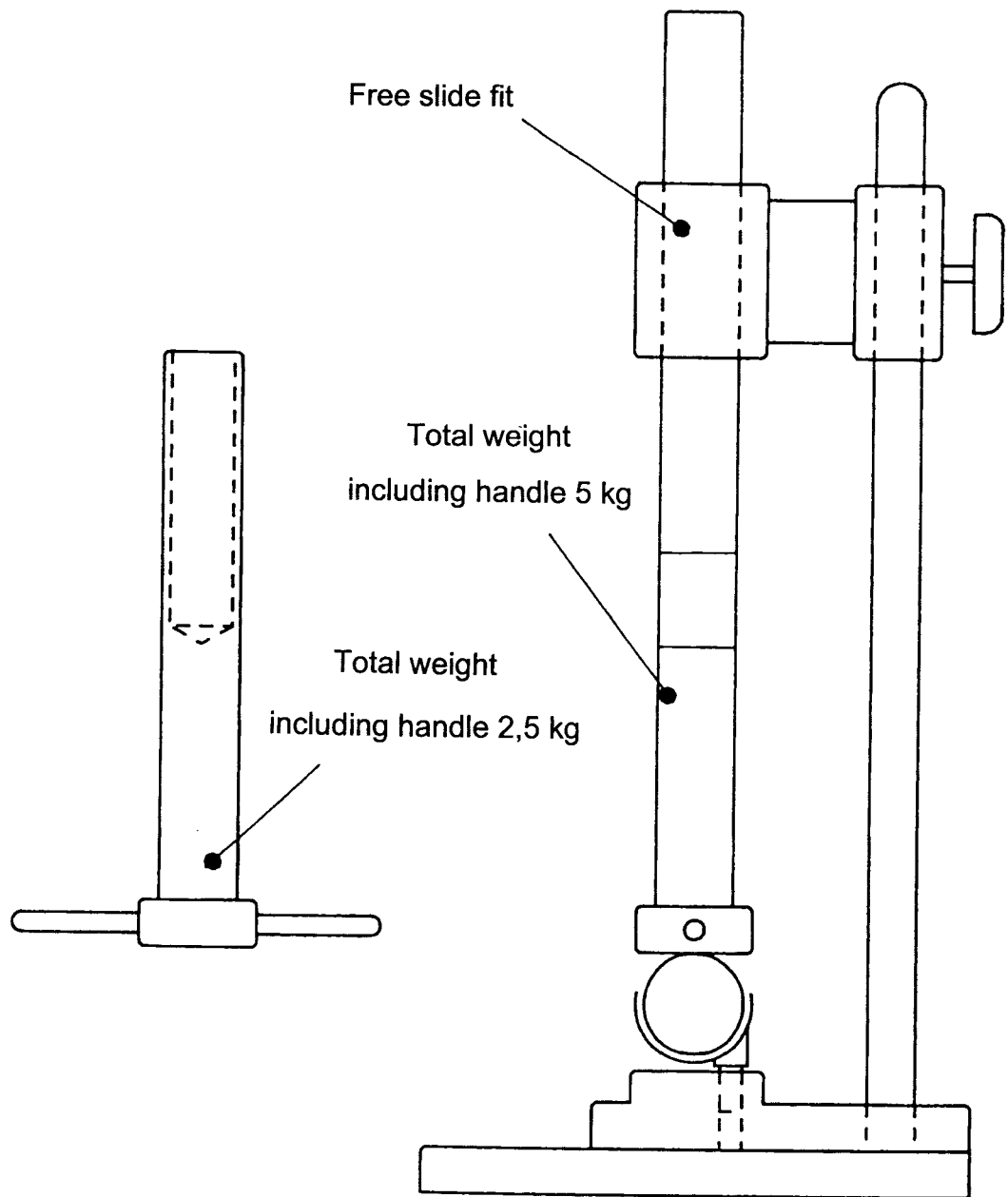


Figure 8 — Impact test rig for swivel chair castors and furniture castors

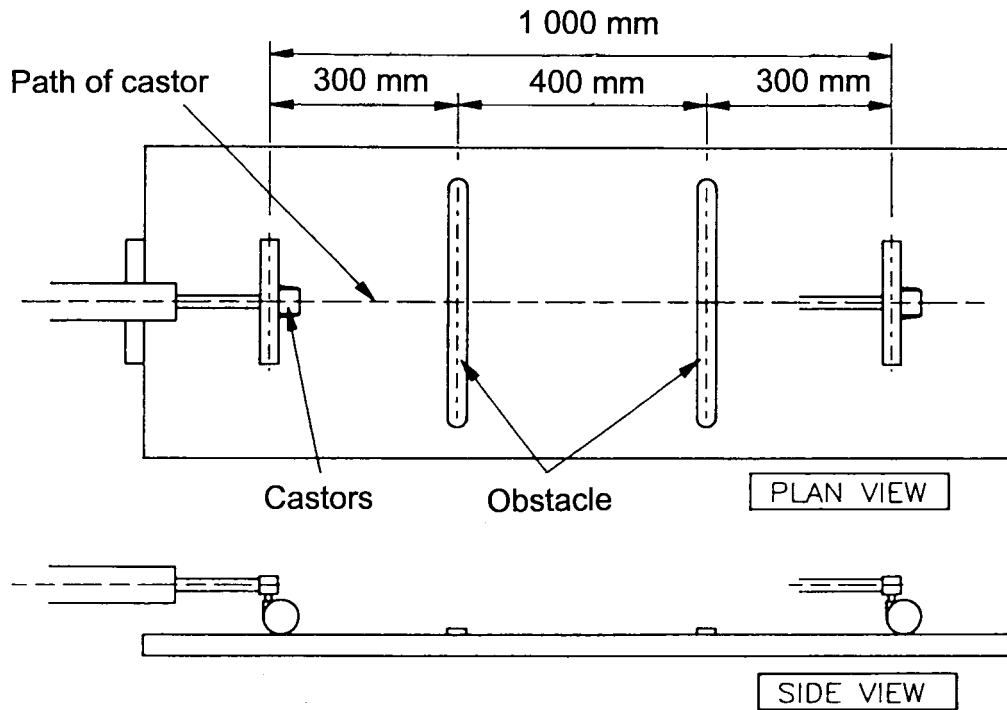


Figure 9 — Linear track dynamic test machine

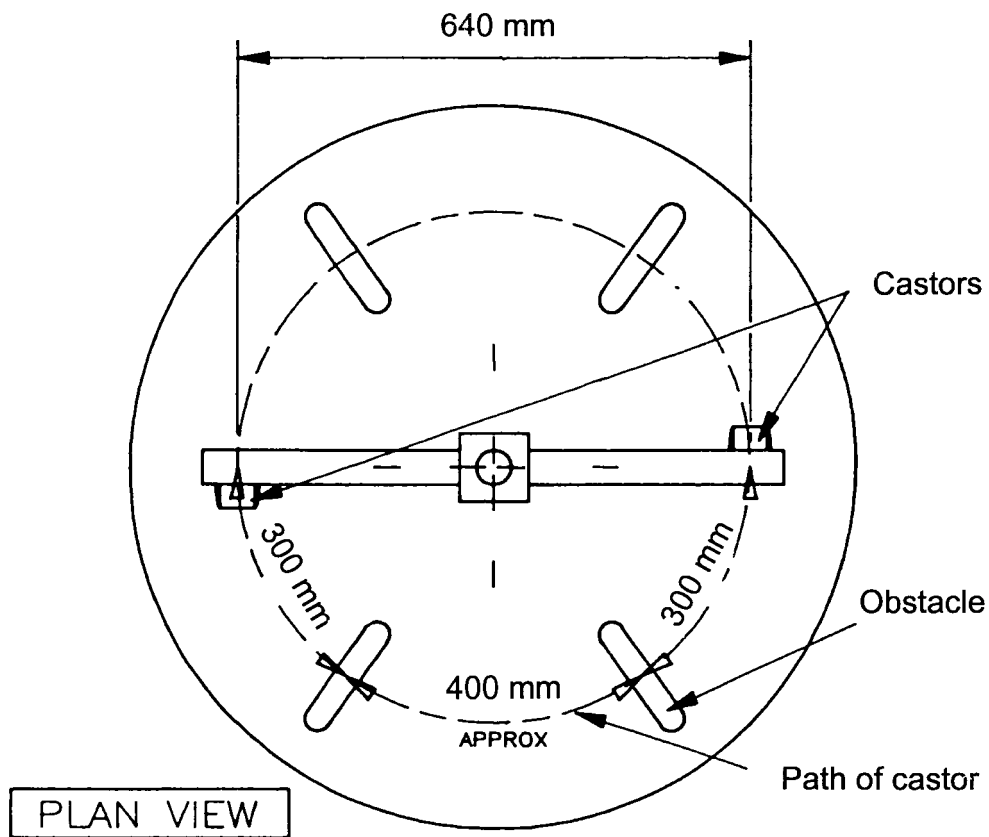


Figure 10 — Circular track dynamic test machine



#### 4.14 Long distance running test

##### 4.14.1 Objectives

This test is to determine the performance over a long distance.

##### 4.14.2 Symbols

The following symbols are to be used:

Symbol	Meaning of the symbol
$L_7$	test load per castor
$r_2$	number of cycles
$z_1$	running period
$z_2$	pause
$z_3$	cycles per minute

##### 4.14.3 Apparatus

A test machine with a linear or circular motion shall be provided, similar to that shown in Figures 9 and 10 but with a horizontal smooth steel surface without any obstacles, that allows one or more castors to be mounted to run the test for a distance of one metre. At the end of one metre the running direction of the castor shall be reversed.

##### 4.14.4 Procedure

The castor is placed in the test apparatus with a correct fitting.

The test consists of a continuous sequence of cycles  $r_2$  performed at a load  $L_7$  completing  $z_3$  cycles per minute. The cycle consists of a path of one metre forward and one metre return stroke. The running period is defined in  $z_1$  followed by a pause  $z_2$ .

#### 4.15 Rolling resistance test

##### 4.15.1 Objectives

This test is to determine the resistance to rolling.

##### 4.15.2 Symbols

The following symbols are to be used:

Symbol	Meaning of the symbol
$L_8$	load
$v_3$	travel speed
$w_3$	horizontal tractive force

##### 4.15.3 Apparatus

The apparatus for this test is identical to that of 4.11.3.

##### 4.15.4 Procedure

A load  $L_8$  (including the frame) is applied for the three arm frame.

A horizontal tractive force is applied in such a way to obtain a travel speed  $v_3$  over the test table, with the castors arranged in the running direction, for a maximum period of 10 s.

No measurements are taken for the first 5 s of the test because of higher friction and initial acceleration.

#### 4.16 Swivel resistance test

##### 4.16.1 Objectives

This test is to determine the swivel resistance.

##### 4.16.2 Symbols

The following symbols are to be used:

Symbol	Meaning of the symbol
$L_9$	test load per castor
$v_3$	travel speed
$w_4$	swivel resistance

##### 4.16.3 Apparatus

The test apparatus is:

- a test machine with a linear or circular motion which allows the castors to be positioned at 90° to the running direction;
- a force measuring device;
- a pulling device;
- a time measurement device.

For testing Type W castors: a horizontal smooth steel surface shall be provided.

For testing Type H castors: a similar table shall be covered with textile having the characteristics of Table 2.

##### 4.16.4 Procedure

One or more castors shall be mounted on a linear or circular test machine with the castor(s) positioned at 90° to the running direction.

A load  $L_9$  is applied to the castor(s). A horizontal tractive force provided by a test machine with a speed of  $v_3$ , for a period of 2 s will cause the castors to swivel. The highest force required to cause the swivelling is measured, and determines the swivel resistance  $w_4$ .

#### 4.17 Stem retention test

##### 4.17.1 Objectives

This test is to determine the stem-retention in the housing of the castor.

##### 4.17.2 Symbols

The following symbols are to be used:

Symbol	Meaning of the symbol
$L_{10}$	minimum pull-out force

##### 4.17.3 Apparatus

The test apparatus is:

- a test rig that allows a force to be applied between the castor and the stem in the direction of the longitudinal axis of the stem;
- a force measuring device;
- a pulling device;
- a time measuring device.

##### 4.17.4 Procedure

A steadily increasing load is applied until the required force  $L_{10}$  is reached. This force is then maintained for a minimum period of 2 min.

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