BS EN 62849:2016

BSI Standards Publication

Performance evaluation methods of mobile household robots

bsi.

National foreword

This British Standard is the UK implementation of EN 62849:2016. It is identical to IEC 62849:2016.

The UK participation in its preparation was entrusted to Technical Committee CPL/59, Performance of household electrical appliances.

A list of organizations represented on this committee can be obtained on request to its secretary.

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English Version

Performance evaluation methods of mobile household robots (IEC 62849:2016)

Méthodes d'évaluation de l'aptitude à la fonction des robots mobiles à usage domestique (IEC 62849:2016)

Verfahren zur Bewertung der Leistungsfähigkeit von mobilen Haushaltrobotern (IEC 62849:2016)

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European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
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European foreword

The text of document 59/655/FDIS, future edition 1 of IEC 62849, prepared by IEC/TC 59 "Performance of household and similar electrical appliances" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 62849:2016.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2017-06-29
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2020-09-29

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The text of the International Standard IEC 62849:2016 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following note has to be added for the standard indicated :

IEC 60335-1:2010	NOTE	Harmonized as EN 60335-1:2012 (modified).

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

Publication	Year	Title	EN/HD	Year
IEC/TS 62885-1	-	Surface cleaning appliances - Part 1: General requirements on test material and test equipment	-	-
IEC 62929	2014	Cleaning robots for household use - Dry cleaning: Methods of measuring performance	EN 62929	2014
ISO 554	-	Standard atmospheres for conditioning and/or testing - Specifications	-	-
ISO 2768-1	1989	General tolerances - Part 1: Tolerances for linear and angular dimensions without individual tolerance indications	EN 22768-1	1993

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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PERFORMANCE EVALUATION METHODS OF MOBILE HOUSEHOLD ROBOTS

FOREWORD

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International Standard IEC 62849 has been prepared by IEC technical committee 59: Performance of household and similar electrical appliances.

The text of this standard is based on the following documents:

FDIS	Report on voting
59/655/FDIS	59/656/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

INTRODUCTION

This standard will cover the generic performance test methods for mobile household robots within one document. However this current version is applicable for indoor floor supported wheeled or wheel-track robots with focus on mobility and power consumption related performance. As the needs for manipulation related performance grows, it will be added into this generic performance standard.

PERFORMANCE EVALUATION METHODS OF MOBILE HOUSEHOLD ROBOTS

1 Scope

This International Standard applies to mobile household robots and provides performance testing and evaluation methods for common features of various mobile household robots.

This standard is neither concerned with safety nor with performance requirements.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC TS 62885-1, *Surface cleaning appliances – Part 1: General requirements on test material and test equipment*

IEC 62929:2014, *Cleaning robots for household use – Dry cleaning: Methods of measuring performance*

ISO 554, *Standard atmospheres for conditioning and/or testing – Specifications*

ISO 2768-1:1989, *General tolerances – Part 1: Tolerances for linear and angular dimensions without individual tolerance indications*

3 Terms and definitions

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

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

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

3.1
household robot
actuated mechanism with a degree of autonomy, operating within the household and similar environment, to perform intended tasks

Note 1 to entry: Operating includes travel and/or robot body movement.

3.2
mobile household robot
household robot able to travel under its own control

3.3
capability of homing function
capability of a mobile household robot to return to the charge station(s) for charging or after completion of the work task or called by user

3.4
pose
the combination of position and orientation

3.5
autonomous mode
mode set by user where the robot travels horizontally with no user interaction

3.6
manual mode
mode set by the user where the robot travels with intermittent or continuous user interaction

4 General conditions for testing

4.1 Conditions prior to testing

The robot shall be completely assembled and fully operational in accordance with the manufacturer's instructions. All necessary leveling operations, alignment procedures and functional tests shall be satisfactorily completed.

Prior to conducting any series of tests, the age, condition, and history of the product shall be recorded.

NOTE Condition information can include model number/name, software version, and accessories used, if available.

4.2 Operating and environmental conditions

4.2.1 General

The performance characteristics determined by the related test methods in this International Standard are valid only under the environmental and normal operating conditions as stipulated by the manufacturer.

4.2.2 Operating conditions

All tests shall be carried out under conditions in which the mobile household robot is operated in normal use; the normal operating conditions used in the tests shall be in accordance with the manufacturer's instructions.

Performance will be affected by the installed software. Therefore installed software shall not be modified or changed during a set of tests.

4.2.3 Atmospheric conditions

Unless otherwise specified, the test procedures and measurements shall be carried out under the following atmospheric conditions (in accordance with ISO 554):

Temperature: (20 ± 5) °C

Air pressure: 86 kPa to 106 kPa

Temperature and humidity conditions if provided shall be aligned with manufacturer's instruction for good repeatability and reproducibility. Care should be taken to avoid changes during a test.

4.2.4 Lighting conditions

Unless otherwise specified, the test procedures and measurements shall be carried out under the following lighting conditions:

Intensity: (200 ± 50) lux

Colour temperature: 2 000 K to 6 000 K

Measurement shall be made at the test surface.

4.3 Test equipment and materials

Measurements on carpets shall be carried out on a level floor consisting of a smooth untreated laminated pine tree plate or equivalent panel, at least 15 mm thick and of a size appropriate for the test.

Equipment and materials for measurements (devices, test carpets, test dust etc.) to be used in a test shall, prior to the test, be kept for at least 16 h at standard atmospheric conditions according to 4.2.3.

4.4 Number of samples

All measurements of performance shall be carried out on the same sample(s) of the robot with its attachments, if any.

Tests carried out to simulate stresses a robot may be exposed to during normal use, possibly causing impairment of the robot performance, may require additional samples of replaceable parts. Such tests shall be carried out at the end of a test programme.

4.5 Preparation of battery

Any new battery shall need to go through at least one full charge and complete discharge cycle in the robot prior to conducting first test of the robot.

Complete discharge in the robot shall be done by performing a normal operation following the manufacturer’s instructions.

NOTE The complete discharge means low battery signal, if any, without any motion.

4.6 Operation of the mobile household robot

If not otherwise specified in this standard,

- The mobile household robot, its attachments, the docking station and any accessories shall be used and adjusted in accordance with the manufacturer's instructions for normal operation before a test is carried out, and
- The operation mode of the robot can be selected and adjusted per manufacturer published instructions only before the test to fit the environment to be operated.
- The operation mode shall be recorded.

Any safety-related device shall be allowed to operate.

4.7 Tolerance of dimensions

For all dimensions which are not presented as a range and no tolerance is specified, the tolerance shall be determined as Table 1.

Table 1 – Tolerance of linear dimension (from ISO 2768-1)

Nominal size range mm	**Tolerance** mm
> 3 ≤ 6	± 0,5
> 6 ≤ 30	± 1,0
> 30 ≤ 120	± 1,5
> 120 ≤ 400	± 2,5
> 400 ≤ 1 000	± 4,0
> 1 000 ≤ 2 000	± 6,0
> 2 000 ≤ 5 000	± 8,0
NOTE Values are taken from Table 1 of ISO 2768-1:1989.	

Table 2 – Tolerance of external radius and chamfer heights (from ISO 2768-1)

Nominal size range mm	**Tolerance** mm
> 0,5 ≤ 3	± 0,4
> 3 ≤ 6	± 1,0
> 6	± 2,0
NOTE Values are taken from Table 2 of ISO 2768-1:1989.	

5 Units

Unless otherwise stated, all dimensions are as follows:

– length in millimetres (mm)
– angle in degrees (°)
– time in seconds (s)
– mass in kilograms (kg)
– velocity in metres per second (m/s)

6 Pose measurements

6.1 General

This test assesses the ability of a robot to accurately arrive at a predetermined pose.

NOTE This test is most relevant to mobile household robot where the end point/orientation of the run is critical to success.

6.2 Test bed

6.2.1 General

The test shall be carried out in the centre area of the test room defined in IEC 62929 without area rug, chair legs, table legs and other items placed on the floor.

The size of the test bed is 4 000 mm × 5 000 mm. The floor shall be untreated laminated pine tree plate or equivalent and its thickness shall be at least 15 mm, or Wilton carpet as specified in IEC TS 62885-1.

6.2.2 Test mode

This mode shall enable the robot to perform a repeatable test mode action in which it shall be driven forward 1 000 mm and turned 90 degrees 4 times in order to form a single loop. This test shall be carried out in clockwise and anticlockwise loop as shown in Figure 1.The precise nature of access to the test mode shall be clearly stated by the manufacturer and it should be simple to execute. Once the test mode operation is completed it should leave the machine in an idle state.

NOTE Examples of access methods to the test mode could be to require the user to have a combination of buttons on the machine pressed when the robot is switched on, or for a combination of buttons to be held for a period of time which would not occur during normal robot operation. The only condition is that this access method is to be documented.

6.3 Test method

The fully charged robot with test mode shall be placed at the starting position as shown in Figure 1. The body centre of robot shall be on top of the starting point, and the robot body shall be aligned along the direction of travel. Clockwise and anti-clockwise operation commands shall be given to robot to follow the commanded paths individually as shown in Figure 1.

After the operation has been performed, the deviation (position and orientation) between actual **pose** and the commanded **pose** of the robot shall be measured. A single test for each operation (clockwise or anticlockwise) consists of three runs.

The floor material used shall be reported in the test report.

NOTE If the test mode which is to generate the motion required for the test is not readily available in the robot the test can be skipped.

The average deviation of the position dP for the trial shall be calculated from the three runs

$$dP = \frac{1}{3}\sum_{n=1}^{3} dP_n \quad .$$

where:

dP_n is the deviation of position from the n^{th} run, n= 1,2,3

dP is defined as the distance between body centre and starting position after run.

The average deviation of the orientation dA for the trial shall be calculated from the three runs

$$dA = \frac{1}{3}\sum_{n=1}^{3} dA_n \quad .$$

where:

dA_n is the deviation of absolute angle from the n^{th} run, n = 1, 2, 3

dA is defined as the angle between body centre and starting position after run.

Dimensions in millimetres

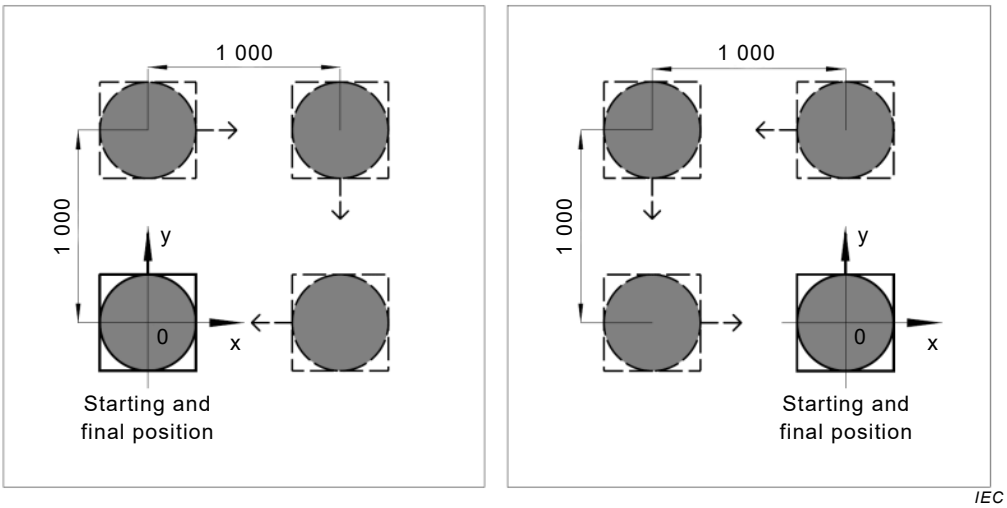


Figure 1 – Pose measurements configuration

7 Capability of homing function

7.1 General

This test assesses the ability of robot to find its way back to its charging station from a remote location, successfully align for recharging, and the time taken to do so.

7.2 Test bed

The length and the width of the test bed shall be 5 000 mm × 4 000 mm as specified in Figure 2. The ceiling height shall be at height of 2 500 mm ± 50 mm from the surface of the test bed floor. The partition wall height is 600 mm to 800 mm. The test floor shall be untreated laminated pine tree plate or equivalent and its thickness shall be at least 15 mm.

A white extension cable shall be installed on top of the baseboard by transparent tape along the east wall toward the partition wall, then up along the top of solid partition wall, to provide the power supply to the station at P_1. The cable from charging station shall be run up over the partition wall to the power supply. As for P_2, a white extension cable shall be installed from the east wall power socket along the baseboard toward to the P_2 station as shown Figure 2.

Dimensions in millimetres

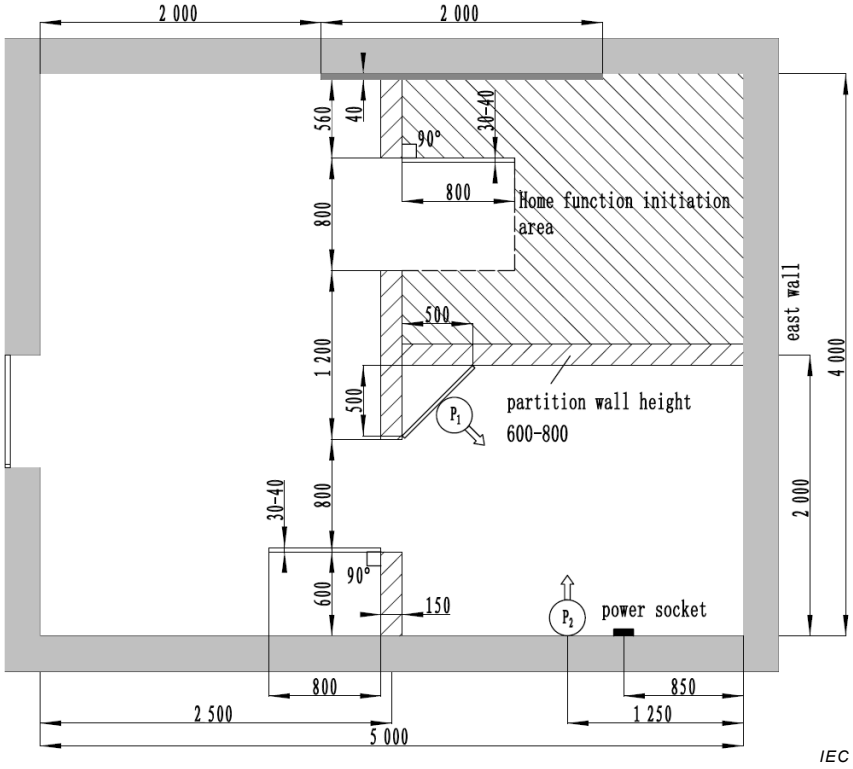


Figure 2 – Capability of homing function configuration

7.3 Test method

The fully charged robot shall be set in accordance with the manufacturer's instructions to perform its normal operation mode from the docking station P_1 and P_2 as shown in Figure 2. The home command shall be given when the whole body of the robot has entered the home function initiation area as shown in Figure 2. The time for returning to the docking station shall be measured and recorded as *t*. In case the robot cannot reach the docking station within 30 minutes the run shall be considered as not completed, including the robot not successfully returning to the charging station. The successful return to the charging station shall be defined as docked and able to initiate the charging process.

A single test trial consists of 5 runs from each starting position and all results shall be reported.

The capability of homing function shall be indicated by the completion rate and average time.

The completion rate shall be calculated as following:

$$R = \frac{C}{10} \times 100\ \%$$

where:

R is the completion rate of returning to the charging station in percentage

C is the number of completion

Average time of returning to the charging station shall be calculated as follows:

$$\overline{t} = \frac{\sum_{i=1}^{n} t_i}{n}$$

where:

t_i is the returning time for from the i^{th} completion case

n is the number of completion

$\bar{t}$ is the average returning time of returning to the charging station

If additional devices are available to improve the guidance of the robot, these can be optionally added according to manufacturer's instructions and shall be recorded in the test report.

8 Operation time per single charge

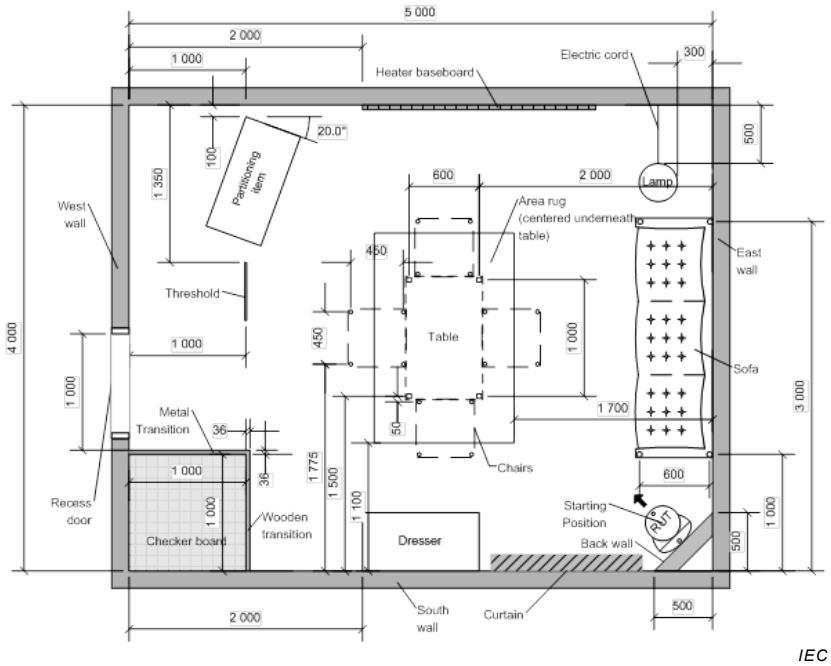
8.1 General

This test estimates the maximum permitted operation time of a robot per single charge cycle.

8.2 Test bed

The length and the width of the test bed shall be 5 000 mm × 4 000 mm as specified in Figure 3. The height of the wall surrounding the test bed floor shall be at least 300 mm. The ceiling height of the room above the test bed shall not be higher than 3 500 mm. The test floor shall be untreated laminated pine tree plate or equivalent and its thickness shall be at least 15 mm. Further furniture details are shown in Annex A.

Dimensions in millimetres



NOTE Test bed in Figure 3 is referred to Figure 8 as described in IEC 62929:2014.

Key

RUT – robot under test

Figure 3 – Operation time per single charge configuration

8.3 Test method

Prior to the test, the robot should be discharged completely by operating it in a sufficiently large area to ensure a complete discharge. Remove the charge station once it is in operation to ensure complete discharge.

NOTE 1 The complete discharge means low battery signal, if any, without any motion.

After discharge the robot shall be fully charged according to the manufacturer's instruction. The test shall be carried out immediately, or the robot shall be removed from the charging station and powered off to prevent additional power dissipation.

The total energy input to the battery charger while charging the robot shall be recorded as E_{max}.

After that, the fully charged robot shall be placed at the starting position as shown in Figure 3. The robot shall be run in the chosen operation mode in the test room until it stops by itself away from charge station or cannot be restarted, or has reached the charge station. Record the total operation time as t_{work} and the chosen operation mode.

The robot shall be fully recharged according to the manufacturer's instruction. The corresponding a.c. energy consumption shall be recorded as E_{work}.

The operation time per single charge is calculated as follows:

$$T_{max} = (E_{max}/E_{work}) \times t_{work}$$

where:

T_{max} is operation time per single charge

E_{max} is the corresponding *a.c.* energy consumption for robot from completely discharged to fully charged

E_{work} is the corresponding *a.c.* energy consumption for robot from fully charged to completely discharged after each run

t_{work} is the total operation time for each run

Three runs shall be carried out, and the average shall be considered as the result of the operation time per single charge.

NOTE 2 This calculation is based on assumption of linear relationships for charging behaviour.

NOTE 3 Although this test method is only defined as single test, the tester, may perform more than 1 test.

NOTE 4 Due to tolerances of the measurement if $E_{work} > E_{max}$, then set $T_{max} = t_{work}$.

9 Managing a single step

9.1 General

The purpose of the test is to determine the robot's management of a single step whilst moving during activities. The mobile robot shall be moving throughout the test time and it is permitted to restart the robot to encourage movement when terminated because of its function. Other possible tasks (e.g. air purifying without movement) are not understood as movement and the time for these tasks are not included to the overall test time.

NOTE The tester is allowed to restart the robot to encourage movement if necessary.

9.2 Test bed

The test bed is shown as in Figure 4. The test bed consists of the base and the step. The base and the step shall be made of untreated laminated pine tree. No surrounding walls shall be placed around the test bed within 700 mm and the test setup shall not be altered during the test.

NOTE 1 It is possible to use different colours and materials for the test bed and floor in different combinations. In this case, the test result may be different.

NOTE 2 In case the robot footprint size is bigger than the size of the test bed, this test method is not applicable.

Dimensions in millimetres

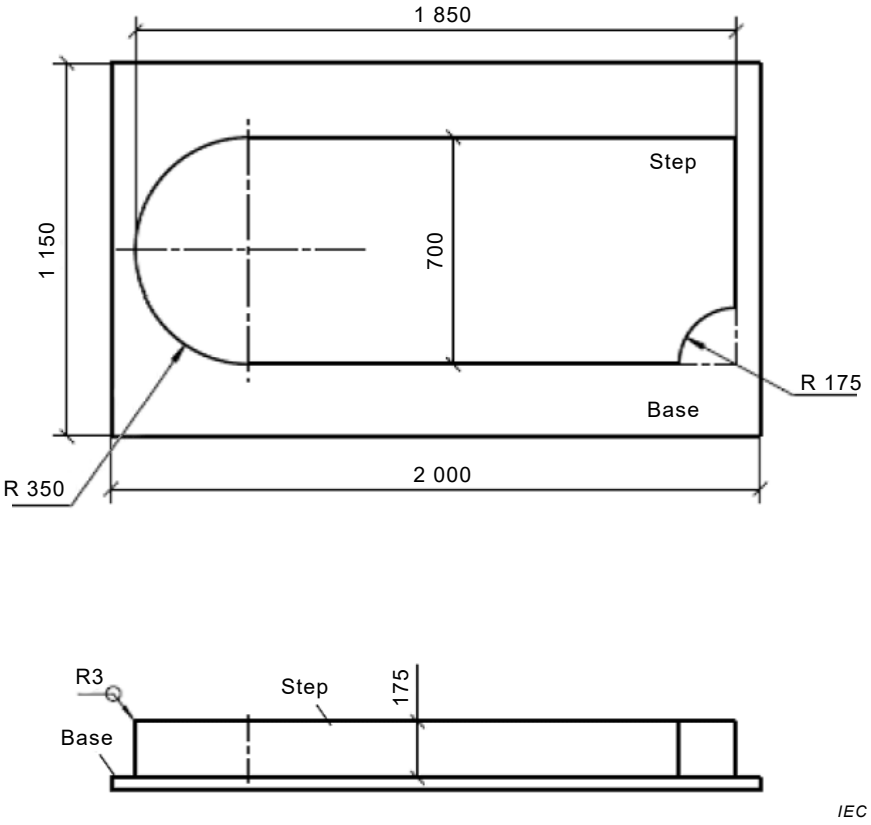


Figure 4 – Managing a single step configuration

9.3 Test method (autonomous modes)

Place the fully charged robot at the starting position as shown in Figure 5. The robot shall operate for 10 min following the manufacturer's instructions. The behaviour of the robot shall be recorded. Different behaviour is possible:

i) Base Touching: The robot does not stop in front of the step, and any part of the robot touches the base plate. The test shall be stopped.

ii) Hanging: The robot hangs at the edge of the step (without any part of it in contact with the base plate) and is not able to continue its movement. In this case, the robot shall be given the opportunity to recover until the 10 min test time is completed. If the robot displays an error message, the test shall be stopped before the 10 min test time is reached.

iii) Running: The robot continues running on the table and detects the edges. In case the robot stops itself during the 10 min test time, the robot shall be restarted at the position, where it stopped, until the 10 min test time is reached.

The test shall be repeated three times in all possible operation modes following the manufacturer's instructions. The behaviour (base touching, hanging, running), the time, and the operation mode shall be recorded for each test.

Dimensions in millimetres

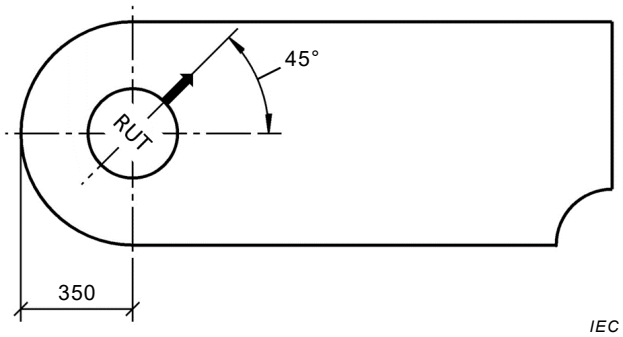


Figure 5 – Starting position for managing a single step test

9.4 Test method (manual modes)

NOTE This method is only applicable if the robot can be moved in a manual mode by the operator.

Place the fully charged robot at the starting position as shown in Figure 5 (refer to 9.2). The robot shall be moved manually for 10 min by the operator in all possible modes. The operator shall try to move the robot over the edge. The robot behaviour shall be recorded in accordance with the given behaviours in 9.2. The test shall be continued until the 10 min test time is reached. All different behaviour (base touching, hanging, running) and the corresponding test times shall be recorded.

10 Obstacle avoidance

10.1 General

This test determines whether a robot makes head-on contact with an object, and if so, with what force.

10.2 Test bed

The test equipment which consists of signal sampling instrument, tester base, force sensor, slide rail, and baseboard are shown in Figure 6. The height of the surrounding guide shall be at least 300 mm. The frequency of signal sampling equipment shall be at least 10 kHz. The tester base shall be fixed on the floor to avoid movement. The force sensor is connected with signal sampling instrument. The baseboard is connected with the slide rail and the surface colour of the baseboard shall be untreated laminated pine tree plate. The height and thickness of the baseboard is 80 mm × 10 mm, its length could be specified by tester and recommended length is 200 mm, 100 mm and 50 mm. The baseboard shall be installed 2 mm ±1 mm above the floor and it shall be adjusted according to the height of robot if required. In order to detect the minimum avoidance distance, a high speed camera with at least 50 fps shall be installed above baseboard, and a ruler with a range of 0 to 500 mm with millimetres graduation shall be placed in between the robot and baseboard on the test bed as shown in Figure 7.

Dimensions in millimetres

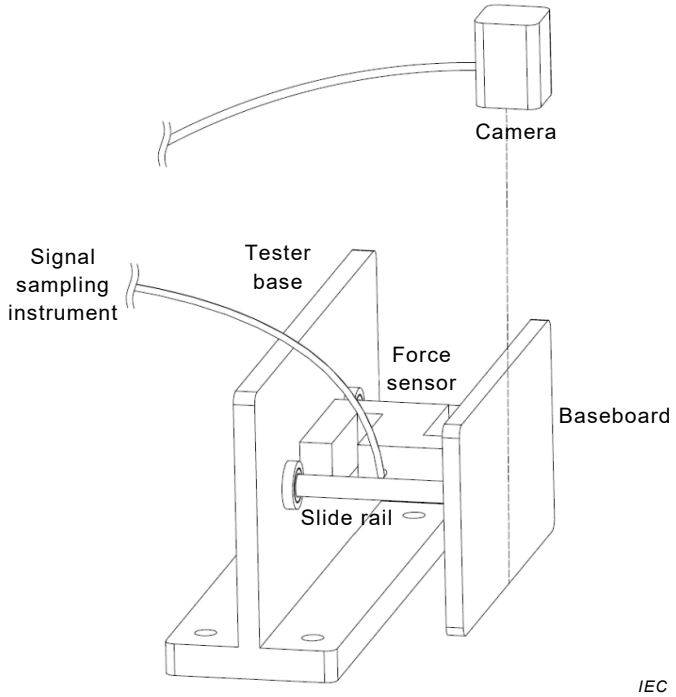


Figure 6 – Obstacle avoidance configuration

Dimensions in millimetres

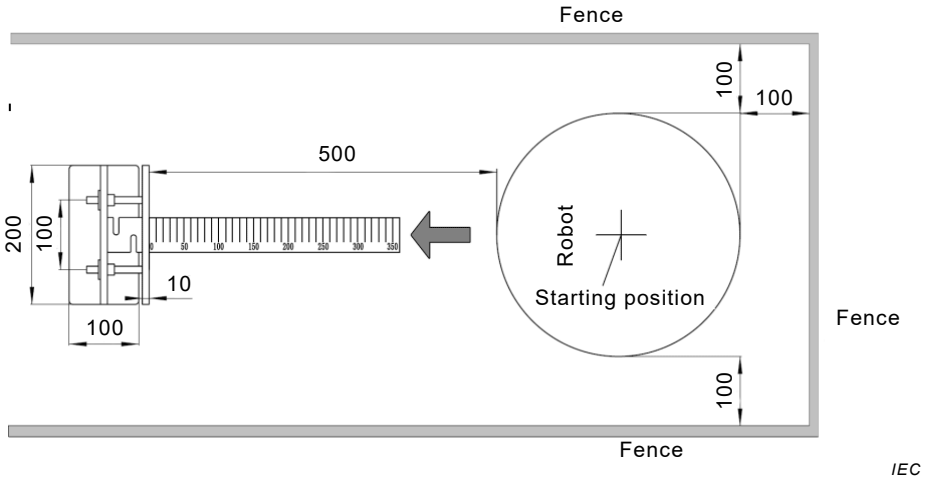


Figure 7 – Starting position for obstacle avoidance test

10.3 Test method

Place the fully-charged robot at the starting position as shown in Figure 7.The robot shall be instructed to perform its normal operation towards the target. The baseboard shown in Figure 6 is an example of an object which can be used as the target .The test shall be terminated if the robot makes a turn or collides with the target. The tester can decide to substitute the baseboard with a different target dimension of their choice. The details of the target shall be clearly referenced in the report. (e.g.: colour, dimension, shape etc.)

NOTE The robot is allowed to warm-up for learning the test environment.

The test will be carried out 5 times, and shall be terminated as per following conditions:

Case 1: Robot avoids the obstacle successfully

Robot is moved toward and does not make contact with the obstacle. The test shall be terminated and the minimum avoidance distance shall be recorded by camera. If the robot stops permanently for any reason during the test, it shall be restarted from the starting position. The rate of avoiding the obstacle shall be indicated as follows.

$$R = \frac{S}{5} \times 100\ \%$$

where:

R is the rate of avoiding the obstacle in percentage

S is the number of avoiding the obstacle

Case 2: Robot collides with obstacle

The test shall be terminated if the robot collides with the obstacle.

The maximum force shall be recorded.

The average force of collision with the obstacle shall be calculated as follows:

$$\bar{F} = \frac{\sum_{i=1}^{n} F}{n}$$

where

F is the maximum force of colliding the obstacle after i^{th} collision case

N is the number of collisions with the obstacles

$\bar{F}$ is the average force of collision with the obstacle

11 Cable traversing behaviour

11.1 General

This test measures the impact of the mobile household robot has on a cable when the robot tries to cross it. By having the cable attached to a pendulum it is possible to measure the pendulum swinging distance. The swinging distance corresponds to the pulse transferred to the cable.

NOTE This is a comparative test within a single lab and absolute values may not be repeatable in different laboratories.

11.2 Test bed

11.2.1 General

The length and width of the test bed shall be at least 2 000 mm × 1 150 mm. Only the obstacle under test shall be placed in the test bed area. A scale, similar to a dartboard, shall be put on the floor where there is a free space, in order to ensure that there is no impact from the surroundings on the product. A carbon fibre pendulum hanging freely from the ceiling with its bottom end freely movable in its X and Y-axes, with Z defined in the direction of the pendulum, and coordinate system fixed at the centre of the pendulum. The pendulum shall be mounted in such a way as the bottom edge sits 15 mm above the floor level. Insert an eyelet into the bottom of the tube through which the wire should be run so that it does not lose contact with the stick as shown in Figure 8.

The length of the carbon fibre tube shall be 2,5 m ± 0,2 m and 20 mm to 40 mm outside diameter. It is important that the pendulum is as stiff and lightweight as possible to get a stable and repeatable result. Colour is preferred matt black and weight shall be 285 g ± 30 g. An extra weight of 800 g shall be firmly attached inside the tube at the bottom in order to create a centre of mass as low as possible. The test shall be performed on untreated laminated pine tree plate or equivalent and its thickness shall be at least 15 mm.

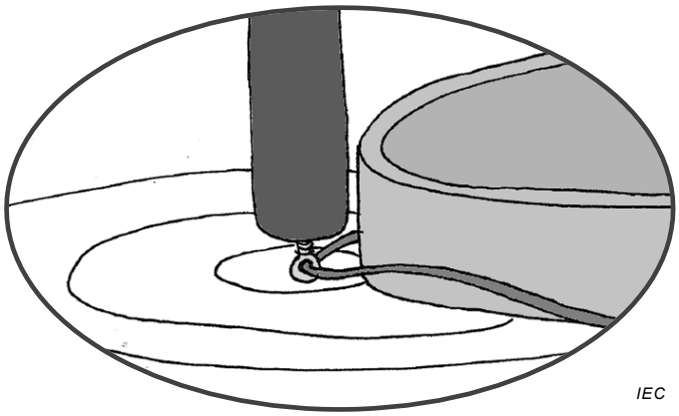


Figure 8 – Wire fastening configuration

11.2.2 Circles mark setting

Set the pendulum centre point at the centre of the circles, and then draw 120 circles with diameter from 10 mm to 1 200 mm in 10 mm intervals as shown in Figure 9.

Dimensions in millimetres

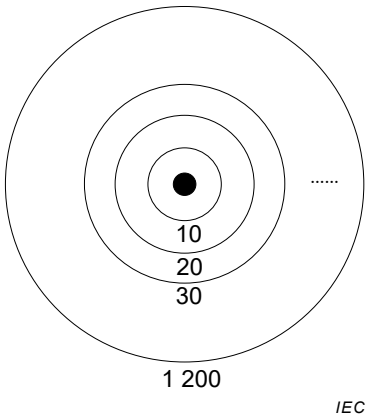


Figure 9 – Floor circle marks schematic diagram

11.2.3 Cable

Any cables used in the test shall be reported. They shall be representative for common indoor cables. For example:

- a flat charger cable with 2 conductors and approximate cross sectional dimensions of 3,7 mm × 1,8 mm.
- a round cable with three conductors with approximate diameter of 7 mm normally used for indoor applications such as table lamps.

The minimum length of the cable is 1 200 mm and it can be extended if required for larger size robot. The length of cable used in the test shall be recorded. The cable shall then be placed at least 100 mm in front of the robot in the longitudinal direction, with the pendulum behind the machine and the cable surrounding it, as shown in Figure 10. The cable must not be perfectly flat to the floor; instead it shall be dropped freely and let to create snares and

imperfections. The maximum height allowed for any snare or bump shall not be allowed to be more than 40 mm and the average along the complete cable shall be about 10 mm to 20 mm.

Dimensions in millimetres

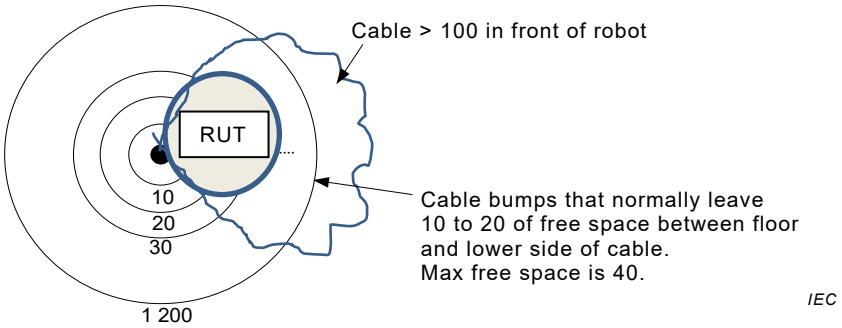


Figure 10 – Floor circle marks schematic diagram with robot

11.3 Test method

Base position: Use any suitable program for the test, preferably one with high speed and straight motions of the robot. Let the robot run straight ahead with the pendulum behind itself in the centre of the product as shown in Figure 11. Check the pendulum centre point movement as shown in Figure 12. This roughly corresponds to the energy transferred to the obstacle.

Dimensions in millimetres

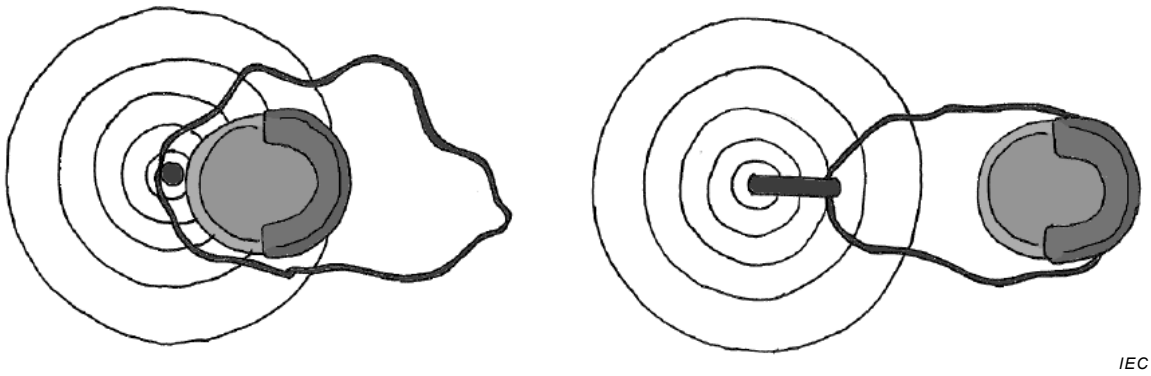


Figure 11 – Top view of cable traversing behaviour Configuration

Dimensions in millimetres

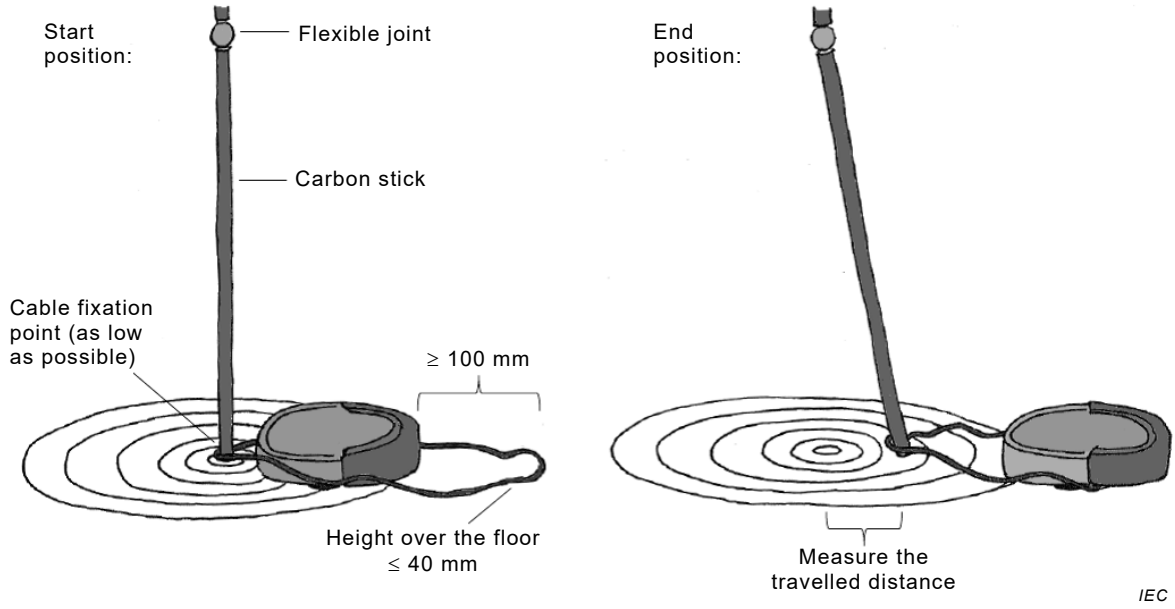


Figure 12 – Side view of cable traversing behaviour Configuration

The test will be carried out at least 10 times and there are 3 possible test outcomes:

Outcome 1: The robot runs over cable, with or without, any displacement of the pendulum. Report the pendulum's maximum swinging distance.

Outcome 2: The robot runs over the cable and becomes entangled in the cable. Report pendulum's maximum swinging distance and cable stuck condition.

Outcome 3: The robot detects the cable, and determines to take another action for handling. Report the pendulum's maximum swinging distance and type of action.

Make a table and report average and maximum swinging distance of pendulum. Extra comments may be added if the result is outcome 2 or outcome 3.

Annex A
(normative)

A.1 General

The test area shall consist of a space measuring 4 000 mm × 5 000 mm (tolerance ± 50 mm) enclosed by four walls and a ceiling. The test floor shall be untreated laminated pine tree plate or suitable alternative. The dimensions and characteristics of the furniture and obstacles on the floor are specified in Table A.1, and the obstacles around table are specified in Figure A.1.

Dimensions in millimetres

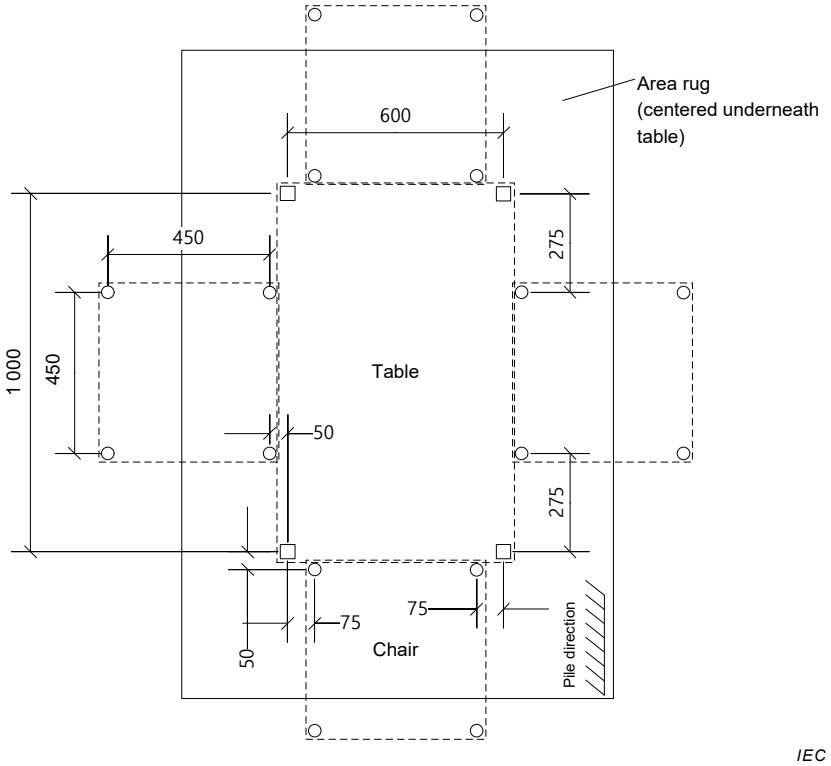


Figure A.1 – Details of obstacles around table

Table A.1 – Dimensions of furniture and obstacles

Item	Quantity	Dimensions (mm)	Surface/ Colour	Remarks
Dresser	1	1 000(L) 500(W) 300(H)	White	It is fixed to the floor. Underneath of the dresser shall be blocked. No legs.
Table	1	1 000 (L) 600 (W)	Natural Cherry	4 legs of 40 mm (L) × 40 mm (W) × 300 mm(H) Distance of 1 000 mm (L) and 600mm (W) are between centrelines of legs. Legs are fixed to the floor.
Chairs	4	450 (L) 450 (W)	Natural Cherry	4 legs of 35 mm (Diameter) × 300 mm (H). Distance between centrelines of legs is 450 mm. Legs are fixed to the floor.
Sofa	1	2 000 (L) 600 (W)	White	4 legs of 48 mm (Diameter) × 300 mm (H). Distance of 2 000 mm (L) and 600 mm (W) are between centrelines of legs. Legs are fixed to the floor.
Partitioning Item	1	1 000 (L) 500 (W) 300(H)	18 % grey	No legs. All sides are enclosed. It is fixed to the floor.
Floor lamp	1	330 (Diameter) 300 (H)	White	Base is 5 mm (H) at the outer edgewith10 degree upward slope. Diameter of the pole at the centre is 30 mm. It is fixed to the floor.
Floor electrical wire	1	6 (Diameter) 900 (L)	Black	One end is fixed at the plug on the north wall at height of 350 mm and the other end is fixed at the side of the lamp base of the lamp. It is not fixed on the floor.
Cylindrical bar	1	15 (Diameter) 500 (L)	Untreated surface	It is cylindrical shape and made of aluminium. It is fixed to the floor. NOTE It represents a cylinder shape of chair legs.
Heater baseboard	1	2 000 (L) 40 (W) 300 (H)	Natural Cherry	It is secured on the wall and floor. It is fixed on the floor.
Area rug	1	1 680 (L) 1 200 (W) 10(H)	Ivory	Wilton type area rug It is fixed to the floor.
Checker board	1	1 000 (L) 1 000 (W) 7 (H)	Black and White	Each tile shall be of size of 100 (±10) mm (W) × 100 (±10) mm (D) × 7 mm (H). White tile surface shall be polished. Matt black is without polishing. Tiles shall be fixed on the floor with no gaps between tiles. The transitions shall be fixed on the floor.

Item	Quantity	Dimensions (mm)	Surface/ Colour	Remarks
Metal transition	1	36 (W) 2 (H)	Untreated surface	Aluminium (refer to Figures A.2 and A.4 for installation) It is M-D Building Products (36"L × 2"W, Model #43858, polished) or similar. It is fixed to the floor. For the corner where the metal transition meets the wooden transition both transitions shall be cut with 45 degrees.
Wooden transition	1	36.5 (W) 10 (H)	Finished wood	Wood (Refer to Figures A.3 and A.4 for installation). It is a Bruce Natural Reducer (Model #11177810) or similar. It is fixed to the floor.
NOTE All colours are specified in web colour RGB format and intended to be an indicative guide of the proposed colour. Colour can vary by ±5 % in each RGB value.				

Dimensions in millimetres

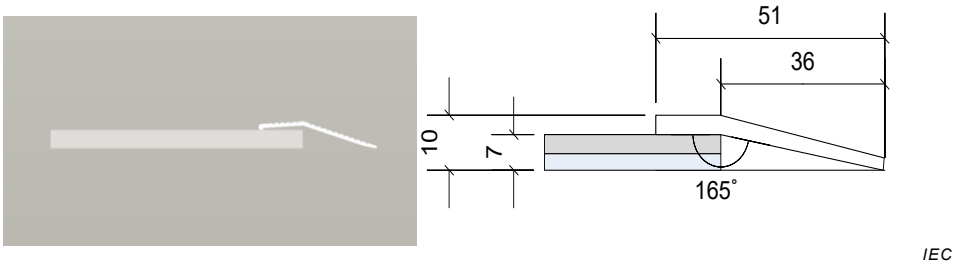


Figure A.2 – Illustration of metal transition installation

Dimensions in millimetres

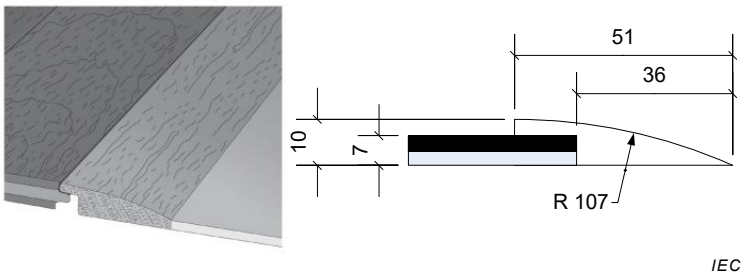


Figure A.3 – Illustration of wood transition Installation

Dimensions in millimetres

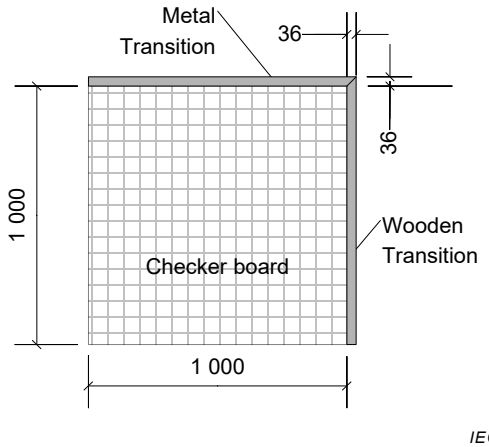


Figure A.4 – Detail view of checker board and transitions

A.2 Door specification

The configuration of the door shall be as in Figure A.5. The door shall have four inset panels. The door shall be surrounded by a frame of 50 mm (W) that shall be mounted flush to the wall (resulting in the door being recessed from the wall by 50 mm). The frame may be shaped on its inner edge only, by a single curved feature with a maximum radius of 50 mm. The handle shall be mounted on the right hand side (when viewed from inside the test area). The door may be opened. If so, the door shall open outwards from the test area.

Dimensions in millimetres

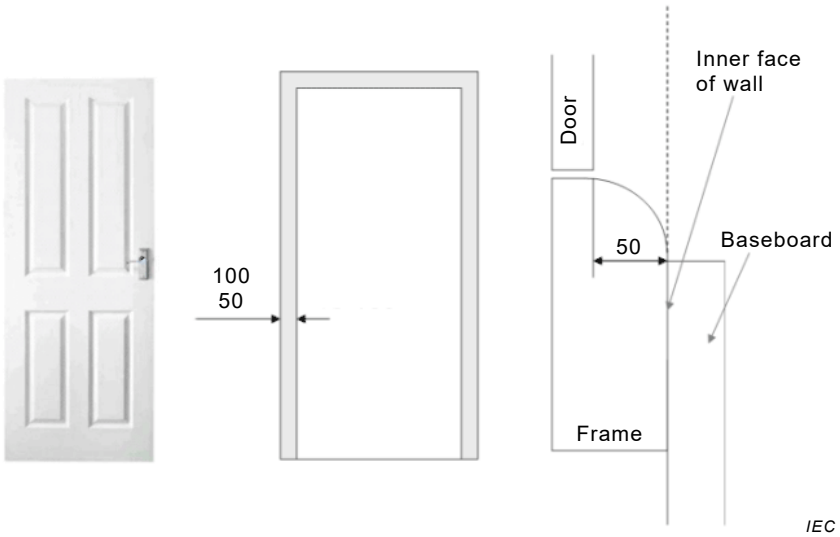


Figure A.5 – Illustration of four-panel door

Bibiography

IEC 60335-1:2010, *Household and similar electrical appliances – Safety – Part 1: General requirements*

ISO 8373, *Robots and robotic devices-vocabulary*

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