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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Performance evaluation methods of mobile household robots

Méthodes d'évaluation de l'aptitude à la fonction des robots mobiles à usage domestique

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMMISSION ELECTROTECHNIQUE INTERNATIONALE

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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- withdrawn,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.

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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

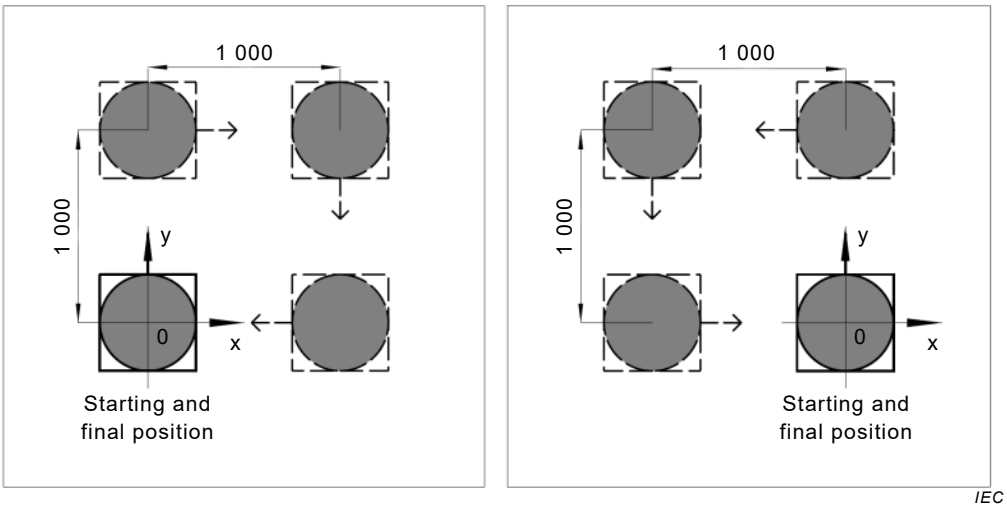

Figure 1 – Pose measurements configuration

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

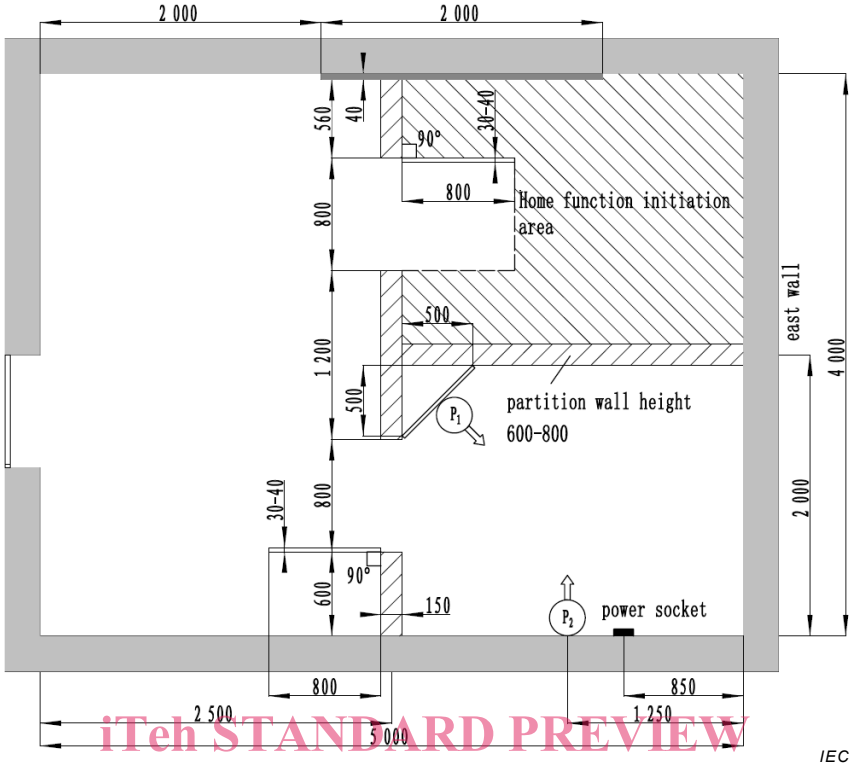

Figure 2 – Capability of homing function configuration

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:

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