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**Robotics — Application of ISO 13482 —  
Part 1:  
Safety-related test methods**

*Robotique — Application de l'ISO 13482 —  
Partie 1: Méthodes d'essai liées à la sécurité*

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# Contents

Page

<b>Foreword</b>	<b>vi</b>
<b>Introduction</b>	<b>vii</b>
<b>1 Scope</b>	<b>1</b>
<b>2 Normative references</b>	<b>1</b>
<b>3 Terms and definitions</b>	<b>1</b>
<b>4 Test conditions</b>	<b>2</b>
4.1 General	2
4.2 Environmental conditions	2
4.3 Test travel surface	2
4.4 Safety of persons involved in testing	3
4.4.1 General	3
4.4.2 Safety harness	3
<b>5 Selection of test sample</b>	<b>4</b>
<b>6 Test of physical hazard characteristics (universal)</b>	<b>4</b>
6.1 Voltage at user-accessible parts	4
6.1.1 Principle	4
6.1.2 Apparatus	5
6.1.3 Procedure	5
6.2 Acoustic noise	6
6.2.1 Principle	6
6.2.2 Apparatus	6
6.2.3 Procedure	6
6.2.4 Pass/fail criteria	7
6.3 Surface temperature	7
6.3.1 Principle	7
6.3.2 Apparatus	8
6.3.3 Procedure	8
6.3.4 Pass/fail criteria	9
<b>7 Test of physical hazard characteristics (for mobile robot)</b>	<b>9</b>
7.1 Injury parameters in collision	9
7.1.1 Principle	9
7.1.2 Apparatus	10
7.1.3 Procedure	10
7.1.4 Pass/fail criteria	11
7.2 Test of force control for intended and unintended contact with a robot	11
7.2.1 Principle	11
7.2.2 Apparatus	12
7.2.3 Procedure	12
7.2.4 Pass/fail criteria	13
<b>8 Test of physical hazard characteristics (for restraint type physical assistant robot)</b>	<b>13</b>
8.1 Principle	13
8.2 Apparatus	14
8.3 Procedure	16
8.4 Pass/fail criteria	17
<b>9 Test of endurance characteristics (universal)</b>	<b>18</b>
9.1 Endurance to environmental temperature/humidity fluctuations and vibration combined with these fluctuations	18
9.1.1 General	18
9.1.2 Temperature/humidity test	18
9.1.3 Sealing test	19
9.1.4 Robustness test	19

9.1.5	Pressure test.....	19
9.1.6	Pass/fail criteria.....	20
9.2	Durability in locomotion (mobile robot).....	20
9.2.1	Principle.....	20
9.2.2	Apparatus.....	20
9.2.3	Procedure.....	22
9.2.4	Pass/fail criteria.....	22
<b>10</b>	<b>Test of endurance characteristics (for mobile robot).....</b>	<b>22</b>
10.1	Endurance to collision impact.....	22
10.1.1	Principle.....	22
10.1.2	Apparatus and procedure.....	23
<b>11</b>	<b>Test of static stability characteristics.....</b>	<b>23</b>
11.1	Principle.....	23
11.2	Apparatus.....	23
11.3	Procedure.....	23
11.4	Pass/fail criteria.....	24
<b>12</b>	<b>Test of dynamic stability characteristics with respect to moving parts (for mobile robot).....</b>	<b>24</b>
12.1	Principle.....	24
12.2	Apparatus.....	24
12.3	Procedure.....	24
<b>13</b>	<b>Test of dynamic stability characteristics with respect to travel (for mobile robot).....</b>	<b>25</b>
13.1	General.....	25
13.1.1	Principle.....	25
13.1.2	Apparatus.....	25
13.1.3	Procedure.....	25
13.2	Stability test on a flat surface.....	26
13.2.1	Braking test on split surface.....	26
13.2.2	Acceleration test on split surface.....	26
13.2.3	Acceleration test from stationary condition.....	26
13.3	Stability test on inclined surface.....	27
13.3.1	General.....	27
13.3.2	Maximum speed test on downward slope.....	27
13.3.3	Downward slope acceleration and braking test.....	28
13.3.4	Upward slope acceleration test.....	29
13.3.5	Downward slope full turn test.....	30
13.3.6	Inclined surface crossing test.....	31
13.3.7	Pivot turn on inclined surface test.....	32
13.4	Stability test for steps and gaps.....	32
13.4.1	General.....	32
13.4.2	Moving upward from stop position.....	32
13.4.3	Moving up at maximum speed.....	33
13.4.4	Moving up while accelerating.....	33
13.4.5	Descending step at low speed.....	34
13.4.6	Descending step at maximum speed.....	34
13.4.7	Gap crossing test.....	35
13.5	Pass/fail criteria.....	36
<b>14</b>	<b>Test of safety-related control functions (universal).....</b>	<b>37</b>
14.1	Test of integration of electro-sensitive protective equipment (ESPE).....	37
14.1.1	Principle.....	37
14.1.2	Sampling.....	37
14.1.3	Apparatus.....	37
14.1.4	Procedure.....	38
14.2	Test of operation in slippery environments.....	39
14.2.1	Principle.....	39
14.2.2	Apparatus and procedure.....	40
14.3	Electromagnetic immunity.....	40

14.3.1	Principle .....	40
14.3.2	Apparatus .....	40
14.3.3	Procedure .....	40
<b>15</b>	<b>Response to safety-related obstacles on the ground (for mobile robot) .....</b>	<b>41</b>
15.1	Distance of protective stop .....	41
15.1.1	Principle .....	41
15.1.2	Apparatus .....	41
15.1.3	Procedure .....	43
15.2	Distance and speed in safety-related speed control .....	44
15.2.1	Principle .....	44
15.2.2	Apparatus and procedure .....	45
15.3	Distance of stopping before convex terrain .....	45
15.3.1	Principle .....	45
15.3.2	Apparatus .....	45
15.3.3	Procedure .....	45
15.4	Distance of stopping before concave terrain .....	47
15.4.1	Principle .....	47
15.4.2	Apparatus .....	47
15.4.3	Procedure .....	48
<b>16</b>	<b>Test of safety-related localization and navigation .....</b>	<b>50</b>
16.1	Principle .....	50
16.2	Apparatus .....	50
16.3	Procedure .....	51
<b>17</b>	<b>Test of reliability of autonomous decisions and actions (universal) .....</b>	<b>51</b>
17.1	General .....	51
17.2	Object identification .....	52
17.2.1	Principle .....	52
17.2.2	Apparatus .....	52
17.2.3	Procedure .....	52
<b>18</b>	<b>Command devices (universal) .....</b>	<b>52</b>
18.1	Safe operation in case of connection, disconnection or reconnection of a command device .....	52
18.1.1	Principle .....	52
18.1.2	Apparatus .....	52
18.1.3	Procedure .....	53
18.2	Response to multiple or unintended command devices .....	53
18.2.1	Principle .....	53
18.2.2	Apparatus .....	53
18.2.3	Procedure .....	53
18.3	Safe operation in case of loss of communication by cableless or detachable command devices .....	53
18.3.1	Principle .....	53
18.3.2	Apparatus .....	54
18.3.3	Procedure .....	54
<b>19</b>	<b>Test report .....</b>	<b>54</b>
<b>Annex A (informative) Information for evaluating test results .....</b>		<b>55</b>
<b>Annex B (informative) Mechanical characteristics of the artificial hypodermis and underneath .....</b>		<b>66</b>
<b>Annex C (informative) Dummy for driverless tests of self-balancing person carrier robot .....</b>		<b>68</b>
<b>Annex D (informative) Examples of the test report format .....</b>		<b>70</b>
<b>Annex E (informative) Measurement test and damage observation on surrogate skin piece: .....</b>		<b>74</b>
<b>Bibliography .....</b>		<b>76</b>

## 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](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 299, *Robotics*.

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](http://www.iso.org/members.html).

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## Introduction

This document describes test methods used to verify safety criteria of personal care robots. This document is intended to facilitate ISO 13482, which summarizes the safety requirements of personal care robots. This document describes test methods which are guidelines to verify compliance to the requirements of ISO 13482. Together with the other verification and validation methods described in ISO 13482, they are selectively applicable according to the robot design and usage.

At the time of publication, the test methods described in this document have not been implemented or evaluated broadly. Due to a lack of test facilities worldwide able to conduct such tests, it has not been possible to conduct formal round robin tests. Users of this document are therefore advised to apply the tests with care.

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# Robotics — Application of ISO 13482 —

## Part 1: Safety-related test methods

### 1 Scope

This document describes methods that can be used to test personal care robots in terms of safety requirements defined in ISO 13482. The target robots of this document are identical to those of ISO 13482.

The manufacturer determines the required tests and appropriate testing parameters based on a risk assessment of the robot's design and usage. This risk assessment can determine that tests and test parameters other than those contained in this document are acceptable.

Not all test methods are applicable to all robot types. Test methods labelled “universal” are applicable to all personal care robots. For other tests, the heading states for which robot types the test can be applied (e.g. “for wearable robot” or “for mobile robot”).

Some test methods can be replaced by using other applicable standards, even if they are not listed in this document.

### 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.

ISO 13482:2014, *Robots and robotic devices — Safety requirements for personal care robots*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 13482:2014 and the following apply.

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

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

#### 3.1

##### **autonomy**

ability to perform intended tasks based on current state and sensing, without human intervention

[SOURCE: ISO 8373:2012, 2.2]

### 3.2

#### **operator**

person designated to make parameter and program changes, and to start, monitor, and stop the intended operation of the personal care robot

[SOURCE: ISO 8373:2012, 2.17, modified — The words “to make parameter and program changes, and” have been added, and the words “of a robot or robot system” have been replaced with “of the personal care robot”.]

### 3.3

#### **electro-sensitive protective equipment**

##### **ESPE**

assembly of devices and/or components working together for protective tripping or presence-sensing purposes and comprising at a minimum

- a sensing device,
- controlling/monitoring devices,
- output signal switching devices and/or a safety-related data interface

Note 1 to entry: The safety-related control system associated with the ESPE, or the ESPE itself, can further include a secondary switching device, muting functions, stopping performance monitor, etc.

Note 2 to entry: A safety-related communication interface can be integrated in the same enclosure as the ESPE.

[SOURCE: ISO 13855:2010, 3.1.4, modified — The words “and/or a safety-related data interface” have been added, and the original Note has been replaced with Notes 1 and 2 to entry.]

## 4 Test conditions

### 4.1 General

This clause describes typical operating conditions for indoor use. Where applicable, tests are carried out under the worst-case operating conditions.

Unless specified differently, the robot is completely assembled, fully charged, and operational based on the manufacturer's specification for all tests. All self-diagnostic tests are satisfactorily completed.

### 4.2 Environmental conditions

The following environmental conditions apply during all tests:

- ambient temperature: 10 °C to 30 °C;
- relative humidity: 0 % to 80 %.

If the environmental conditions specified by the manufacturer are outside the given conditions, this is declared within the test report.

### 4.3 Test travel surface

The coefficient of friction for test travel surface is between 0,75 and 1,0 (see ISO 7176-13) unless specified otherwise by the manufacturer.

## 4.4 Safety of persons involved in testing

### 4.4.1 General

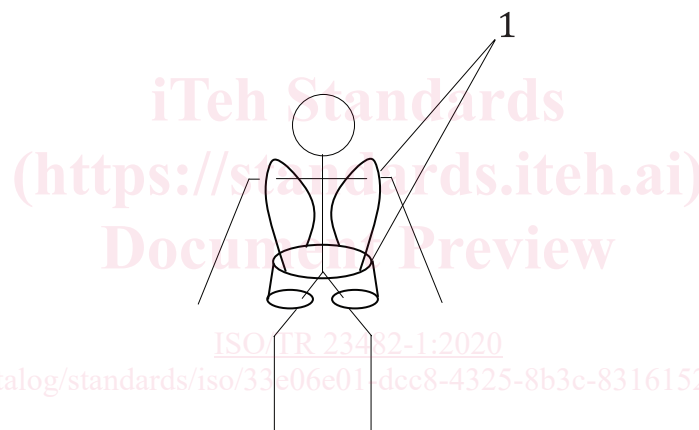
During the preparation and conduction of verification and validation tests, the persons involved in testing are protected as far as possible from any risk originating from the robot and the test apparatus. Special attention is paid when tests provoke hazardous situations such as collisions and instability.

Where possible, tests are conducted remotely with no person near the robot. Human presence and intervention are simulated where applicable by using dummies.

Where a human tester cannot be replaced by a dummy or by an automated device, a risk assessment is performed to identify the hazards that can occur during the test. Where necessary, test persons are advised to wear protective equipment to lower risks from collision and falling.

### 4.4.2 Safety harness

The test operator of a person carrier robot and physical assistant robot is exposed to hazards of falling down. Therefore, in addition to conventional safety apparatus such as helmets, kneepads and elbow pads, the test operator is secured by a safety harness suspended from a supporting structure over the test travel surface if the expected risk is not tolerable ([Figure 1](#)).



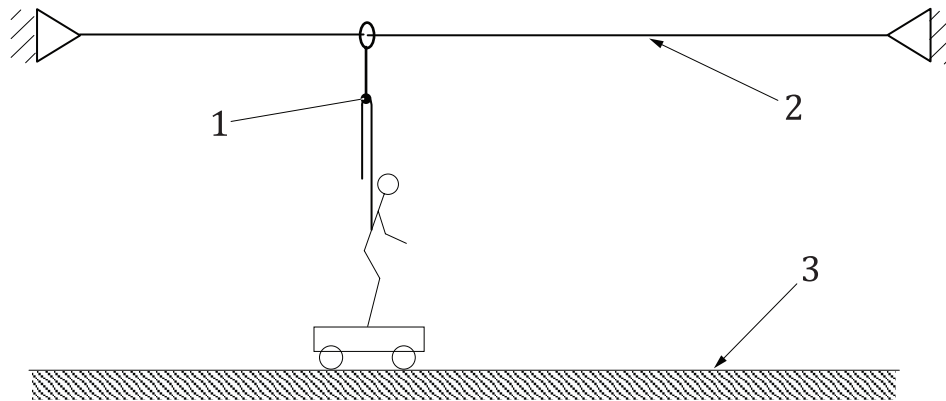
#### Key

1 safety jacket

**Figure 1 — Example of safety harness**

The safety harness has sufficient reliability, equivalent to harnesses used for fall protection. The cable connected to the supporting structure has sufficient elasticity. Additionally, its length is adjusted to prevent the test operator from falling to the travel surface. The supporting upper structure can be a rigid rail or a flexible wire on which a pulley block runs. The pulley block can be powered to follow the test operator's movement. ([Figure 2](#))

NOTE ISO 16024 specifies design and performance of personal protective equipment for protection against falls from a height.



**Key**

- 1 movement device
- 2 guide rail
- 3 test travel surface

**Figure 2 — Example of supporting upper structure and pulley block**

## 5 Selection of test sample

The sample item, either a robot system or a robot component, is representative of the target design.

NOTE 1 If the sample item is broken, it is repaired or replaced between test sequences.

NOTE 2 Some functions of the sample can be intentionally disabled or tuned when the test demands irregular conditions, e.g. an obstacle detection sensor in a mobile-type robot is disconnected in a collision impact test.

## 6 Test of physical hazard characteristics (universal)

### 6.1 Voltage at user-accessible parts

#### 6.1.1 Principle

This test measures voltages supplied at user-accessible parts in order to verify designs protecting against “contact with live parts of the robot” (see ISO 13482:2014, 5.3.1.1).

This test is applicable to all robots that are operated by electrical power.

The test consists of two steps:

- a) examining accessible parts, and
- b) measuring the supplied voltage in the accessible parts.

The test uses three different apparatuses:

- test fingers,
- a load cell or force limiter attached to the test fingers, and
- a voltmeter.

This test is conducted once for a new robot and once for a test sample that has been in operation for a number of use cycles representative for the lifetime of the robot. The used test sample is carefully examined for signs of wear, which can have one of the following effects:

- breaking of cables that lead to parts becoming live,
- breaking of guards that lead to more parts becoming accessible.

Where other tests described in this document lead to severe damage of the robot or some of its parts (e.g. collision tests), it is advisable to repeat this test if new hazards might have formed then.

### 6.1.2 Apparatus

#### a) Test finger (test probe code according to IEC 61032)

A jointed type probe (probe code B), an unjointed type probe (probe code 11) and a small-diameter jointed type probe if the test is necessary with regards to children (probe code 18 or 19).

#### b) Load cell or customized jig tool

A load cell able to measure compression force or a jig tool, such as a limiter, that can be removed when applying a specified compression force.

#### c) Voltmeter

### 6.1.3 Procedure

#### a) Survey of accessible parts

The accessible parts of conductive areas are identified with the following procedure. These are user-accessible parts on the robot. They can be accessible during normal use or during maintenance and inspection, etc. (The scope of maintenance and inspection work by the user is specified by the manufacturer in the user manual.)

- 1) Opening covers and doors that can be opened without tools, keys, etc.
- 2) Visual inspection of the accessible area
- 3) Identification of accessibility by a jointed test finger. The test finger is applied with a force not exceeding 1 N to openings of the robot. Through openings, the test finger is applied to any depth that the test finger will permit and is rotated or angled before, during and after insertion to any position. If the opening does not allow the entry of the test finger, the force on the test finger in the straight position is increased to 20 N. If the test finger then enters the opening, the test is repeated with the test finger in the angled position.

Where necessary, the unjointed test finger is used and a force of  $10\text{ N} \pm 1\text{ N}$  or a higher, if specified by the manufacturer, is applied.

#### b) Measuring electrical potential

A voltage between an accessible part judged in a) and a reference point is measured under normal operating condition of the robot with power on (during operation, if necessary). The reference point of electrical potential is the protective earthing point or an equipotential point if the robot is equipped with a protective earthing system, or otherwise the functional earthing point or an equipotential point or the potential point of the power source's negative terminal. At locations of electric potential, the standard resistance of 2 k $\Omega$  or, if operation under high humidity is anticipated, a resistance of 500  $\Omega$  is applied between the reference points. The electrical current through this resistance or the voltage is measured.

If the operational mode influences which robot parts become live, the measurement is performed for each potentially harmful operational mode.

c) Report of test data

Results are recorded through with the diagram or photo of the tested area.

## 6.2 Acoustic noise

### 6.2.1 Principle

This test measures the maximum sound level of acoustic noise that is transmitted to a human passing by at a 1 m distance, as well as noise transmitted to a person onboard/user wearing the robot, in order to verify designs protecting against “hazardous noise” (see ISO 13482:2014, 5.7.1.1).

This test is applicable to all robots generating sound.

The test consists of three steps:

- a) programming a travel pattern,
- b) measuring pass-by noise, and
- c) measuring noise while riding/wearing (if applicable) using sound level meters.

The measurement employs A-weighted sound pressure level. Allowable background noise is not necessarily eliminated to perform the measurement.

### 6.2.2 Apparatus

a) Test travel surface

Test travel surface is composed of measurement section of a 10 m straight-line preceded by an acceleration section of enough length for accelerating the target robot to its rated speed. The travel surface is chosen to simulate the worst-case travel environment for the robot. Background noise on the travel surface is insulated to be at least 10 dB lower than the measured noise level (e.g., compliance with Grade 3 of ISO 11202:2010, Annex B). Secondary noise reflected from objects around the travel surface is sufficiently suppressed.

b) Precision noise meter (Class I) (IEC 61672-1) for pass-by noise measurement

The test is carried out by positioning microphones as described in 6.2.3 b). The noise meter has microphone(s) connected to frequency analysis-capable data logger.

c) Precision noise meter (Class 1) for measuring noise heard by the person on board

The noise meter is portable in order to be carried by the robot during the test. It is equipped with a windshield and is fixed where the ear of the person on board/user wearing the robot is located during normal operation.

### 6.2.3 Procedure

a) Preparation of robot travel pattern

Two robot travel patterns to sample sound level are as follows:

- 1) tracing straight-line path keeping rated speed during measurement section, and
- 2) tracing straight-line path, starting with the rated speed at beginning of the measurement section, then performing the maximum deceleration to stop at the midway point of the measurement section for 1 s, and finally performing the maximum acceleration to return to the rated speed until the end of the measurement section.