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Part 1: Safety-related test methods

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Partie 1: Méthodes d'essai liées à la sécurité

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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

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).

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

This document was prepared by Technical Committee ISO/TC 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.

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.

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

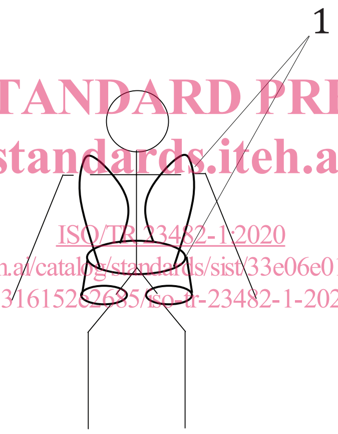
During the preparation and conduction of verification and validation tests, the persons involved in testing are protected as far as possible from any risk originating from the robot and the test apparatus. Special attention is paid when tests provoke hazardous situations such as collisions and instability.

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).



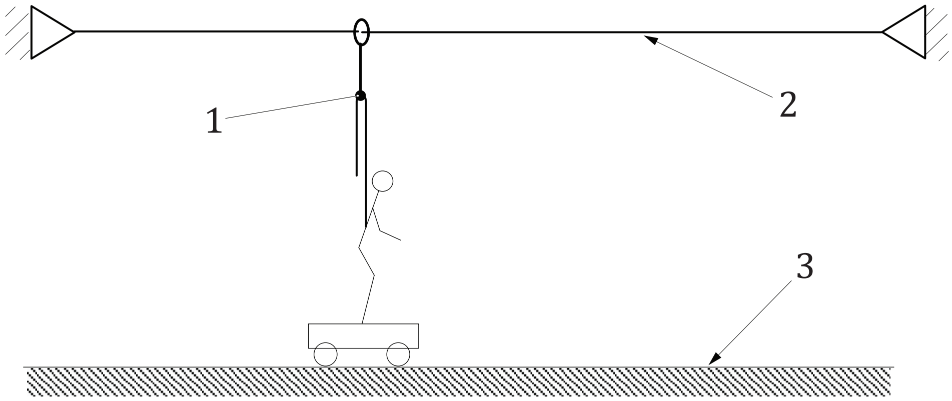
Key

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 N ± 1 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 kΩ or, if operation under high humidity is anticipated, a resistance of 500 Ω 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 supressed.

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.

The robot is programmed to perform these patterns, when testing a mobile servant robot. If the robot cannot be programmed, it is prepared to be manually controlled. A test person onboard or a test person wearing the robot is instructed to manoeuvre the robot to perform these patterns, when testing a person carrier robot or a physical assistant robot. In the latter case, the rated speed is considered to be the fastest walking speed specified by the manufacturer.

During the measurement, it is checked whether the specified test speed is achieved.

b) Installation of microphones for the noise meter for pass-by noise measurement

Four microphones for the pass-by noise meter are placed on the centre of the measurement section of the test travel surface, with two microphones at the height of 0,2 m above the travel surface, with interval of 1 m. The remaining two microphones are fixed at a height of 1,6 m at an interval of 1 m. All microphones are directed at the right angles to the travel path of the robot, positioned on a vertical plane 0,5 m away from the closest point of the robot surface.

c) Measurement of pass-by noise

The target robot performs the two travel patterns a) 1) and a) 2) a minimum of four times each. The sound pressure level with fast A-weighting measured by the four microphones is recorded during the test. The pass-by noise for each repeated measurement is determined by averaging the maximum overall values sampled by the two microphones at each height level from the travel surface. Pass-by noise for each travel pattern is calculated as the average value from all repeated measurements. The maximum value among the pass-by noise for the two travel patterns and the two microphone heights is recorded as the test result.

d) Measurement of noise heard by the person on board/user wearing the robot

The target robot performs the two travel patterns a) 1) and a) 2) a minimum of four times each. The sound pressure level with fast A-weighting is measured by a microphone fixed where the ear of the person on board/user wearing the robot is located during normal operation for this test. The noise heard by the person on board/user wearing the robot for each pattern is calculated as the average of the maximum overall value of recorded sound pressure. The higher noise of the two travel patterns is recorded as the test result.

NOTE The sound pressure level is averaged by the following formula.

$$L_m = 10 \log_{10} \left(\frac{1}{n} \sum_{i=1}^{n} 10^{L_i/10} \right)$$

where

L_m is the average of the sound pressure level (dB);

L_i is the sound pressure level measured as the i-th data (dB);

n is the number of the data.

6.2.4 Pass/fail criteria

Reference can be made to Clause A.2 to define pass/fail criteria for the test, and the data described in it.

6.3 Surface temperature

6.3.1 Principle

This test measures surface temperatures of the robot in order to verify designs protecting against "extreme temperature" (see ISO 13482:2014,5.7.4.1).

This test is applicable to all robots.

