International Standard

ISO 18646-6

First edition
2026-05

Robotics — Performance criteria and related test methods for service robots —

Part 6: Lower-limb wearable robots

Robots et composants robotiques — Critères de performance et méthodes d'essai correspondantes pour robots de service —

Partie 6: Robot portable pour les membres inférieurs

Reference number
ISO 18646-6:2026(en)

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

Contents

Page

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 document 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).

ISO draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). ISO takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, ISO had received notice of (a) patent(s) which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at www.iso.org/patents. ISO shall not be held responsible for identifying any or all such patent rights.

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.

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

A list of all parts in the ISO 18646 series can be found on the ISO website.

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.

Robotics — Performance criteria and related test methods for service robots —

Part 6: Lower-limb wearable robots

1 Scope

This document specifies performance index and related test methods to evaluate the assistance and enhancement performance of lower-limb wearable robots by using an anthropomorphic test dummy robot (ATDR).

This document applies to wearable robots that are operated by being attached to lower limbs regardless of the purpose of use or the driving method (powered/non-powered, electric/hydraulic).

This document does not apply to lower-limb wearable robots that operate based on biosignals such as electromyography.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

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

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

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
wearable robot
robot that supplements or augments physical capabilities by driving human body while attached to a human

Note 1 to entry: Wearable robots are referred to as restraint-type physical assistant robots in ISO 13482.

[SOURCE: ISO 18646-4:2021, 3.2, modified — The words “while attached to a human during use” have been replaced with “by driving human body while attached to a human”.]

3.2
lower-limb wearable robot
wearable robot attached to (part of) human lower-limbs

3.3
anthropomorphic test dummy robot
ATDR
robot that has a similar configuration to the lower-limb skeleton of a human and actively performs movements such as walking and half squats while wearing a lower-limb wearable robot

3.4
tester
person who manages and conducts performance evaluation tests, performs ATDR management and writes up the test result during the test process

3.5
stance phase
period of time in which the foot is in contact with the ground, the state in which weight is exerted to the ground

Note 1 to entry: Stance phase is divided into heel strike, single-limb support and double-limb support.

3.6
swing phase
period of time in which the foot is not in contact with the ground

3.7
single-limb support
state in which one leg supports the weight and the other leg performs the swing motion

3.8
double-limb support
state in which both legs are in contact with the ground and support the body weight

4 Test conditions

4.1 General

The lower-limb wearable robot (hereinafter referred to as the wearable robot) shall be completely assembled. The battery shall be charged to a level sufficient for testing. All self-diagnostic tests, if applicable, shall be satisfactorily completed. It should also be ensured that the robot operates in a safe manner throughout the test so that no one is injured during the test.

The tests shall be preceded by the preparations for operation as specified by the manufacturer, including calibration of any relevant sensors that can affect the test results.

All conditions specified in Clause 4 should be satisfied for the tests described in this document, unless stated otherwise in the specific clauses.

4.2 Wearable robot conditions

The wearable robot shall satisfy the following conditions for the test:

a) The wearable robot used in the test shall be stored at room temperature and tested with sufficient power required for each test.

b) All accessories required for the use of the wearable robot shall be available during the test.

c) The movable part of the wearable robot shall be warmed up to a state where it can perform the test operation without difficulty.

d) Tests shall be performed only for:

   1) the weight below the payload of the wearable robot;

   2) the speeds below the maximum walking speed of the wearable robot;

   3) the angles within the maximum range of joint motion of the wearable robot.

e) Before the test, the length of the link of the wearable robot shall be adjusted to ensure proper alignment with the ATDR joint.

f) When fastening with the ATDR, apply the specified clamping pressure (or tension) of the cuff. If there is no specified value, fasten it to the extent that two fingers (index and middle finger) can be inserted.

4.3 Environmental conditions

The following environmental conditions shall be maintained 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, then this shall be declared in the test results.

4.4 Operating conditions

All performance shall be measured under normal operating conditions. When the performance is measured under conditions outside the normal operating conditions, these conditions shall be specified along with the test results.

5 Test device

5.1 ATDR configuration requirements

The ATDR shall satisfy the following requirements:

a) To connect the wearable robot, it shall consist of an upper body and two legs.

b) It shall be able to perform walking and a half-squat motion on a treadmill. These are the main test motions.

c) A minimum of two degree of freedom (DOF) active rotational joints (one DOF knee joint, one DOF hip joint) are required for each leg.

d) The ankle shall be made of rotational joint with one or more degrees of freedom. If the wearable robot actively assists the ankle joint and its performance evaluation is required, the ankle joint shall be manufactured as an active rotation joint.

e) To measure and control the joint angle, the rotation angle of the joint shall be measured with an incremental or absolute encoder.

f) When the ATDR is supported by a harness or structure, the upper body (or neck joint) shall be able to move up and down and forward and backward so that the upper body can move naturally while walking. A rotational joint about an axis perpendicular to the sagittal plane for the point of support shall be provided.

g) To determine the walking state or walking cycle and the suitability of the walking trajectory, it shall be possible to measure the ground reaction force.

NOTE 1 The ground reaction force can be measured by installing two force sensors on the front and back of the sole.

h) It shall be possible to measure the angle of the upper body to confirm the control stability of the ATDR and the repeatability of the posture during the test.

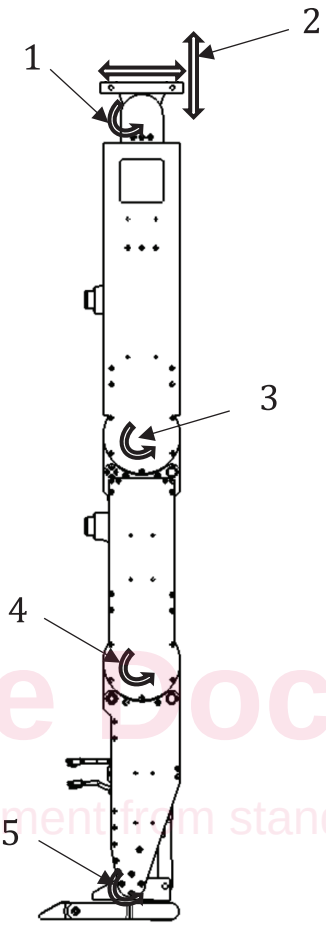
NOTE 2 The posture can be measured with a tilt sensor or an inertial measurement sensor.

i) The ATDR shall be controlled to generate joint motion and a ground reaction force similar to those generated by humans during walking.

j) The torque and angular velocity of the joint drive motor or the joint shall be measurable.

k) In all tests, a harness (or a device equivalent to the harness) shall be applied to secure the accuracy and safety of the test and protect the ATDR and the wearable robot from damage. The harness shall be firmly fixed by a support device. In addition, the harness support device shall be able to maintain enough rigidity to prevent the ATDR from falling over.

Figure 1 is an example of an ATDR design implemented for testing.



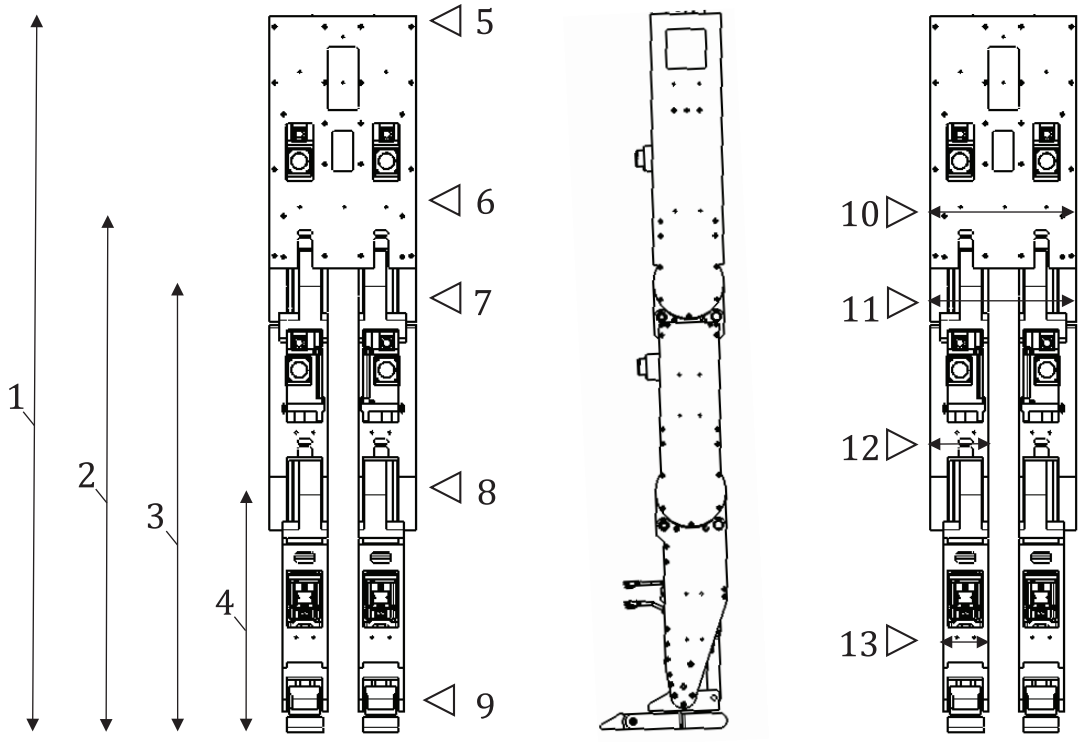
Key

1	passive rotating joint
2	optional (active/passive) prismatic joint
3	active rotational joint
4	active rotational joint
5	optional (active/passive) rotational joint

Figure 1 — ATDR design example

5.2 ATDR size

The wearable robot user's weight and body size are distributed over a wide range. In general, the wearable robot can variably adjust the link length according to the body length. It is therefore not necessary to specify the size of the ATDR by a representative value. In addition, since the ATDR walks while supporting its own weight or operates with its own power, the weight does not have a significant effect on the test results. However, in order to maximize the objectivity and universality of the test results, the dimension ratio of each body part should be similar to IEC 60601-1:2005, Figure A.19. Each body part of the ATDR and its corresponding height is shown in Figure 2. Table 1 shows example dimensions of body parts. Depending on the geographical location, the size of the ATDR can vary to better represent the morphology of the users.



Key

1	shoulder height
2	waist height
3	hip height
4	knee height
5	shoulder
6	waist
7	hip
8	knee joint
9	ankle joint
10	waist circumference
11	hip circumference
12	thigh circumference
13	calf circumference

Figure 2 — Size of each body part of the ATDR

Table 1 — Example of ATDR size

Weight	75 ± 32 kg
Thigh circumference	496 ± 119 mm
Calf circumference	365 ± 83 mm
Hip circumference	948 ± 150 mm
Waist circumference	783 ± 200 mm
Shoulder height	1 336 ± 174 mm
Knee high	430 ± 60 mm
Hip height	807 ± 100 mm
Waist height	1 088 ± 108 mm