INTERNATIONAL STANDARD

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Earth-moving machinery — Falling-object protective structures — Laboratory tests and performance requirements

Engins de terrassement — Structures de protection contre les chutes d'objets — Essais de laboratoire et critères de performance

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 3449 was prepared by Technical Committee ISO/TC 127, *Earth-moving machinery*, Subcommittee SC 2, *Safety requirements and human factors*.

This fifth edition cancels and replaces the fourth edition (ISO 3449:1992), which has been technically revised.

Introduction

This International Standard provides performance criteria for falling-object protective structures (FOPS). It recognizes that there are various classes and sizes of machines that operate in a variety of environmental conditions. It is intended to assure operators of reasonable protection from falling objects of different sizes and masses.

Its laboratory tests are a means of evaluating the characteristics of the structures used to protect the operator from localized impact penetration and, indirectly, of the load-carrying capacity of the supporting structure to resist impact loading.

This International Standard establishes a consistent, repeatable means of evaluating characteristics of FOPS under loading and prescribes performance requirements for these structures under such loading in a representative test.

For similar tests on FOPS for excavators and excavator-based machines, see ISO 10262.

Earth-moving machinery — Falling-object protective structures — Laboratory tests and performance requirements

1 Scope

This International Standard specifies laboratory tests for measuring the structural characteristics of, and gives performance requirements in a representative test for, falling-object protective structures (FOPS) intended for use on ride-on earth-moving machines as defined in ISO 6165. It is applicable to both FOPS supplied as an integral part of the machine and those supplied separately for attachment to the machine. It is not intended to apply to FOPS intended for use on landfill compactors, excavators, rollers, trenchers, pipelayers, for the additional seat for operation of an attachment (e.g. attachment backhoe), or on machines with a power rating of less than 15 kW.

NOTE This International Standard can be used to provide guidance to the manufacturers of roll-over or falling-object protective structures should it be decided to provide such protection for these or other machines for a particular application.

2 Normative references

The following referenced documents are indispensable for the application 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 148:1983, *Steel — Charpy impact test (V-notch)*[1)]

ISO 898-1:1999, *Mechanical properties of fasteners made of carbon steel and alloy steel — Part 1: Bolts, screws and studs*

ISO 898-2:1992, *Mechanical properties of fasteners — Part 2: Nuts with specified proof load values — Coarse thread*

ISO 3164:1995, *Earth-moving machinery — Laboratory evaluations of protective structures — Specifications for deflection-limiting volume*

ISO 3471:1994, *Earth-moving machinery — Roll-over protective structures — Laboratory tests and performance requirements*

ISO 6165:—[2)], *Earth-moving machinery — Basic types — Vocabulary*

1) Under revision.
2) To be published. (Revision of ISO 6165:2001)

3 Terms and definitions

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

3.1
falling-object protective structure
FOPS
system of structural members arranged in such a way as to provide operators with reasonable protection from falling objects (trees, rocks, small concrete blocks, hand tools, etc.)

3.2
roll-over protective structure
ROPS
system of structural members whose primary purpose is to reduce the possibility of a seat-belted operator being crushed should the machine roll-over

NOTE Structural members include any subframe, bracket, mounting, socket, bolt, pin, suspension or flexible shock absorption used to secure the system to the machine frame, but exclude mounting provisions that are integral with the machine frame.

3.3
deflection-limiting volume
DLV
orthogonal approximation of a large male, seated operator wearing normal clothing and a hard hat

NOTE See ISO 3164.

3.4
level I impact protection
impact strength for protection from small falling objects (e.g. bricks, small concrete blocks, hand tools) encountered in operations such as highway maintenance, landscaping and other construction site services

3.5
level II impact protection
impact strength for protection from heavy falling objects (e.g. trees, rocks) for machines involved in site clearing, overhead demolition or forestry

3.6
representative test
test of a specimen whose material, dimensional and processing requirements are typical of production FOPS

4 General

The FOPS may be integrated into the operator cab structure.

This test procedure is generally destructive of the FOPS assembly, as permanent deformation will occur to the structure, and might not reproduce structural deformations, owing to variation in the actual impact of the falling objects.

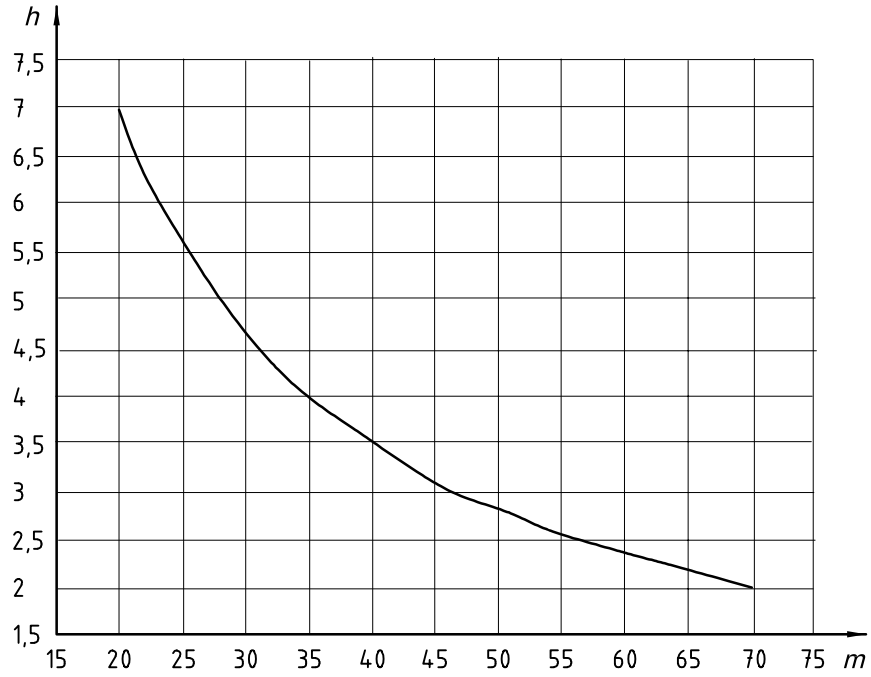
Two levels of performance criteria are specified for impact protection, based on the machine end use.

a) Level I: protection against the impact of a round test object dropped from a height sufficient to develop an energy of 1 365 J. See Figures 1 a) and 2 a).

b) Level II: protection against the impact of a cylindrical test object dropped from a height sufficient to develop an energy of 11 600 J. See Figures 1 b) and 2 b).

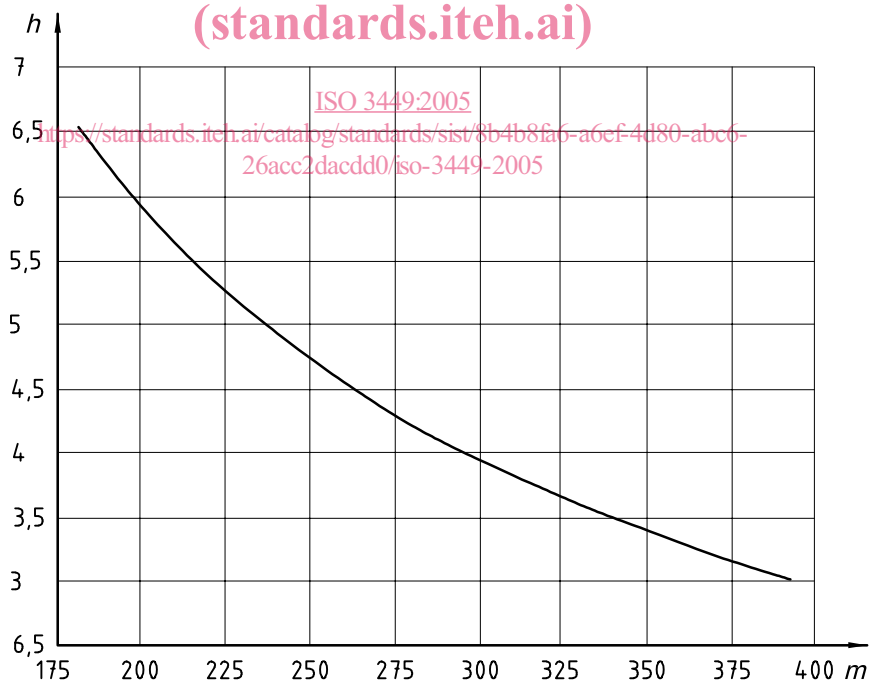
The drop height of the test object is defined as a function of its mass, as shown in Figure 1.

NOTE Although FOPS meeting these criteria do not give crush protection under all the circumstances in which the machine could be struck from above, it is expected that protection from penetration will be ensured under conditions a) and b).



EXAMPLE 45 kg × 9,807 m/s^2 × 3,1 m ≈ 1 365 J

a) Level I energy requirement curve



EXAMPLE 227 kg × 9,807 m/s^2 × 5,22 m ≈ 11 600 J

b) Level II energy requirement curve

Key

h height, m

m mass, kg

Figure 1 — Height and mass for test object with capability of developing energy requirements

5 Laboratory tests

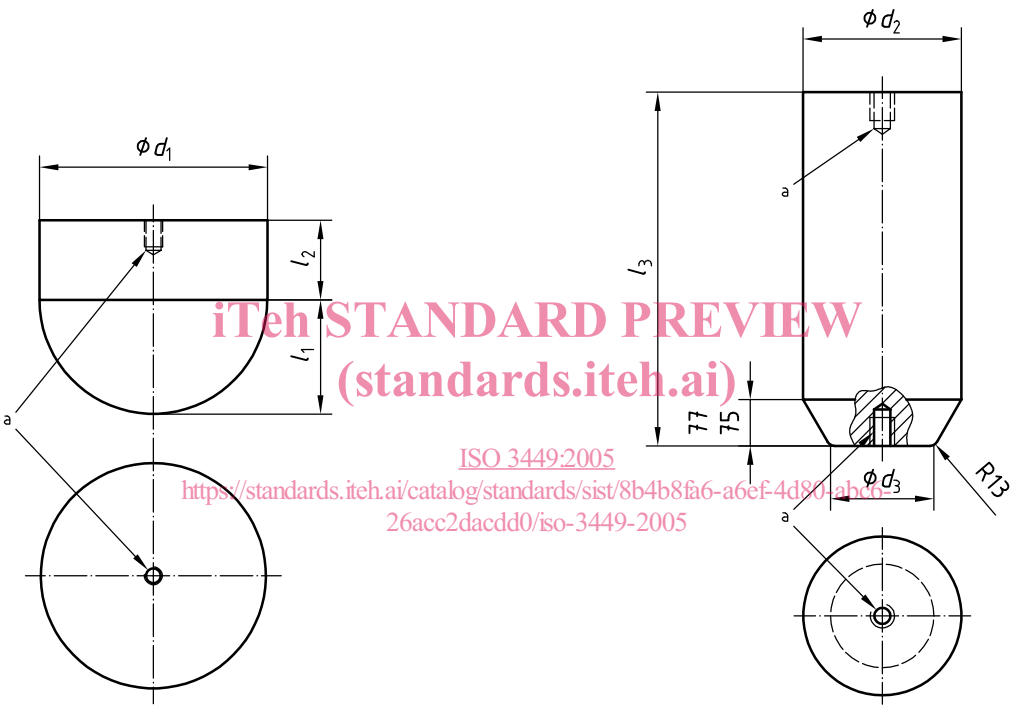
5.1 Test apparatus

5.1.1 Test object, whose impact surface has properties to protect against deformation during testing, and which

— for level I testing, has a solid steel or ductile iron cylinder, as shown in Figure 2 a), a typical mass of 45 kg and a spherical contact surface diameter of between 200 mm and 250 mm, and

— for level II testing, has a solid steel or ductile iron cylinder, as shown in Figure 2 b), and a typical mass of 227 kg.

Dimensions in millimetres



a) Level I: mass of 45 kg **b) Level II: mass of 227 kg**

Key

d_1 204 mm

d_2 255 mm to 260 mm

d_3 203 mm to 204 mm

l_1 ≈ 102 mm

l_2 ≈ 109 mm

l_3 ≈ 584 mm

NOTE 1 Actual values of dimensions are given here as examples.

NOTE 2 All the dimensions specified are variable, depending on the mass of the test object required to match the height of drop that will provide the energy according to Clause 4 a) and b). Dimensions of the drop test object are determined with respect to both its mass and drop-height (as determined from Figure 1), to provide the required energy.

a May be drilled and tapped for lifting eye.

Figure 2 — Example of test object

5.1.2 Test facility apparatus that provides a means to

a) raise the test object to the required height,

b) release it so that it drops without restraint, and

c) determine whether the FOPS enters the deflection-limiting volume (DLV) during the test.

The means of determining c) may be either 5.1.3 or 5.1.4.

5.1.3 DLV structure, placed upright and made of a material that will indicate any penetration by the FOPS — grease or other suitable material being permitted to be put on the lower surface of the FOPS cover to indicate such penetration.

The DLV structure and its location shall be in accordance with ISO 3164. The DLV structure shall be fixed firmly to the same part of the machine as the operator's seat and shall remain there during the entire formal test period.

5.1.4 Suitable dynamic instrumentation system, with a dynamic measurement accuracy of ± 5 %, for measuring the expected deflection of the FOPS with respect to the DLV.

5.2 Test conditions

5.2.1 Test bed

The FOPS to be evaluated shall be attached to the machine structure, as it would be in actual machine use. Although a complete machine is not required, the portion on which the FOPS is mounted shall be identical to the actual structure, and the vertical stiffness of the test bed shall be not less than that of an actual machine according to 5.2.2.

5.2.2 Machine-mounted FOPS

For FOPS mounted on a machine:

— the machine may be provided with equipment or attachments as specified by the manufacturer;

— all ground-engaging tools shall be in the normal transport position;

— all suspension systems, including pneumatic tyres, shall be set at operating levels, and variable suspensions shall be in the “maximum stiffness” range;

— all cab elements, such as windows, normally removable panels or non-structural fittings, shall be removed so that they do not contribute to the strength of the FOPS.

5.3 Test procedure

5.3.1 FOPS

The test procedure shall be performed as follows, in the sequence given.

a) Place the test object on top of the FOPS, with the small end downwards for level II, at the impact location. The impact location shall touch, or be within the vertical projection of, the uppermost plane area of the DLV, as specified in the following three cases and shown in Figure 3. Major FOPS structural members that have a significant effect on FOPS deformation need to be considered according to each of these cases.