International Standard 3449

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

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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Descriptors : earth handling equipment, safety devices, falling bodies protection, tests, laboratory tests, drop tests.

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards institutes (ISO member bodies). The work of developing International Standards is carried out through ISO technical committees. Every member body interested in a subject for which a technical committee has been set up 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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 3449 was developed by Technical Committee ISO/TC 127, *Earth-moving machinery*, and was circulated to the member bodies in November 1978.

It has been approved by the member bodies of the following countries :

Australia	Finland	South Africa, Rep. of
Austria	France	Spain
Belgium	Germany, F. R.	Sweden
Bulgaria	Italy	Turkey
Chile	Japan	United Kingdom
Czechoslovakia	Poland	USA
Egypt, Arab Rep. of	Romania	USSR

No member body expressed disapproval of the document.

This second edition cancels and replaces the first edition (i.e. ISO 3449-1975).

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INTERNATIONAL ORGANIZATION FOR STANDARDIZATION • МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ • ORGANISATION INTERNATIONALE DE NORMALISATION

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

AMENDMENT 1

Amendment 1 to International Standard ISO 3449-1980 was drawn up by Technical Committee ISO/TC 127, *Earth moving machinery*. It was submitted directly to the ISO Council in accordance with clause 5.10.1 of part 1 of the Directives for the technical work of ISO.

Page 1 :

Sub-clause 4.1, replace the definition by the following :

"**roll-over protective structure (ROPS)** : System of structural members arranged on a machine in such a way as to accomplish its primary purpose to reduce the possibility of an operator, when wearing a seat belt, from being crushed should his machine roll over. Structural members include any subframe, bracket, mounting, socket, bolt, pin suspension or flexible shock absorber used to secure the system to the machine frame but excludes mounting provisions which are integral with the machine frame."

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Descriptors : earth-moving equipment, safety devices, falling bodies protection, tests, laboratory tests, drop tests.

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

0 Introduction

This International Standard is intended to assure operators of reasonable overhead protection from falling trees, rocks and other objects under the conditions as stated in clause 5.4.

1 Scope

1.1 This International Standard sets out

a) the laboratory tests for measurement of structural characteristics and

b) the requirements for performance in a representative test of a falling-object protective structure (FOPS).

1.2 The laboratory tests are a means of testing 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 resisting impact loading.

1.3 This International Standard is intended to establish a consistent, repeatable means of evaluating characteristics of FOPS under loading and to prescribe performance requirements for these structures under such loading in a representative test.

1.4 For the purposes of this International Standard "representative test" means a test of a specimen whose material, dimensional, and processing requirements are typical of those FOPS currently being produced.

2 Field of application

2.1 This International Standard applies to the following types of operator-controlled machines; regardless of the type of steering system utilized, as defined in ISO 6165.

— crawler loaders and wheel loaders;

— crawler tractors and wheel tractors;

— graders;

— tractor-scrapers.

2.2 Excluded from this International Standard are :

— self-propelled compactors;

— drills;

— paving machines;

— machines having a power rating less than 15 kW (20 hp);

— belt loaders;

— excavators;

— cranes;

— drag lines.

3 References

ISO 3164, *Earth-moving machinery — Laboratory evaluations of roll-over and falling-object protective structures — Specification for the deflection-limiting volume.*

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

ISO 6165, *Earth-moving machinery — Basic types — Vocabulary.*

4 Definitions and abbreviations

For the purposes of this International Standard, the following definitions and abbreviations apply :

4.1 roll-over protective structure (ROPS) : A system of structural members arranged on a machine in such a way as to reduce the possibility of the machine crushing the operator in the even of an accidental turn-over.

4.2 deflection-limiting volume (DLV) : That volume, related to the operator, which serves to set limits and deflections permissible when performing laboratory evaluations of ROPS and FOPS. The volume, an approximation, is based on the seated dimensions of the large operator.

4.3 falling-object protective structure (FOPS) : A system of structural members arranged in such a way as to provide operators with reasonable protection from falling objects (for example, trees, rocks).

5 General

The following points are stated to aid in understanding the underlying principles, intention and application of this International Standard.

5.1 The FOPS can be integrated in the cab of the operator.

5.2 This evaluation procedure will not necessarily duplicate structural deformations due to a given actual impact of falling trees, rocks or other objects.

5.3 This evaluation procedure is generally destructive of the FOPS assembly, as permanent deformation is apt to be induced.

5.4 Although FOPS meeting these criteria may not give crush protection under all conceivable circumstances in which the machine could be struck from above, it is expected that crush protection will be ensured under at least the following condition : a blunt object (see figure 1) dropped from a height sufficient to develop an energy of 11 600 J (8 500 ft·lbf).

5.5 The temperature-material requirement of 7.3 is intended to be a base-line of measurement for testing to ensure that the FOPS will have meaningful resistance to brittle fracture and does not necessarily relate to operating conditions.

5.6 Because, in an actual situation involving a falling object, loading will be dynamic (possibly impact), the use of conventional "safety factors" based on static force loading should be used with caution. The "safety factor" of a FOPS is related more to energy absorption capability and details of weld design and welding procedure than it is to static force resistance.

6 Laboratory tests

6.1 Facilities

The following items shall be provided :

6.1.1 A standard laboratory drop test object, made of steel, as shown in figure 1.

6.1.2 A means of raising the standard object to the required height.

6.1.3 A means of releasing the standard object so that it drops without restraint.

6.1.4 A surface of such firmness that it is not penetrated by the machine or test bed under the loading of the drop test.

6.1.5 A means of determining whether the FOPS enters the deflection-limiting volume during the drop test. This may be either of the following :

a) a DLV, in the upright attitude, made of a material which will indicate any penetration by the FOPS; grease may be put on the lower surface of the FOPS cover to indicate such penetration;

b) a dynamic instrumentation system of sufficient frequency reponse to indicate the pertinent deflection with respect to the DLV.

6.1.6 The DLV and its location should be in accordance with ISO 3164. The DLV should be fixed firmly to the same part of the machine to which the operator's seat is secured, and should remain there during the entire formal test period.

6.2 Test conditions

6.2.1 Measuring accuracy

The following measuring accuracy shall be adhered to when conducting the test :

Means for measuring	Accuracy
Deflection of FOPS	± 5 % of maximum deflection measured

6.2.2 Machine or test bed condition

6.2.2.1 The FOPS to be evaluated shall be attached to the machine structure as it would be in actual machine use. A complete machine is not required; however, the portion to which the FOPS is mounted shall be identical to the actual structure, and the vertical stiffness of a test bed shall be not less than that of an actual machine as described in 6.2.2.2.

6.2.2.2 If the FOPS is mounted on a machine, the following stipulations apply :

— there are no limitations on customary attachments and/or payload;

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

— all suspension systems, including pneumatic tyres, shall be set at operating levels. 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.

6.3 Procedure

The test procedure shall consist of the following operations, in the order listed.

6.3.1 Place the standard laboratory drop test object (6.1.1), on top of the FOPS (small end of the object down) at the location designated in 6.3.2.

NOTE — An optional drop test object is a sphere or ball with a maximum diameter of 400 mm (15.75 in) and with the capability of developing an energy of 11 600 J (8 500 ft·lbf).

6.3.2 The small end of the object shall be entirely within the vertical projection of the DLV, in that volume's upright position, on the FOPS top.

Case 1

When major, upper, horizontal members of FOPS do not enter the vertical projection of the DLV on the FOPS top.

The centre of the drop test object shall be at that point which has the greatest possible sum of perpendicular distances (X + Y in figure 2) from the major, upper, horizontal structural members.

Case 2

Where major, upper, horizontal members of the FOPS do enter the vertical projection of the DLV on the FOPS top.

Where the covering material of all the surface areas above the DLV, in the same thickness, the centre of the drop test object shall be in the surface of greatest area. This area is the vertical projected area of the DLV without major, upper, horizontal members. The centre of the drop test object shall be at that point, within the surface of greatest area, which has the greatest possible sum of perpendicular distances (X + Y in figure 2) from the major, upper, horizontal structural members.

Where other materials or a different thickness are used in different areas above the DLV, each area in turn shall be subjected to a drop test.

6.3.3 Raise the drop test object vertically to a height above the position indicated in 6.3.1 and 6.3.2 to develop an energy of 11 600 J (8 500 ft·lbf) based on the mass of an object shaped as shown in figure 1. The drop test object shall be aimed to impact at a location on the FOPS to produce the maximum deflection.

NOTE — To develop an energy of 11 600 J (8 500 ft·lbf), the drop test object shall be raised to between 3,6 and 5,2 m (12 to 17 ft). The height to be selected will vary according to the mass of the drop test object (see figure 3).

6.3.4 Release the drop test object so that it falls without effective restraint onto the FOPS.

6.3.5 As it is unlikely that the free fall will result in the drop test object hitting at the location and/or in the attitude of 6.3.1 and 6.3.2, the following limits are placed on deviations.

6.3.5.1 The initial impact of the small end of the drop test object shall be entirely within a circle of 200 mm (8 in) radius (the centre of this circle is to coincide with the vertical centre line of the drop test object as positioned according to 6.3.1 and 6.3.2) but not on any major, upper, horizontal member.

6.3.5.2 The first contact between the drop test object and the FOPS shall only be along the small end of the drop test object and/or the radius contiguous to that end (see figure 1).

6.3.5.3 There is no limitation on location or attitude of subsequent impacts due to rebound.

7 Performance requirements

7.1 The protective properties of the FOPS system shall be estimated by the ability of the cab or protective structure to resist the impact. The DLV (see ISO 3164) shall not be entered by any part of the protective structure under the first or subsequent impact of the drop test object. Should the drop test object penetrate the FOPS, it shall be assumed that the FOPS has failed.

7.2 Where the structure provides for both ROPS and FOPS, the FOPS shall also meet the performance requirements for the appropriate ROPS as given in ISO 3471. Where ROPS is not involved, a different structure may be used to support the FOPS as long as the DLV is not violated in the test.

The FOPS shall completely cover and overlap the vertical projection of the DLV.

NOTES

1 Should the same structure be used for both evaluations, the drop test procedure shall precede the ROPS loading and the removal of impact dents or replacement of the FOPS cover is permitted.

2 It is not required that the included volume of a ROPS of FOPS having four or more vertical members entirely enclose the positioned DLV. Nor is it intended that a simple (two-post) frame be excluded as either a FOPS or ROPS.

7.3 Temperature-material requirements

7.3.1 The laboratory evaluations shall be performed with FOPS and machine frame members soaked to − 18 °C (0 °F) or below.

7.3.2 If the evaluations are not performed at this temperature, the following minimum material requirements shall be met.

7.3.2.1 Bolts and nuts used to attach the FOPS (or FOPS cover and its supporting structure) to the machine frame and to connect structural parts to the FOPS cover shall be property class 8.8 or 10.9 bolts (ISO/R 898/1) and 8 or 10 property class nuts (ISO/R 898 2).

7.3.2.2 Structural members of the FOPS and ROPS (or FOPS cover) and the mounts which attach them to the machine frame shall be made from steels and shall have one of the following Charpy V-notch impact strengths :

10 mm × 10 mm specimen : 10,8 J at − 30 °C (8 ft·lbf at − 20 °F)

10 mm × 7,5 mm specimen : 9,5 J at − 30 °C (7 ft·lbf at − 20 °F)

10 mm × 5 mm specimen : 7,5 J at − 30 °C (5.5 ft·lbf at − 20 °F)

10 mm × 2,5 mm specimen : 5,5 J at − 30 °C (4 ft·lbf at − 20 °F)

Structural members made from materials other than steel shall have equivalent low temperature impact resistance.

NOTES

1 Specimens are to be "longitudinal" and taken from flat stock, tubular, or structural sections before forming or welding for use in FOPS. Specimens from tubular or structural sections are to be taken from the middle of the side of greatest dimension and shall not include welds.

2 In those countries using the inch system, the grade of the bolts or nuts used shall be of an equivalent grade as set out in their national standards (i.e. equal to the FOPS material).

3 The requirements of 8.3.2.2 are set forth as information until such time as ISO develops an International Standard.

7.3.3 Materials used shall be processed in such a manner as to eliminate sharp corners and edges that are adjacent to the operator or service personnel work areas.

8 Labelling

8.1 A label shall be applied to every FOPS. When the structure meets the performance requirements for both FOPS and ROPS, the labelling shall be as described in ISO 3471, *Earth moving machinery — Roll-over protective structures — Laboratory tests and performance requirements.*

8.1.1 Label specification

8.1.1.1 The label shall be of a permanent type and permanently attached to the structure.

8.1.1.2 The label shall be located on the structure so that it can be easily read and is protected from environmental defacing.

8.1.2 Label content

8.1.2.1 Name and adress of the manufacturer of fabricator of the FOPS.

8.1.2.2 FOPS identification number, if any.

8.1.2.3 Machine make, model(s), or series number(s) the structure is designed to fit.

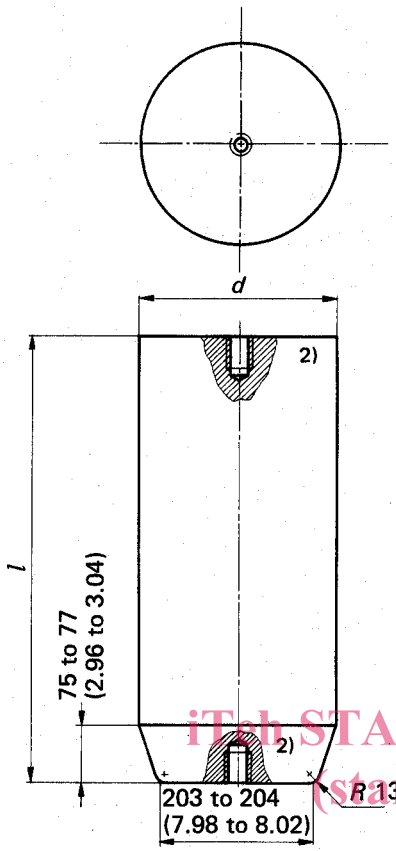
8.1.2.4 The ISO International Standard number(s) for which the structure meets all of the performance requirements. National regulations may be included.

8.1.2.5 The manufacturer may include such other information as deemed appropriate (for example, installation, repair or replacement information).

9 Reporting of results

A test report shall include the results of the test and be presented in a typical test report according to annex A. Additional information presented in Annex B shall be reported only to the originator of the test request.

Dimensions in millimetres
(Inch values in parentheses)



1) Dimensions d and l are optional, depending on the mass of the test object required to match the height of drop that will provide the energy specified in 6.3.3.

For example, for a drop test object mass of 227 kg (500 lb)

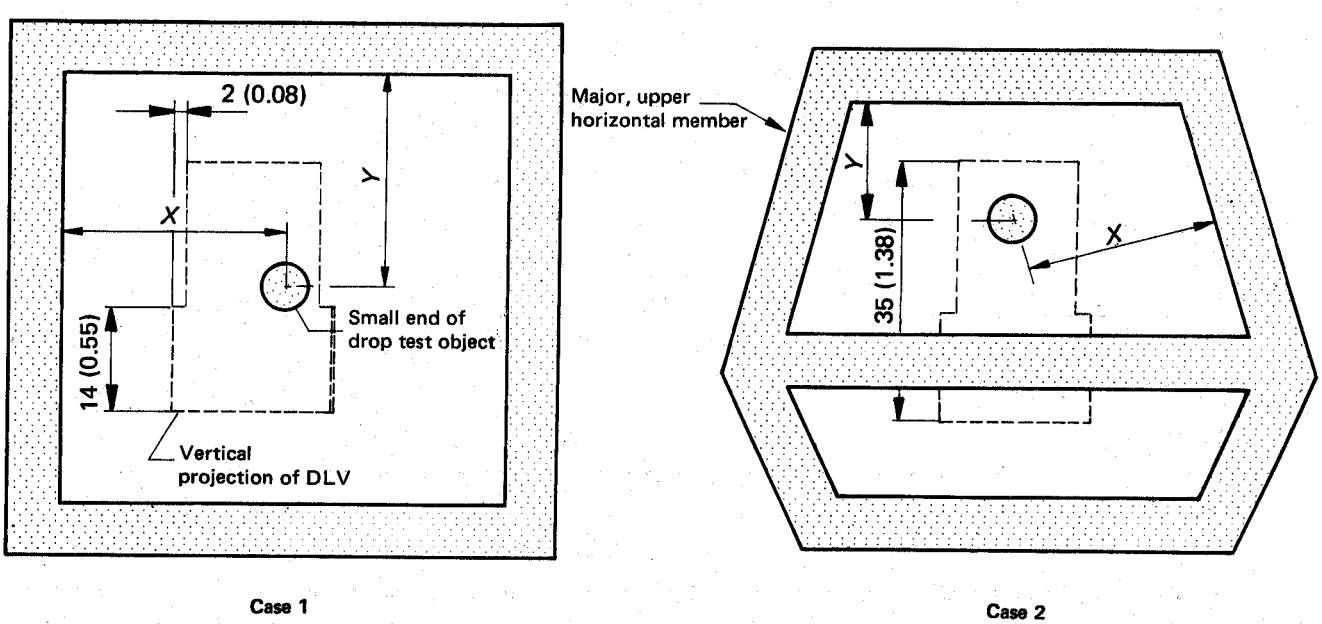
d = 255 to 260 (10.00 to 10.20)

l = 583 to 585 (22.96 to 23.04)

2) May be drilled and tapped for a lifting eye.

3) To determine drop height, see figure 3.

Figure 1 — Standard laboratory drop test object



Case 1

Case 2

Figure 2 — Drop test impact points