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# Earth-moving machinery — Roll-over protective structures — Laboratory tests and performance requirements

*Engins de terrassement — Structures de protection au retournement — Essais de laboratoire et exigences de performance*

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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.

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 3471 was prepared by Technical Committee ISO/TC 127, *Earth-moving machinery*, Subcommittee SC 2, *Safety requirements and human factors*.

This fourth edition cancels and replaces the third edition (ISO 3471:1994), which has been technically revised. It also incorporates the Amendment ISO 3471:1994/Amd 1:1997 and the Technical Corrigendum ISO 3471:1994/Cor 1:2000.

# Introduction

A review of the initial work on the criteria for roll-over protective structures (ROPS) indicated that these criteria were based on requirements for machines now identified as mid-range size machines. Since the ROPS criteria were established, both smaller and larger machines have become common within the size range of earth-moving machines.

The criteria are a combination of linear and exponential, with respect to mass. For small machines, the exponential criterion has been changed to a linear function with respect to machine mass. For larger machines, the exponential criterion was excessive at very large machine masses, and thus was changed to become a linear function with respect to machine mass.

The longitudinal force criteria were added as new data became available. Situations could arise where ROPS designs would meet the lateral and vertical loading requirements, but yet be considered as lacking sufficient performance capability in the longitudinal load direction. For this reason, this International Standard incorporates a ROPS longitudinal force criterion. The longitudinal force criterion has been established at 80 % of the lateral force requirement.

The evaluation procedure will not necessarily duplicate structural deformations due to a given actual roll. However, specific requirements are derived from investigations on ROPS that have performed the intended function in a variety of actual roll-overs, as well as analytical considerations based upon the compatibility of ROPS and the machine frame to which it is attached.

# Earth-moving machinery — Roll-over protective structures — Laboratory tests and performance requirements

## 1 Scope

This International Standard specifies performance requirements for metallic roll-over protective structures (ROPS) for earth-moving machinery, as well as a consistent and reproducible means of evaluating the compliance with these requirements by laboratory testing using static loading on a representative specimen.

NOTE 1 The structure can also provide FOPS (falling-object protective structure) protection.

This International Standard is applicable to ROPS intended for the following mobile machines with seated operator as defined in ISO 6165 and with a mass greater than or equal to 700 kg:

- dozer;
- loader;
- backhoe loader;
- dumper;
- pipelayer;
- tractor section (prime mover) of a combination machine (e.g. tractor scraper, articulated frame dumper);
- grader;
- landfill compactor;
- roller;
- trencher.

This International Standard is not applicable to training seats or additional seats for operation of an attachment.

NOTE 2 It is expected that reasonable crush protection for a seat-belted operator will be provided under at least the conditions of an initial forward velocity of 0 km/h to 16 km/h on a hard clay surface of 30° maximum slope in the direction of roll, and 360° of roll about the longitudinal axis of the machine without loss of contact with the slope.

NOTE 3 This International Standard can be used to provide guidance to the manufacturers of roll-over 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 148-1:2006, *Metallic materials — Charpy pendulum impact test (V-notch) — Part 1: Test method*

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 5353:1995, *Earth-moving machinery, and tractors and machinery for agriculture and forestry — Seat index point*

ISO 6165:2006, *Earth-moving machinery — Basic types — Identification and terms and definitions*

ISO 9248:1992, *Earth-moving machinery — Units for dimensions, performance and capacities, and their measurement accuracies*

## 3 Terms and definitions

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

**3.1**
**bedplate**
substantially rigid part of the test fixture to which the machine frame is attached to conduct the test

**3.2**
**boundary plane**
**BP**
plane defined as the vertical projected plane of the back, side, or knee area of the DLV

NOTE The boundary planes are used to determine the load application point.

**3.3**
**deflection-limiting volume**
**DLV**
orthogonal approximation of a large, seated, male operator wearing normal clothing and a protective helmet

NOTE Adapted from ISO 3164:1995.

**3.4**
**deflection of ROPS**
movement of the ROPS, mounting system and frame section as measured at the load application point (LAP), excluding the effect of any movement of the test fixture(s)

**3.5**
**falling-object protective structure**
**FOPS**
system of structural members arranged in such a way as to provide operators with reasonable protection from falling objects (e.g. trees, rocks, small concrete blocks, tools)

**3.6**
**head portion of DLV**
upper 270 mm by 330 mm rectangular section of the DLV, whose dimensions are in accordance with ISO 3164

**3.7**
**lateral simulated ground plane**
**LSGP**
plane defined as where the machine comes to rest on its side, where the plane is 15° away from the DLV.

NOTE It is created by rotating a vertical plane parallel to the machine's longitudinal centreline about a horizontal line through the outermost point of the upper ROPS member, to which the lateral load is applied (see Figure 6). The LSGP is established on an unloaded ROPS and moves with the member to which the load is applied while maintaining its 15° angle with respect to the vertical.