
British Standard

Roll-over protective structures on earth-moving machinery: laboratory tests and performance requirements

Part 1. Specification for crawler, wheel loaders and tractors, backhoe loaders, graders, tractor scrapers and articulated steel dumpers

[ISO title : Earth-moving machinery — Roll-over protective structures — Laboratory tests and performance requirements — Part 1 : Crawler, wheel loaders and tractors, backhoe loaders, graders, tractor scrapers, articulated steer dumpers)

Structures de protection au retournement des engins de terrassement: essais de laboratoire
et critères de performance

Partie 1. Chargeuses et tracteurs sur chenilles et sur roues, chargeuses-pelleteuses, niveleuses,
décapeuses et tombereaux avec avant-train — Spécifications

Überrollschutzaufbauten für Erdbaumaschinen: Prüfungen und Anforderungen

Teil 1. Lader und Schlepper auf Raupenketten oder an Rädern, Baggerlader, Erdhobel,
Motorschürfwagen, Muldenfahrzeuge mit Knicklenkung

Contents

	Page		Page
National foreword	1	Tables	
Committees responsible	Back cover	1 Minimum force F attained during side loading	7
		2 Minimum energy U absorbed during side loading	7
Specification		Figures	
1 Scope	2	1 Wheel loaders, wheel tractors and backhoe loaders	8
2 Field of application	2	2 Graders	9
3 References	2	3 Tractor scrapers and articulated steer dumpers	10
4 Definitions	3	4 Crawler tractors and crawler loaders	11
5 Symbols	3	5 Side loading	12
6 General	3	6 Force-deflection curve for side loading test	13
7 Static laboratory tests	4	7 Deflection-limiting volume (DLV) application	14
8 Performance requirements	5		
9 Labelling	6		
10 Reporting of results	7		
Annexes			
A Standard test report	15		
B Test report — Additional information for the originator of the test report	16		

National foreword

This Part of BS 5527 has been prepared under the direction of the Road Engineering Standards Committee and is a revision of BS 5527 : 1981 published to take account of minor changes made in the 1980 edition of ISO 3471. This revision of BS 5527 is identical with ISO 3471/1-1986 'Earth-moving machinery — Roll-over protective structures — Laboratory tests and performance requirements — Part 1 : Crawler, wheel loaders and tractors, backhoe loaders, graders, tractor scrapers, articulated steel dumpers' published by the International Organization for Standardization (ISO), and the 1981 edition of BS 5527 is superseded and withdrawn.

Terminology and conventions. The text of the international standard has been approved as suitable for publication as a British Standard without deviation. Some terminology and certain conventions are not identical with those used in British Standards; attention is drawn especially to the following.

Wherever the words 'Part 1 of ISO 3471' and 'part of ISO 3471' appear, referring to this standard, they should be read as 'BS 5527 : Part 1' and 'Part of BS 5527' respectively. In clauses 4 and 5 'International Standard' should be read as 'Part of BS 5527'.

Cross-references

International standard	Corresponding British Standard
ISO 898/1-1978	BS 6104 Mechanical properties of fasteners Part 1 : 1981 Specification for bolts, screws and studs (Technically equivalent)
ISO 898/2-1980	Part 2 : 1983 Specification for nuts with specified proof load values (Technically equivalent)
ISO 3164-1979	BS 5495 : 1980 Specification for laboratory evaluations of roll-over and falling-object protective structures: the deflection-limiting volume for earth-moving machinery (Identical)
ISO 3449-1980	BS 5526 : 1985 Specification for falling object protective structures on earth-moving machinery : laboratory tests and performance requirements (Identical)
ISO 6165-1978	BS 5718 : 1979 Glossary of terms for basic types of earth-moving machinery (Identical)

At present there are no corresponding British Standards for ISO 3471/2, which is at the stage of draft, and ISO 7132-1984. As ISO 3471/2 is referred to for information only the validity of this British Standard is not affected. The Technical Committee has reviewed the provisions of ISO 7132 and has decided that they are acceptable for use in conjunction with this standard. It is intended to implement ISO 7132 as a British Standard.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

British Standard

Roll-over protective structures on earth-moving machinery: laboratory tests and performance requirements

Part 1. Specification for crawler, wheel loaders and tractors, backhoe loaders, graders, tractor scrapers and articulated steer dumpers

1 Scope

1.1 Part 1 of ISO 3471 sets out

- a) the static laboratory tests for measurement of structural characteristics, and
- b) the requirements for performance in a representative test,

of a roll-over protective structure (ROPS) design; it is closely related to the deflection-limiting volume (DLV) (see ISO 3164).

1.2 The static laboratory tests are means of measuring the characteristics of the structures used to protect the operator at velocities of 0 to 16 km/h (0 to 10 mile/h) over hard clay where roll-over would be limited to a maximum roll angle of 360° down a slope of 30° maximum without penetration of the specified DLV by structural members of the ROPS.

1.3 This part of ISO 3471 is intended to establish a consistent, reproducible means of evaluating force-deflection characteristics of ROPS under static loading and to lay down performance requirements for these structures under such loading in a representative test.

1.4 For the purposes of this part of ISO 3471, "representative test" means a test of a specimen the material, dimensional, and processing requirements of which are typical of those ROPS being produced.

1.5 ISO 3471/2 deals with the requirements for ROPS on machinery for forestry.

2 Field of application

2.1 Part 1 of ISO 3471 applies to the following types of operator-controlled machines as defined in ISO 6165 :

- crawler loaders and wheel loaders;

- crawler tractors, wheel tractors and backhoe loaders;
- graders;
- tractor-scrapers;
- articulated steer dumpers (see ISO 7132, figures 3, 5 and 8).

2.2 This part of ISO 3471 does not apply to :

- compactors;
- machines having a power rating less than 15 kW (20 hp);
- excavators;
- drag lines;
- rigid frame dumpers;
- pipelayers.

3 References

ISO 898, *Mechanical properties of fasteners —*

Part 1: Bolts, screws and studs.

Part 2: Nuts with specified proof load values.

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

ISO 3449, *Earth-moving machinery — Falling-object protective structures — Laboratory tests and performance requirements.*

ISO 3471/2, *Earth-moving machinery — Roll-over protective structures — Laboratory tests and performance requirements — Part 2: Machinery for forestry.*¹⁾

¹⁾ At present at the stage of draft.

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

ISO 7132, *Earth-moving machinery — Dumpers — Terminology and commercial specifications*.

4 Definitions

For the purposes of this International Standard, the following definitions apply.

4.1 roll-over protective structure (ROPS) : System of structural members arranged on a machine in such a way as to accomplish its primary purpose of reducing the likelihood of an operator, when wearing a seat belt, 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 exclude mounting provisions which are integral with the machine frame.

4.2 machine frame : The main chassis or main load-bearing member(s) of the machine which extend(s) over a major part of the machine and upon which the ROPS is directly mounted.

4.3 ROPS-machine frame assembly : The ROPS system attached to the machine frame.

4.4 bedplate : A substantially rigid part of the test structure to which the machine frame is attached for the purpose of the test.

4.5 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 falling-object protective structures (FOPS). The volume, an approximation, is based on the seated dimensions of the larger operator. (See ISO 3164.)

4.6 simulated ground plane (SGP) : Surface on which an earth-moving machine after rolling over is assumed to come to a standstill with the machine lying on its side (see 8.1.2).

5 Symbols

The following symbols and abbreviations are used in this International Standard.

5.1 ROPS : Roll-over protective structure.

5.2 U : Energy absorbed by the structure related to the machine mass, expressed in joules or inches pounds-force.

5.3 F : Force, expressed in newtons or pounds-force.

5.4 M : Machine mass, expressed in kilograms (pounds).

5.4.1 The machine mass is the manufacturer's maximum recommended mass including attachments in operating condition with all reservoirs full to capacity, tools and ROPS;

exclusive of towed equipment such as rollers, compactors, and drawn scrapers. For the tractor scraper and articulated steer dumper, it is the manufacturer's maximum recommended mass of the tractor portion only.

5.4.2 Kingpins, hitches, and articulated steering components that attach to hitches or towed units are excluded from the mass of these machines. Soil, mud, rocks, branches, debris, etc. that commonly adhere to or lie on machines in use are not considered as part of the mass of any machine. Material dug, carried, or handled in any manner is not to be considered part of the machine mass in determining test requirements.

5.5 DLV : Deflection-limiting volume.

5.6 Δ : Deflection of ROPS, expressed in millimetres (inches).

6 General

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

6.1 The ROPS can be integrated into the operator's cab or into the FOPS.

6.2 This evaluation procedure will not necessarily duplicate structural deformation caused by a given actual roll.

6.3 This evaluation procedure is generally destructive of the ROPS-machine frame assembly, as permanent deformation is apt to be induced in either or both.

6.4 Although ROPS meeting these criteria may not give crush protection under all conceivable circumstances in which a machine could overturn, it is expected that crush protection will be ensured under at least the following conditions :

- an initial forward velocity of 0 to 16 km/h (0 to 10 mile/h) on a hard clay surface of 30° maximum slope;
- 360° of roll about the machine's longitudinal axis without losing contact with the slope and without penetration of the DLV by structural members of the ROPS.

6.5 The horizontal force requirement and limitation on deflection (DLV) are intended to ensure that the ROPS will penetrate unfrozen soil thereby giving a braking action to a roll.

6.6 The energy requirement and limitation on deflection (DLV) are intended to ensure that the ROPS will deflect when it strikes or impacts a surface that will not significantly deform (frozen ground, concrete, rock) while retaining significant capability to withstand subsequent impacts.

6.7 The vertical loading requirement is intended to ensure that a deformed ROPS will be able to support the machine when it is upside-down.

6.8 The criteria established for the deflection limitation, for the energy absorbed and for the lateral loading do not mean that the minimum side force and the minimum energy required correspond to the permissible limits of the DLV nor that they are attained simultaneously.

6.9 The temperature-material requirements of 8.3 are intended to be a base-line of measurement for testing, to ensure that the ROPS will have meaningful resistance to brittle fracture; they do not necessarily relate to operating conditions.

6.10 Because, in an actual roll, 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 ROPS is related more to energy absorption capability and details of weld design and welding procedure than it is to static force resistance.

7 Static laboratory tests

7.1 Facilities

Facilities for securing the ROPS-machine frame assembly to the bedplate, as described below, and for applying the horizontal and vertical loads shall be provided.

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

7.2 Instruments

The test apparatus shall be equipped with instruments for measuring the force applied to the protective structure and the deflection (deformation) of the structure.

The percentages below are nominal ratings of the accuracy of the instrumentation and shall not be taken to indicate that compensating tests are required.

Measurement	Accuracy
Deflection of ROPS	$\pm 5\%$ of maximum deflection measured
Force applied to ROPS	$\pm 5\%$ of maximum force measured

7.3 Arrangements for load application

Typical, but not mandatory, loading arrangements are shown in the figures as follows.

7.3.1 Wheel loaders, wheel tractors and backhoe loaders : figures 1c), 1d).

7.3.2 Graders : figures 2c), 2d).

7.3.3 Tractor scrapers and articulated steer dumpers : figures 3c), 3d).

7.3.4 Crawler tractors and crawler loaders : figures 4c), 4d).

7.3.5 Side loading : figures 5a), 5b), 5c), 5d).

7.4 Apparatus

7.4.1 General considerations

7.4.1.1 Assembly of the ROPS to the machine frame

The ROPS shall be attached to the machine frame as it would be on an operating machine. A complete machine is not required for the evaluation; however, the machine frame and ROPS mounting shall represent an operating installation. All normally detachable windows, panels, doors, and other non-structural elements shall be removed so that they do not contribute to or detract from the structural evaluation.

7.4.1.2 Attachment of the ROPS-machine frame assembly to the bedplate

The ROPS-machine frame assembly shall be secured to the bedplate so that the members connecting the assembly and bedplate experience minimal deflection when the ROPS is horizontally loaded. During side loading, the ROPS-machine frame assembly shall not receive any support from the bedplate, other than that due to the initial attachment.

7.4.1.3 Elimination of suspension elements and shock absorbers

The machine frame shall be secured and/or modified so that any machine suspension element that might be considered as a suspension element (rubber, gas, gas-oil, or mechanical spring) shall be effectively eliminated as an energy absorber. However, the ROPS-structural members as defined in 4.1 may include suspension or flexible shock absorbers which shall not be altered.

7.4.2 Specific considerations related to particular types of machine — Side loading

7.4.2.1 Wheel loaders, wheel tractors, backhoe loaders and graders

Connections to the bedplate shall be directly from the machine frame at or near the front-axle support and the rear drive support. For articulated machines, if both frames are used in the evaluation, the hinge shall be locked so that the attitude of the frames is in a straight line. If only that frame on which the ROPS is mounted is used, the connections shall be at or near the extreme ends of the frame. See figures 1a), 1b), 2a), 2b).

7.4.2.2 Tractor scrapers and articulated steer dumpers

Connection to the bedplate shall be directly from the machine frame at or near the drive tyre or axle location. See figures 3a), 3b).

7.4.2.3 Crawler tractors and crawler loaders

Connection to the bedplate shall be through the main housing or track frames. See figures 4a), 4b).

7.4.3 Vertical loading — All machines

For vertical loading there is no limitation on securing or supporting the ROPS-machine frame assembly.