BRITISH STANDARD

BS EN
13510:2000
BS 6912-14:2000

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

The European Standard EN 13510:2000 has the status of a British Standard

ICS 53.100

National foreword

This British Standard is the official English language version of EN 13510:2000. It supersedes BS 6912-14:1995 which is withdrawn.

The UK participation in its preparation was entrusted by Technical Committee B/513, Construction machinery and plant, and site safety, to Subcommittee B/513/1, Earth-moving machinery (international), which has the responsibility to:

— aid enquirers to understand the text;

— present to the responsible European committee any enquiries on the interpretation, or proposals for change, and keep the UK interests informed;

— monitor related international and European developments and promulgate them in the UK.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

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Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 27 and a back cover.

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This British Standard, having been prepared under the direction of the Sector Committee for Building and Civil Engineering, was published under the authority of the Standards Committee and comes into effect on 15 October 2000

ISBN 0 580 36561 1

Amendments issued since publication

Amd. No.	Date	Comments

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 13510

January 2000

ICS 53.100

English version

Earth-moving machinery - Roll-over protective structures - Laboratory tests and performance requirements (ISO 3471:1994, including Amendment 1:1997 modified)

Engins de terrassement - Structures de protection au retournement - Essais de laboratoire et critère de performance (ISO 3471:1994, Amendement 1:1997 modifié inclus)

Erdbaumaschinen - Überrollschutzaufbauten - Prüfungen und Anforderungen (ISO 3471:1994, einschließlich Änderung 1:1997 modifiziert)

This European Standard was approved by CEN on 12 November 1999.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Central Secretariat: rue de Stassart, 36 B-1050 Brussels

Ref. No. EN 13510:2000 E

Foreword

The text of the International Standard ISO 3471:1994 + Amendment 1:1997 from Technical Committee ISO/TC 127 "Earth-moving machinery" of the International Organization for Standardization (ISO) has been taken over with modifications as a European Standard by Technical Committee CEN/TC 151 "Construction equipment and building material machines - Safety", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by July 2000, and conflicting national standards shall be withdrawn at the latest by July 2000.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this standard.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom.

Endorsement notice

The text of the International Standard ISO 3471:1994 and Amendment 1:1997 has been approved by CEN as a European Standard with agreed common modifications as given below:

- scope is modified;
- normative references are updated;
- based on the revised scope the technical content of some clauses was modified;
- annex A is amended to include some further means of verification.

Introduction

A review of the initial work on the ROPS criteria indicated that the criteria were based on requirements for machines now identified as mid-range size machines. Over a period of 20 years, since the ROPS criteria were established, both smaller and larger machines have become common within the size range of earth-moving machines. Thus it was necessary to change the criteria for the lower and upper mass machines.

The criteria are a combination of linear, with respect to mass, 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.

A second criterion of longitudinal force was added as a new generation of ROPS designers became active, some of the early expertise that was developed through the process of establishing the criteria being lost. Situations could arise where ROPS designs would meet the lateral and vertical loading requirements, but yet be considered to lack sufficient performance capability in the longitudinal load direction. For this reason this European Standard now incorporates a ROPS longitudinal force criterion. The longitudinal force criterion was established at 80 % of the lateral force requirement.

1 Scope

This European Standard establishes a consistent and reproducible means of evaluating the load-carrying characteristics of Roll-Over Protective Structures (ROPS) under static loading, and prescribes performance requirements for a representative specimen under such loading.

It applies to the following seated design operator-controlled machines as defined in ISO 6165:

- dozers (crawler and wheeled);
- graders;
- loaders (crawler and wheeled);
- earth- and landfill compactors;
- skid-steer loaders and backhoe loaders;
- tractor portion (prime mover) of scrapers and articulated steer dumpers;
- rollers;
- rigid frame dumpers.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN 20898-1:1991	Mechanical properties of fasteners - Part 1: Bolts, screws and studs
EN 20898-2:1993	Mechanical properties of fasteners - Part 2: Nuts with specified proof load values - Coarse thread
ISO 148:1983	Steel - Charpy impact test (V-notch)
ISO 3164:1995	Earth-moving machinery - Laboratory evaluations of roll-over and falling-object protective structures - Specifications for deflection-limiting volume
ISO 6165:1997	Earth-moving machinery - Basic types - Vocabulary
ISO 9248:1992	Earth-moving machinery - Units for dimensions, performance and capacities, and their measurement accuracies

3 Definitions

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

3.1 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. 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 that are integral with the machine frame.

3.2 Machine frame: Main chassis or main load-bearing member(s) of the machine which extend(s) over a major portion of the machine and upon which the ROPS is directly mounted.

3.3 Rollbar ROPS: One- or two-post ROPS without FOPS or any cantilevered load-carrying structural members.

3.4 Bedplate: Substantially rigid part of the test fixtures to which the machine frame is attached for the purpose of the test.

3.5 Deflection-limiting volume (DLV): Orthogonal approximation of a large, seated, male operator wearing normal clothing and a hard hat. (See ISO 3164:1992, figure 1.)

3.6 **Representative specimen**: ROPS, mounting hardware and machine frame (complete or partial) for test purposes that is within the manufacturer's specifications.

3.7 **Load distribution device**: Device used to prevent localized penetration of the ROPS members at the load application point.

3.8 **Load application point**: Point on the ROPS structure where the test load is applied to the ROPS structure.

3.9 **Deflection of ROPS**: Movement of the ROPS structure caused by the application of the load and measured at the load application point.

3.10 **Falling-object protective structure (FOPS)**: System of structural members arranged in such a way as to provide operators with reasonable protection from failing objects (for example, trees, rocks, small concrete blocks, tools).

3.11 **Simulated ground plane (SGP)**: Flat surface on which a machine, after rolling over, is assumed to come to rest.

3.11.1 **Lateral simulated ground plane (LSGP)**: For a machine coming to rest on its side, the plane 15° away from the DLV about the horizontal axis within the plane established in the vertical plane passing through the outermost point (see figure 4). This establishes the LSGP. The LSGP is established on an unloaded ROPS and moves with the member to which load is applied while maintaining its 15° angle with respect to the vertical.

3.11.2 **Vertical simulated ground plane (VSGP)**: For a machine coming to rest in an upside-down position, the plane is defined by the top cross-member of the ROPS and that front (rear) part of the machine likely to come in contact with flat ground at the same time as the ROPS and capable of supporting the upside-down machine. The VSGP moves with the deformed ROPS (see figure 5).

NOTE: The VSGP applies only to rollbar ROPS.

4 Symbols

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

4.1 *U*: Energy absorbed by the structure, related to the machine mass as specified in 4.3, expressed in joules.

4.2 *F*: Force, expressed in newtons.

4.3 *M*: Manufacturer's maximum recommended mass, expressed in kilograms.

4.3.1 The manufacturer's maximum recommended mass includes attachments in operating condition with all reservoirs full to capacity, tools and ROPS; it excludes towed equipment such as rollers and drawn scrapers.

4.3.2 For the tractor scraper and articulated steer dumper, it is the manufacturer's maximum recommended mass of the tractor portion (prime mover) only. In most cases it is the tractor portion, but it should be the ROPS-bearing member or ROPS-carrying part. Kingpins, hitches and articulated-steering components that attach to hitches or towed units are excluded from the mass of these machines.

4.3.3 For rigid frame dumpers, *M* excludes the mass of the dump body and the payload when the "ROPS only" criteria are selected. When the "body only" criteria are selected, *M* includes the mass of the dump body but excludes the mass of the payload.

4.3.4 For rollers, loosely contained ballast is also to be excluded from *M*. 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 considered part of the machine mass in determining test requirements.

4.4 *L*: Length of the ROPS in millimetres as expressed below.

a) For a one- or two-post ROPS with a FOPS and/or cantilevered load-carrying structural members, the length, *L*, is that portion of the cantilevered load-carrying members which covers at least the vertical projection of the length of the DLV of the operator. It is measured at the top of the ROPS, from the extreme face of the ROPS post(s) to the far end of the cantilevered load-carrying members (see figure 1).

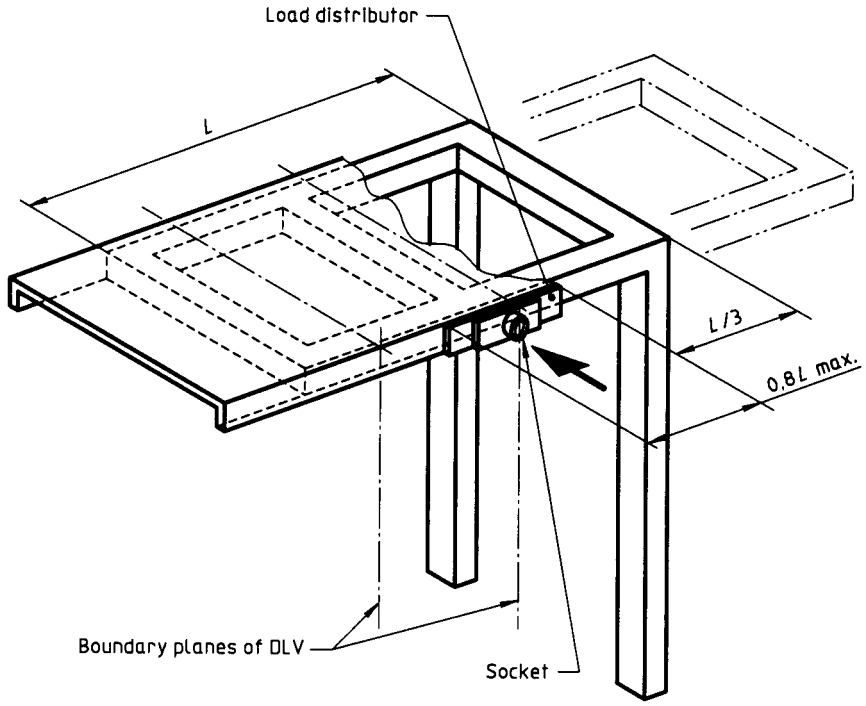
b) For all other ROPS, the length, *L*, is the greatest total longitudinal distance between the outsides of the front and rear posts (see figure 2).

4.5 *W*: Width of the ROPS in millimetres as expressed below.

a) For a one- or two-post ROPS with a FOPS and/or cantilevered load-carrying structural members, the width, *W*, is that portion of the cantilevered load-carrying members which covers at least the vertical projection of the width of the DLV. It is measured at the top of the ROPS, from the extreme face of the ROPS structure left and right post to the far side of the cantilevered load-carrying members.

b) For all other ROPS, the width, *W*, is the greatest total width between the outsides of the left and right ROPS posts (see figure3).

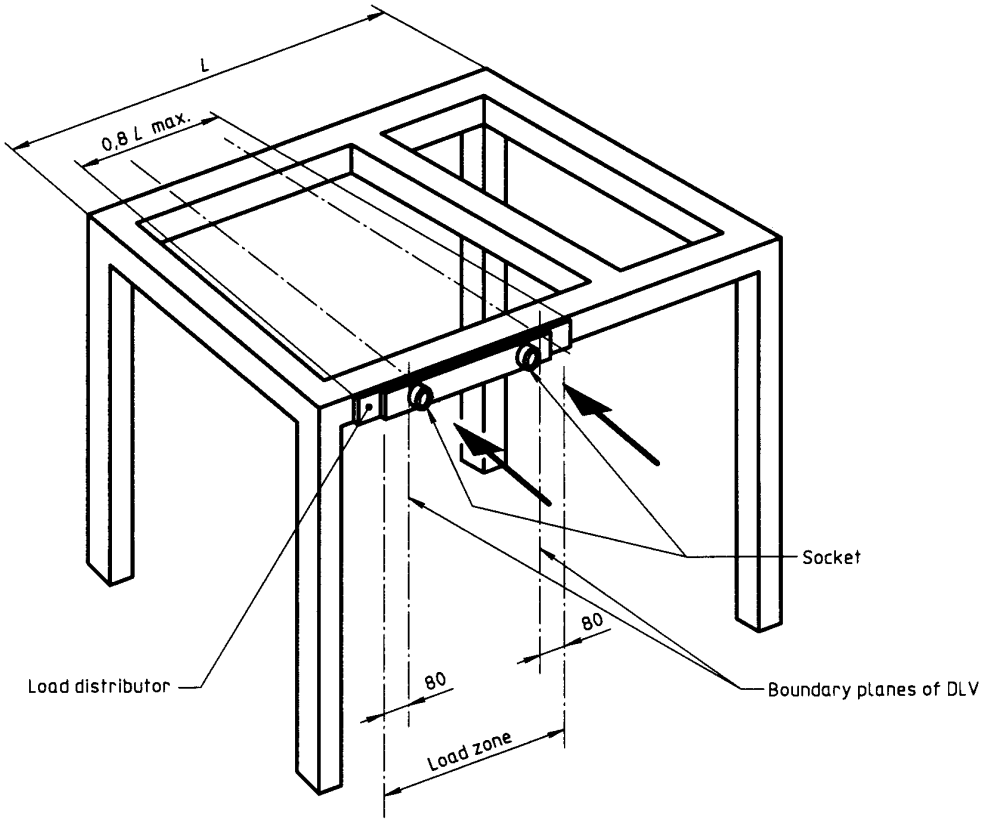
4.6 Δ: Deflection of the ROPS, expressed in millimetres.



NOTE: Load distributor and socket are to prevent local penetration and to hold end of load-generating device.

Figure 1: Two-post ROPS with FOPS lateral load application point

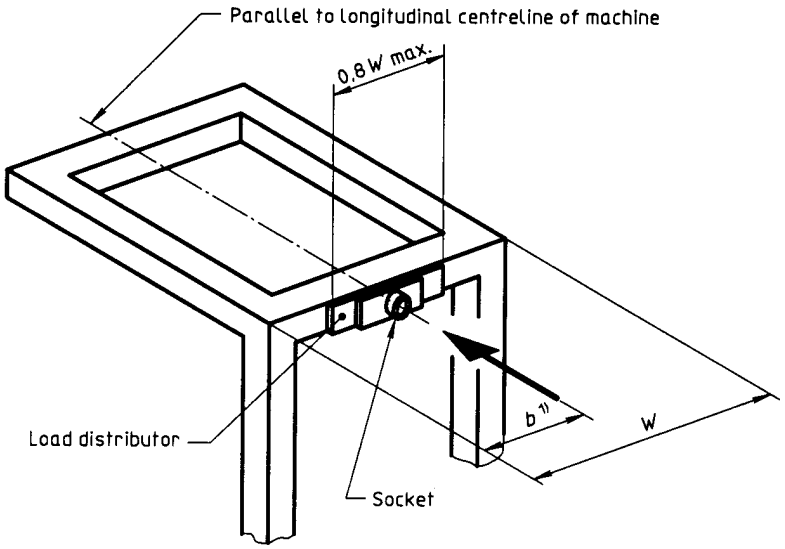
Dimensions in millimetres



NOTE 1: Load distributor and socket are to prevent local penetration and to hold end of load-generating device.

NOTE 2: Typical but not mandatory layout.

Figure 2: Four-post ROPS lateral load application point

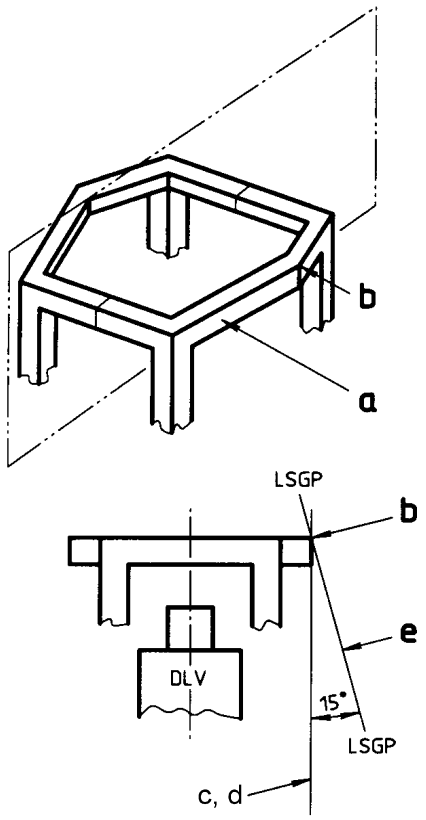


1) $b = W/2$

NOTE 1: Load distributor and socket are to prevent local penetration and to hold end of load-generating device.

NOTE 2: Typical but not mandatory layout.

Figure 3: Longitudinal load application point



Key

a Upper ROPS member to which the lateral load is applied
b Outermost point from the end view of member a
c Vertical line through point b
d Vertical plane parallel to the machine longitudinal centreline through line c
e Lateral simulated ground plane (LSGP)

Figure 4: Determination of lateral simulated ground plane (LSGP)

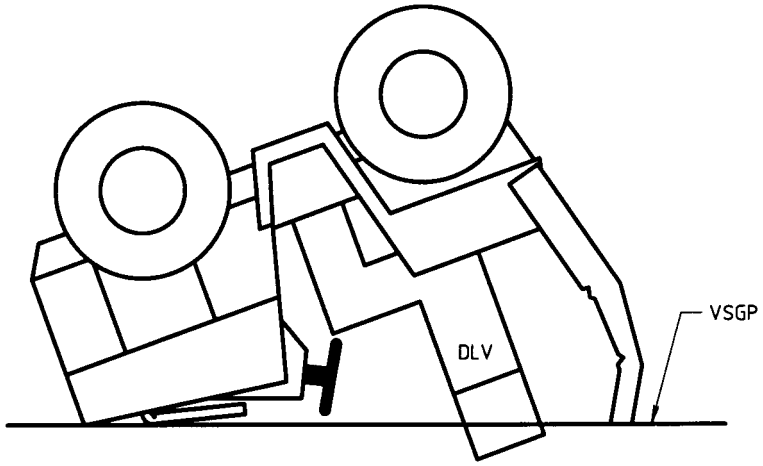


Figure 5: Intrusion of vertical simulated ground plane (VSGP) into DLV

5 Test method and facilities

5.1 General

The requirements are force resistance in the lateral, vertical and longitudinal directions and energy absorption in the lateral direction. There are limitations on deflections under the lateral, vertical and longitudinal loading. The energy requirement and limitations on deflection (DLV) under lateral loading are intended to ensure that the ROPS will deflect when it impacts a surface which will not significantly deform (frozen ground, concrete, rock) while retaining significant capability to withstand subsequent impacts in an overturn.

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 attaches. Therefore, it is expected that crush protection for a seat-belted operator will be ensured 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;

- 360° of roll about the machine longitudinal axis without losing contact with the slope.

5.2 Instrumentation

Systems used to measure mass, force and deflection shall be capable of meeting the requirements of ISO 9248.

5.3 Test facilities

Fixtures shall be adequate to secure the ROPS/machine frame assembly to a bedplate and to apply the required lateral, vertical and longitudinal loads as determined by the formulae given in table 1.

Table 1: Force and energy equations

Machine mass, *M* kg	**Lateral load force**, *F* N	**Lateral load energy**, *U* J	**Vertical load force**, *F* N	**Longitudinal load force**, *F* N
1) Crawler dozers and loaders				
$700 < M \leq 4\,630$	$6\,M$	$13\,000 \left(\frac{M}{10\,000}\right)^{1,25}$		$4,8\,M$
$4\,630 < M \leq 59\,500$	$70\,000 \left(\frac{M}{10\,000}\right)^{1,2}$	$13\,000 \left(\frac{M}{10\,000}\right)^{1,25}$	$19,61\,M$	$56\,000 \left(\frac{M}{10\,000}\right)^{1,2}$
$M > 59\,500$	$10\,M$	$2,03\,M$		$8\,M$
2) Graders				
$700 < M \leq 2\,140$	$6\,M$	$15\,000 \left(\frac{M}{10\,000}\right)^{1,25}$		$4,8\,M$
$2\,140 < M \leq 38\,010$	$70\,000 \left(\frac{M}{10\,000}\right)^{1,1}$	$15\,000 \left(\frac{M}{10\,000}\right)^{1,25}$	$19,61\,M$	$56\,000 \left(\frac{M}{10\,000}\right)^{1,1}$
$M > 38\,010$	$8\,M$	$2,09\,M$		$6,4\,M$
3) Wheeled loaders and dozers, earth- and landfill compactors, skid-steer loaders, and backhoe loaders				
$700 < M \leq 10\,000$	$6\,M$	$12\,500 \left(\frac{M}{10\,000}\right)^{1,25}$		$4,8\,M$
$10\,000 < M \leq 128\,600$	$60\,000 \left(\frac{M}{10\,000}\right)^{1,2}$	$12\,500 \left(\frac{M}{10\,000}\right)^{1,25}$	$19,61\,M$	$48\,000 \left(\frac{M}{10\,000}\right)^{1,2}$
$M > 128\,600$	$10\,M$	$2,37\,M$		$8\,M$

(continued)

4) Tractor portion of scrapers and articulated steer dumpers				
$700 < M \leq 1\,010$	$6\,M$	$20\,000 \left(\frac{M}{10\,000}\right)^{1,25}$		$4{,}8\,M$
$1\,010 < M \leq 32\,160$	$95\,000 \left(\frac{M}{10\,000}\right)^{1,2}$	$20\,000 \left(\frac{M}{10\,000}\right)^{1,25}$	$19{,}61\,M$	$76\,000 \left(\frac{M}{10\,000}\right)^{1,2}$
$M > 32\,160$	$12\,M$	$2{,}68\,M$		$9{,}6\,M$
5) Rollers (mass *M* excludes mass of loosely contained ballast)				
$700 < M \leq 10\,000$	$5\,M$	$9\,500 \left(\frac{M}{10\,000}\right)^{1,25}$		$4\,M$
$10\,000 < M \leq 53\,780$	$50\,000 \left(\frac{M}{10\,000}\right)^{1,2}$	$9\,500 \left(\frac{M}{10\,000}\right)^{1,25}$	$19{,}61\,M$	$40\,000 \left(\frac{M}{10\,000}\right)^{1,2}$
$M > 53\,780$	$7\,M$	$1{,}45\,M$		$5{,}6\,M$
6) Rigid frame dumpers – ROPS only option (mass *M* excludes dump body and payload mass)				
$700 < M \leq 1\,750$	$6\,M$	$15\,000 \left(\frac{M}{10\,000}\right)^{1,25}$		$4{,}8\,M$
$1\,750 < M \leq 22\,540$	$85\,000 \left(\frac{M}{10\,000}\right)^{1,2}$	$15\,000 \left(\frac{M}{10\,000}\right)^{1,25}$		$68\,000 \left(\frac{M}{10\,000}\right)^{1,2}$
$22\,540 < M \leq 58\,960$	$10\,M$	$1{,}84\,M$	$19{,}61\,M$	$8\,M$
$58\,960 < M \leq 111\,660$	$413\,500 \left(\frac{M}{10\,000}\right)^{0,2}$	$61\,450 \left(\frac{M}{10\,000}\right)^{0,32}$		$330\,800 \left(\frac{M}{10\,000}\right)^{0,2}$
$M > 111\,660$	$6\,M$	$1{,}19\,M$		*4,8 M*
7) Rigid frame dumpers – Body only option (mass *M includes dump body mass but not payload mass*)				
$700 < M \leq 10\,000$	$6\,M$	$6\,000 \left(\frac{M}{10\,000}\right)^{1,25}$		$4{,}8\,M$
$10\,000 < M \leq 21\,610$	$60\,000 \left(\frac{M}{10\,000}\right)^{1,2}$	$6\,000 \left(\frac{M}{10\,000}\right)^{1,25}$		$48\,000 \left(\frac{M}{10\,000}\right)^{1,2}$
$21\,610 < M \leq 93\,900$	$7\,M$	$0{,}73\,M$	$19{,}61\,M$	$5{,}6\,M$
$93\,900 < M \leq 113\,860$	$42\,000 \left(\frac{M}{10\,000}\right)^{0,2}$	$16\,720 \left(\frac{M}{10\,000}\right)^{0,63}$		$336\,000 \left(\frac{M}{10\,000}\right)^{0,2}$
$M > 113\,860$	$6\,M$	$0{,}68\,M$		*4,8 M*
8) Rigid frame dumpers – Combination of ROPS only and body only option				
When both ROPS and body are used, the lateral loading force and energy requirements and the longitudinal loading force for each shall be 60 % of those indicated by the equations of ROPS only and body only respectively. Lateral, longitudinal or vertical loading of the ROPS and/or body need not be applied simultaneously to both members of a combination. The only limitation on the order of the six loadings is that the vertical loading of members shall be applied after the lateral loading and the longitudinal loading of members shall be applied after the vertical loading. See figures 11 and 12.				

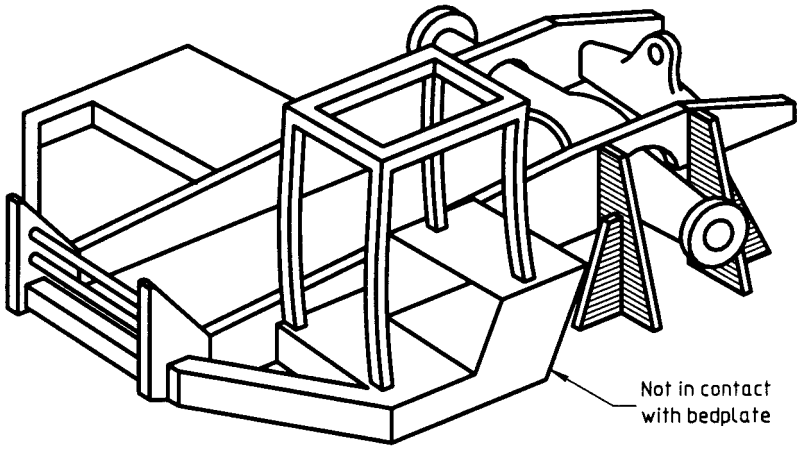
5.4 ROPS/machine frame assembly and attachment to bedplate

5.4.1 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 mounted ROPS test specimen shall represent the structural configuration of an operating installation. All normally detachable windows, panels, doors and other non-structural elements shall be removed so that they neither contribute to nor detract from the structural evaluation.

5.4.2 The ROPS/machine frame assembly shall be secured to the bedplate so that the members connecting the assembly and bedplate experience minimal deflection during testing. The ROPS/machine frame assembly shall not receive any support from the bedplate, other than that due to the initial attachment.

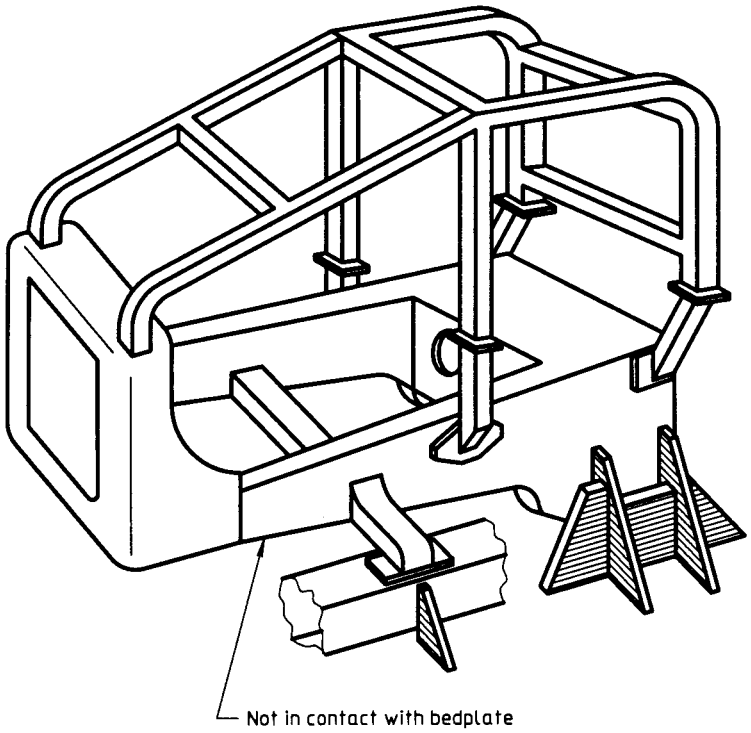
5.4.3 The test shall be conducted with any machine/ground suspension elements blocked externally so that they do not contribute to the load-deflection behaviour of the test specimen. Suspension elements used to attach the ROPS to the machine frame and acting as a load path shall be in place and functioning at the start of the test.

5.4.4 For non-articulated machines and articulated machines using both frames, connections to the bedplate shall be directly from the machine frame at or near the front and rear axle supports, or equivalent. For articulated machines, the hinge shall be locked if both frames are used in the evaluation. If only that frame to which the ROPS is mounted is used, the connections shall be at or near the articulation joint and axle support or alternatively at the extreme end of the frame. For single-axle prime movers, the support shall be at the drive axle. Tracked machines shall be connected to the bedplate through the main housing and/or track frames. (See figures 6 to 12.)



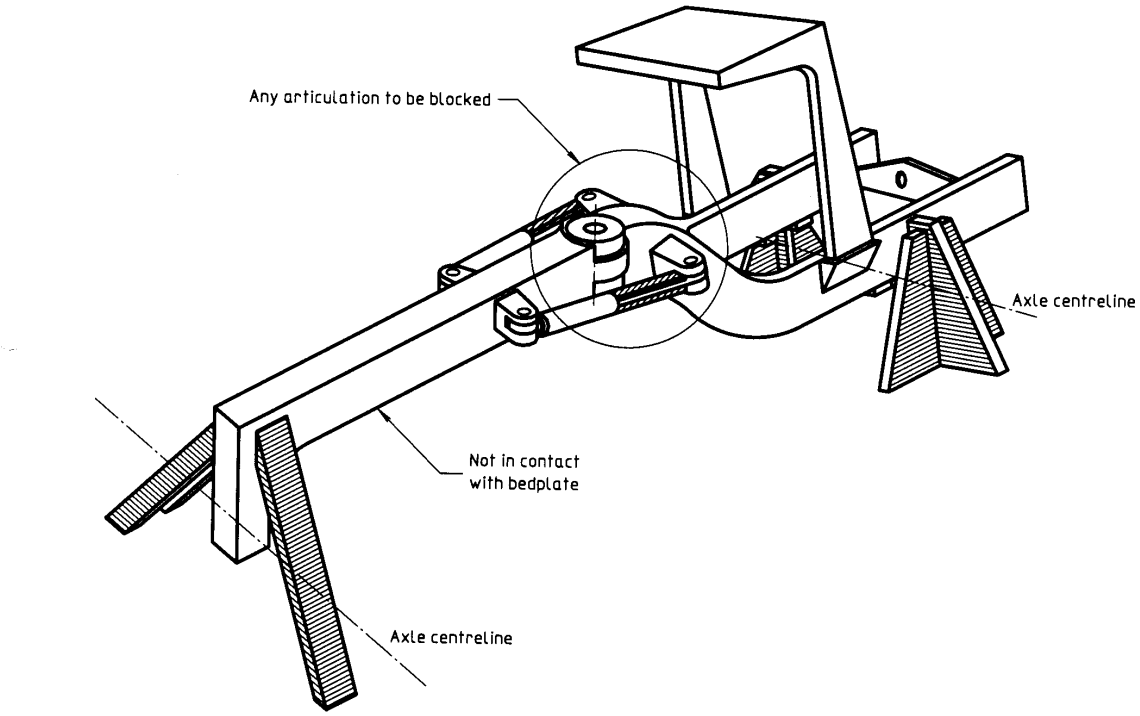
NOTE: Typical but not mandatory layout.

Figure 6: Test bed anchorage of tractor portion (prime mover)



NOTE: Typical but not mandatory layout.

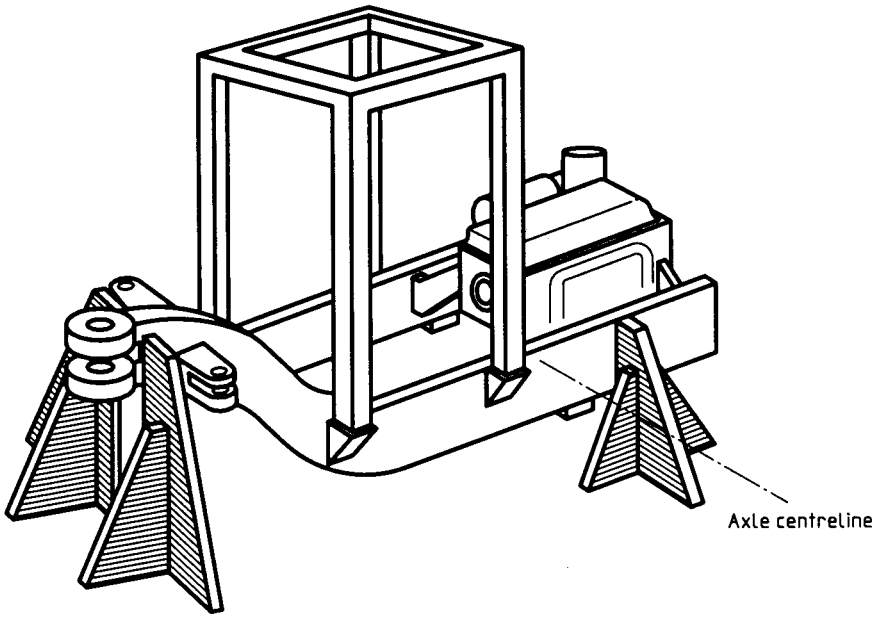
Figure 7: Test bed anchorage of track-type tractor



NOTE 1: 0° articulation is required.

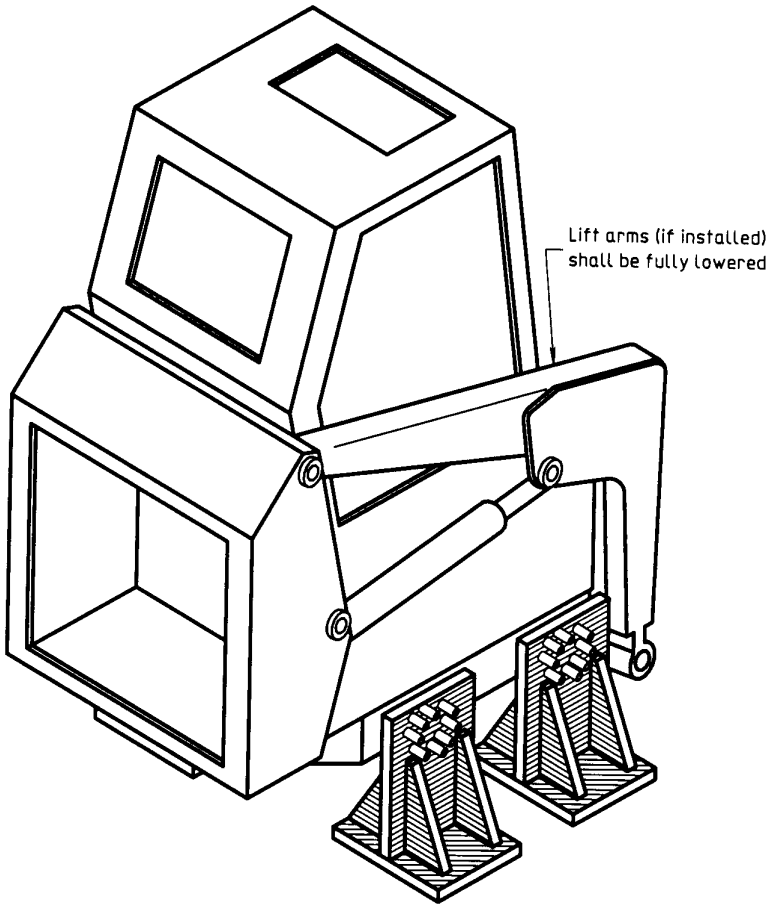
NOTE 2: Typical but not mandatory layout.

Figure 8: Anchorage of articulated motor grader (complete frame)



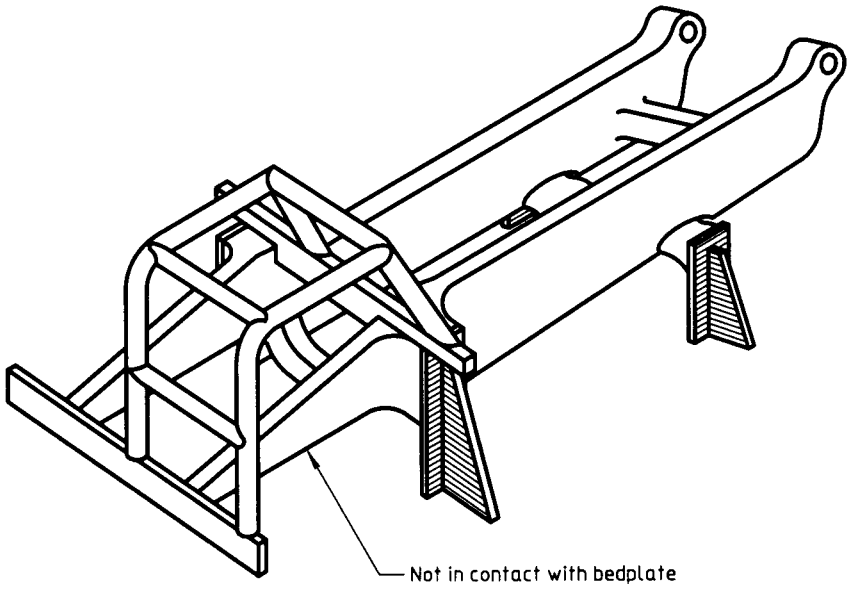
NOTE: Typical but not mandatory layout.

Figure 9: Test bed anchorage of half articulated frame



NOTE: Typical but not mandatory layout.

Figure 10: Anchorage of skid-steer loader



NOTE: Typical but not mandatory layout.

Figure 11: Anchorage of dumper frame – "ROPS only" option

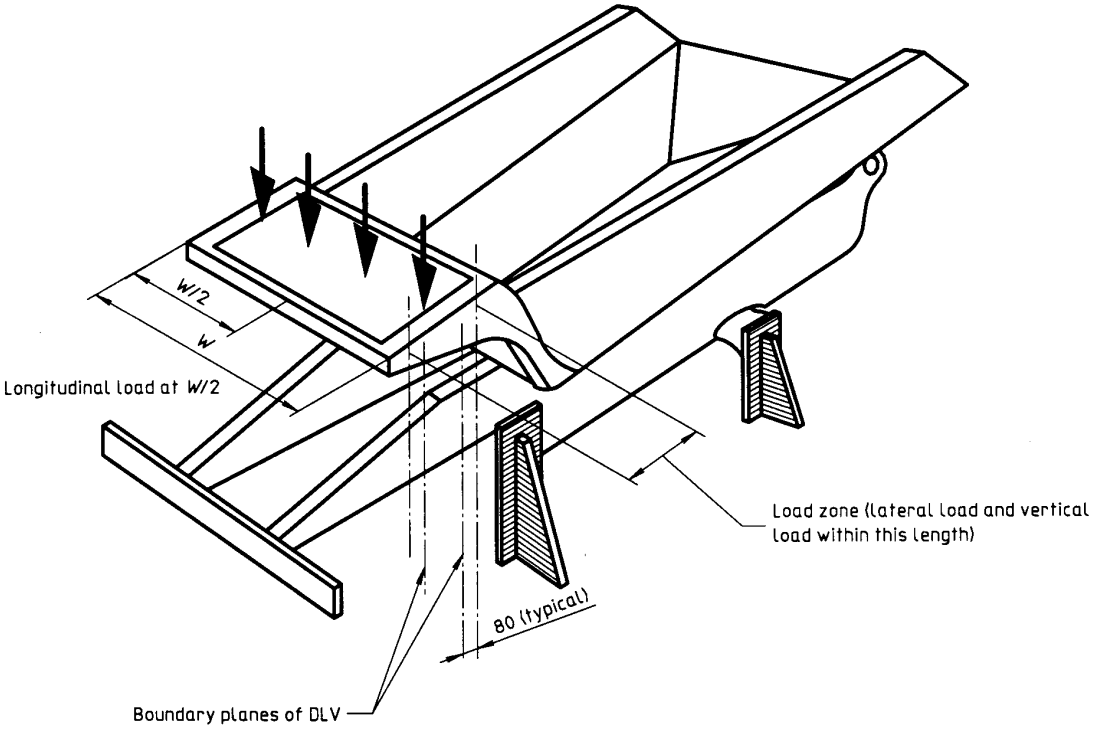


Figure 12: Loading of dumper – "body only" option

6 Test loading procedure

6.1 General

6.1.1 All load application points shall be identified and marked on the structure before any loading is applied.

6.1.2 The loads shall be calculated according to table 1 and the loading sequence shall be lateral, vertical and then longitudinal.

6.1.3 No straightening or repair is permitted during or between loading phases.

6.1.4 A load-distribution device may be used to prevent localized penetration. It shall not impede rotation of the ROPS.

6.2 Lateral loading

6.2.1 The load distribution device may not distribute the load over a distance greater than 80 % of the length, *L*.

6.2.2 For a rollbar ROPS, the load application point shall be in line with the upper lateral cross-member.

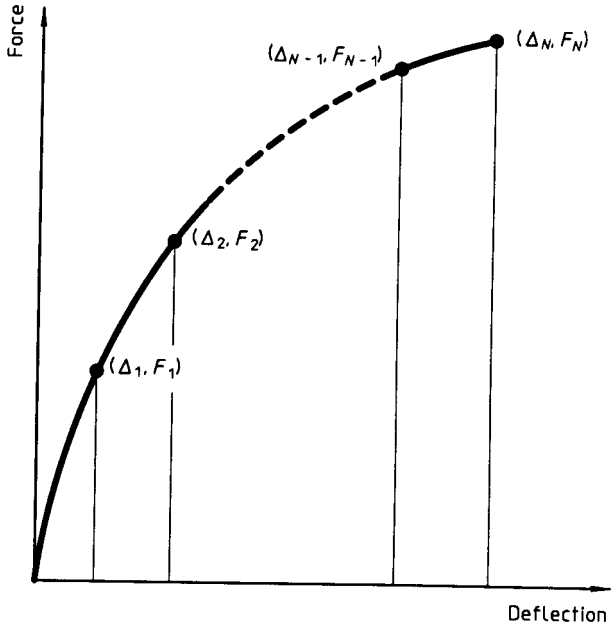
6.2.3 For all other one- or two-post ROPS, initial loading shall be dictated by the length, *L*, and the vertical projections of the front and rear planes of the DLV. The load application point may not be within *L*/3 of the ROPS structure. Should the *L*/3 point be between the vertical projection of the DILV and the ROPS structure, the load application point shall be moved away from the structure until it enters the vertical projection of the IDLV (see figure 1).

6.2.4 For a ROPS of more than two posts, the load application point(s) shall be located between vertical projections of planes 80 mm outside of the front and rear boundary planes of the DLV (see figure 2).

6.2.5 Where the operator's seat is off the machine longitudinal centreline, the loading shall be against the outermost side nearest the seat. Where the operator's seat is on the machine longitudinal centreline, if the ROPS structure and mounting are such that different force-deflection results are likely by loading from left or right, the side loaded shall be that which will place the most severe loading requirements on the ROPS/machine frame assembly.

6.2.6 The initial direction of the loading shall be horizontal and perpendicular to a vertical plane through the machine longitudinal centreline. As loading continues, ROPS/machine frame deformations may cause the direction of loading to change; this is permissible.

6.2.7 The rate of deflection shall be such that the loading may be considered static. The rate of load application may be considered static if the rate of deflection at the load application point is not greater than 5 mm/s. At deflection increments no greater than 15 mm (at the point of application of the resultant load), the values of force and deflection shall be recorded. This loading is to continue until the ROPS has achieved both the force and energy requirements. See figure 13 for the method of calculating the energy, *U*. The deflection used in calculating the energy is that of the ROPS along the line of action of the force. Any deflection of members used to support the load application device shall not be included in the total deflection.



Energy:

$$U = \frac{\Delta_1 F_1}{2} + (\Delta_2 - \Delta_1)\frac{F_1 + F_2}{2} + \left|(\Delta_N - \Delta_{N-1})\frac{F_N - 1 + F_N}{2}\right|$$

Figure 13: Force-deflection curve for loading test

6.3 Vertical loading

6.3.1 After completion of the lateral loading, a vertical load shall be applied to the top of the ROPS.

6.3.2 For a rollbar ROPS, the vertical load shall be applied in the same plane as the lateral load of 6.2.2. For all other one- or two-post ROPS structures the centre of the vertical load application shall not be any nearer to the ROPS posts than was the lateral load in 6.2.3.

6.3.3 In no instance is there any further limitation on the manner of distributing this load on the ROPS, provided it is symmetrically applied. Figure 14 shows a typical vertical load application.

6.3.4 The rate of deflection shall be such that the loading may be considered static (see 6.2.7). Loading is continued until the ROPS has achieved the force requirement. The structure shall support this load for a period of 5 min or until any deformation has ceased, whichever is shorter.

6.4 Longitudinal loading

6.4.1 After removal of the vertical load, a longitudinal load shall be applied to the ROPS.

6.4.2 The longitudinal load shall be applied at the deformed location of the originally established point, since the lateral (and vertical) loading of the ROPS is likely to result in permanent deformation of the structure. The originally established point is determined by the location of the load distributor and socket prior to any test being performed on the structure.

The load distribution device may span the width in cases where no rear (front) cross-member exists. In all other cases, the device may not distribute the load over a length greater than 80 % of the width, *W*, of the ROPS (see figure 3).

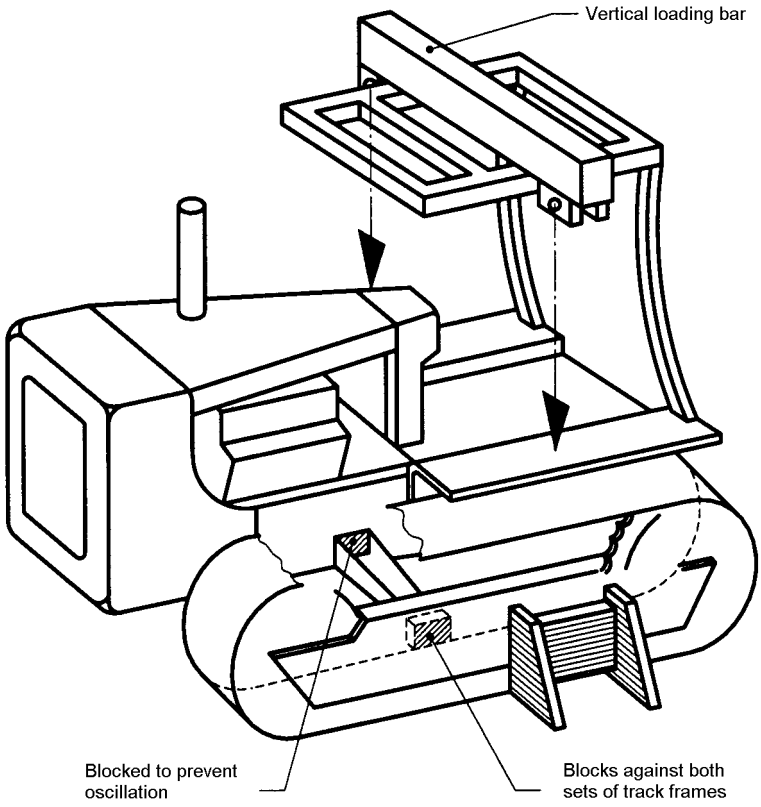


Figure 14: Vertical loading example

6.4.3 The longitudinal load shall be applied to the upper structural members of the ROPS along the longitudinal centreline of the ROPS.

6.4.4 For all machines the direction of loading (fore or aft) shall be selected to place the most severe requirements on the ROPS/machine frame assembly. The initial direction of loading shall be horizontal and parallel to the original longitudinal centreline of the machine. Some additional factors to consider in deciding on the direction to apply the longitudinal load are:

a) location of ROPS relative to DLV and the effect that longitudinal deflection of the ROPS would have on providing crush protection for the operator;

b) machine characteristics, e.g. other structural members of the machine which may resist longitudinal deflection of the ROPS, that can limit direction of the longitudinal component of loading on the ROPS;

c) experience which may indicate the possibility of longitudinal tipping or the tendency of a particular classification of machine to skew as it rotates about a longitudinal axis during an actual roll-over.

6.4.5 The rate of deflection shall be such that the loading may be considered static (see 6.2.7). This loading is to continue until the ROPS has achieved the force requirement(s).

7 Temperature and material criteria

7.1 In addition to the loading requirements, there are material and temperature requirements to ensure that the ROPS will have meaningful resistance to brittle fracture. This requirement shall be met by applying the static loadings with all structural members at, or below, – 18 °C if material specifications and procurement guarantee that materials in ROPS subsequently manufactured will have toughness characteristics similar to those in the representative specimen tested. Alternatively, the requirement may be met by applying the loadings at higher temperatures if all ROPS structural members are fabricated from materials that meet the mechanical requirements in 7.2 to 7.4.

7.2 Bolts used structurally shall be metric property class 8.8, 9.8 or 10.9 (see EN 20898-1). Nuts used structurally shall be metric property class 8 or 10 (see EN 20898-2).

7.3 Structural members of the ROPS and the mounts which attach it to the machine frame shall be made of steels that meet or exceed one of the Charpy V-notch (CVN) impact strengths at – 20 °C or – 30 °C shown in table 2. (The Charpy V-notch evaluation is primarily a quality control check and the indicated temperature does not directly relate to operating conditions.)

Specimens are to be "longitudinal" and taken from flat stock, tubular or structural sections before forming or welding for use in the ROPS. Specimens from tubular or structural sections shall be taken from the middle of the side of greatest dimension and shall not include welds (see ISO 148).

7.4 Steel less than 2,5 mm in thickness with a maximum carbon content of 0,2 % shall be considered to meet the Charpy requirement.

Table 2: Minimum Charpy V-notch impact strengths

Specimen size mm	Strength in J	
	– 30 °C	– 20 °C [2)]
10 x 10 [1)]	11	27,5
10 x 9	10	25
10 x 8	9,5	24
10 x 7,5 [1)]	9,5	24
10 x 7	9	22,5
10 x 6,7	8,5	21
10 x 6	8	20
10 x 5 [1)]	7,5	19
10 x 4	7	17,5
10 x 3,3	6	15
10 x 3	6	15
10 x 2,5 [1)]	5,5	14

1) Indicates preferred size. Specimen size shall be no less than the largest preferred size that the material will permit.
2) The energy requirements at – 20 °C is 2,5 times the value specified for – 30 °C. Other factors affect impact energy strength, i. e. direction of rolling, yield strength, grain orientation and welding. These factors shall be considered when selecting and using a steel.

8 Acceptance criteria

8.1 The specific lateral force and lateral energy, vertical load-carrying capacity and the longitudinal force requirements shall be met or exceeded in the testing of a single representative specimen. The equations for determining the values to be met are given in table 1.

8.2 The force and energy requirements under lateral loading need not be attainable simultaneously. One may be significantly exceeded before the other is attained. If the force is attained before the energy, the force may decrease but shall again attain the required level when the lateral energy requirement is met or exceeded.

8.3 The limitations on the deflections are absolute; no part of the ROPS shall enter the DLV at any time during the lateral, vertical or longitudinal loading phases of the test.

8.4 The lateral simulated ground plan (LSGP) shall not enter the DLV (upright mode) at any time during the lateral loading phase of the test, except as noted in 8.6 (see figure 4).

8.5 For a rollbar ROPS, the vertical simulated ground plane (VSGP) shall not enter the DLV at any time during the vertical loading phase of the test (see figure 5).

8.6 During lateral loading with a side-mounted operator seat (mounted off the machine longitudinal centreline) or for longitudinal loading with the operator facing the direction that the ROPS will deflect under load application, it is permissible for the upper portion of the DLV to be rotated "forward" up to 15° about its locating axis (LA), as defined in ISO 3164, to prevent intrusion of ROPS members (or the LSGP in lateral loading only). Forward rotation of the DLV shall be limited to less than 15° if interference with any machine components or controls occurs at a lesser angle (see figure 15).

8.7 If a longitudinal load is applied in the direction opposite to that indicated in 8.6 (i.e. with the operator facing the direction opposite that the ROPS will deflect towards under load application), no rotation of the DLV is allowed. The force requirement shall be attained within the same conditions as required to achieve the lateral energy requirement.

8.8 The ROPS shall not break away from the machine frame due to failure of the machine frame or mounting.

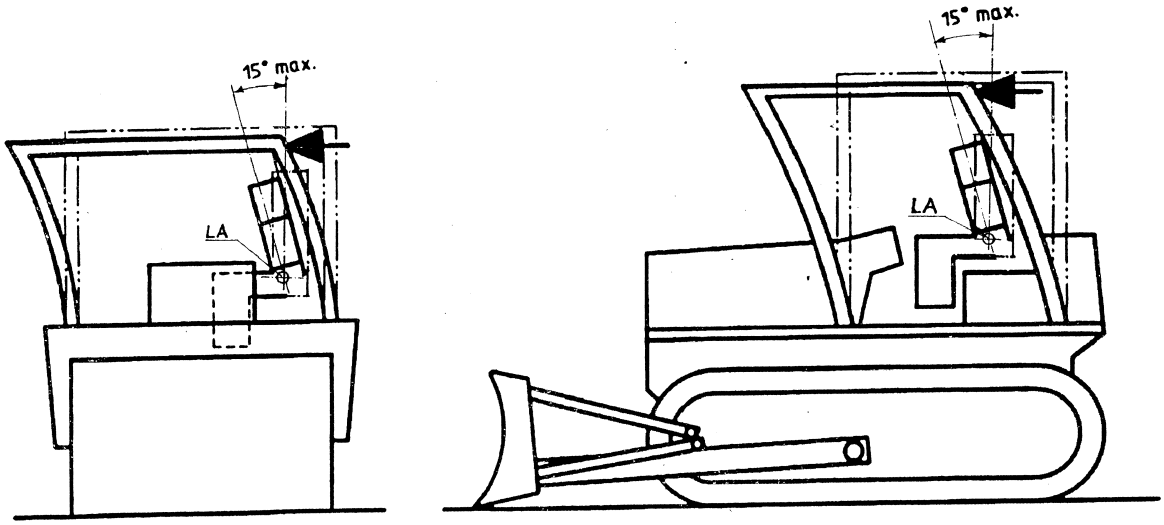


Figure 15: Allowable rotation of upper DLV about locating axis

9 Labelling of ROPS

ROPS meeting the requirements of this European Standard shall be labelled as in 9.1 and 9.2.

NOTE: FOPS information may be included on the label.

9.1 Label specifications

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

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

9.2 Label content

The label shall indicate the following:

a) the name and address of the ROPS manufacturer;

b) ROPS identification number, if any;

c) machine make, model(s), or series number(s) the structure is designed to fit;

d) maximum machine mass, *M*, for which the ROPS structure meets all of the performance requirements of this European Standard;

e) standard number(s) for which the structure meets all of the performance requirements;

f) other such information as deemed appropriate (for example, installation, repair or replacement information).

10 Reporting results

The results of the tests shall be reported using a test report such as that presented in annex A.

Annex A (normative)
ROPS test report

A.1 Identification

A.1.1 Machine

Type: . .....
Manufacturer: . .....
Model: .....
Serial number: .....
Machine frame part number: .....

A.1.2 ROPS

Manufacturer: .....
Model: .....
Serial number: .....
ROPS part number: .....

A.2 Information supplied by manufacturer

Maximum recommended mass: ..... kg
Location of DLV: .....

A.3 Criteria

Lateral load force: ..... N
Lateral load energy: ..... J
Vertical load force: ..... N
Longitudinal load force: ..... N

A.4 Test results

The following force and energy levels were achieved or exceeded with no penetration by the ROPS structural member or the simulated ground planes (where applicable) into the DLV.

A.4.1 Lateral loading

Maximum force attained after the energy requirement was achieved or exceeded:
..... N
Absorbed energy attained: ..... J

A.4.2 Vertical loading

Maximum force attained: ..... N

A.4.3 Longitudinal loading

Maximum force attained: ..... N

A.4.4 Temperature and material

A.4.4.1 The test was performed with ROPS and machine frame members soaked to:
..... °C

A.4.4.2 (to be completed only if the temperature in A.4.4.1 is over – 18 °C)

The Charpy V-notch impact strength requirements for ROPS structural metallic members were tested on a specimen size ..... mm X ..... mm.
The absorbed energy was: ..... J
Nut property class: .....
Bolt property class: .....

A.4.5 Use of special suspension or shock-absorption system

Manufacturer: .....
Model: .....
Serial no.: .....

A.4.6 Force-deflection curve for loading test

A force-deflection curve based on the actual test results shall be included in the test report.

A.4.7 Photo report

A photo report illustrating the test facilities, the test specimen before and after each of the test criteria (lateral, vertical and longitudinal) shall be supplied.

A.5 Attestation statement

The minimum performance requirements of EN 13510 (ISO 3471:1994, including Amendment 1:1997 modified) were met in this test for a maximum machine mass of .....kg

Date of test: .....
Name and address of test facility: .....
Test engineer: .....
Date of test report: .....

Annex ZA (informative)
Relationship of this European Standard with EU Directives

This European standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association and supports essential requirements of the following EU Directives:

Machinery Directive 98/37/EC.

Compliance with this standard provides one means of conforming with the specific essential requirements of the Directive concerned and associated EFTA regulations.

WARNING: Other requirements and other EC Directives may be applicable to the products falling within the scope of this standard.

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