# INTERNATIONAL STANDARD

# ISO 12117-2

First edition
2008-12-01

## Earth-moving machinery — Laboratory tests and performance requirements for protective structures of excavators —

## Part 2:
## Roll-over protective structures (ROPS) for excavators of over 6 t

*Engins de terrassement — Essais de laboratoire et exigences de performance des structures de protection des pelles —*

*Partie 2: Structures de protection au retournement (ROPS) pour pelles de terrassement de plus de 6 t*

Reference number
ISO 12117-2:2008(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.org
Web www.iso.org

Published in Switzerland

# 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 12117-2 was prepared by Technical Committee ISO/TC 127, *Earth-moving machinery*, Subcommittee SC 2, *Safety, ergonomics and general requirements*.

ISO 12117 consists of the following parts, under the general title *Earth-moving machinery — Laboratory tests and performance requirements for protective structures of excavators*:

— *Part 1: Tip over protective structures (TOPS) for compact excavators*

— *Part 2: Roll-over protective structures (ROPS) for excavators of over 6 t*

# Introduction

It was long thought that hydraulic excavators did not overturn as easily as other earth-moving machines because their large attachments support the machine bodies once they start inclining. However, in some regions of the world, accident data have shown a need for roll-over protection of hydraulic excavators. Standardization was thus needed.

This part of ISO 12117 provides a test method for roll-over protective structures (ROPS) for hydraulic excavators of over 6 t used in earth-moving. Unlike the machines covered by ISO 3471, hydraulic excavators feature large attachments which affect the required performance capability of the ROPS. Therefore, the test method and criteria required for hydraulic excavators are different from those needed for the other earth-moving machines.

It is also applicable to hydraulic excavators used in forestry applications. The criteria of ROPS for hydraulic excavators, used in forestry, with cab riser, have been included for information.

# Earth-moving machinery — Laboratory tests and performance requirements for protective structures of excavators —

# Part 2: Roll-over protective structures (ROPS) for excavators of over 6 t

## 1 Scope

This part of ISO 12117 establishes a consistent and reproducible means of evaluating the load-carrying characteristics of roll-over protective structures (ROPS) for excavators under static loading, and prescribes performance requirements of a representative specimen under such loading.

It applies to ROPS of hydraulic excavators as defined in ISO 6165 with a mass of over 6 t and less than 50 t. ROPS will ensure minimum crush protection space for a seat-belted operator when the machine rolls 360° about longitudinal axis of its revolving frames without losing contact with a hard clay slope of less than 30°. ROPS is to be applied where the risk of roll-over exists.

It also applies to ROPS for excavator-based or derivated excavators used in object or material handling, demolition or with attachments such as magnets, clamshell, grab or multi-claw grab.

It does not apply to excavators with elevating cab risers.

NOTE This part of ISO 12117 is intended to be applied to excavators having a gross operating mass up to 50 000 kg due to the limitation of the experimental and statistical data set used to derive acceptance criteria. This does not preclude the possibility of applying the procedure described in this part of ISO 12117 to excavators having larger or smaller masses, with the exclusion of excavators specially designed for mining application, where the requirements may lead to impractical design.

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

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

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

ISO 9248, *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**
**attachment**
assembly of components that can be mounted onto the base machine or equipment for specific use

[ISO 6016:—, definition 3.1.4]

**3.2**
**bedplate**
substantially rigid part of the test fixtures to which the machine frame is attached for the purpose of the test

**3.3**
**boundary plane**
**BP**
plane defined as the vertical projected planes of the back, side and knee area of the DLV

NOTE The boundary plane is used to determine the load application zone.

**3.4**
**boundary simulated ground plane**
**BSGP**
plane, defined by structurally stiff points on the machine, that can provide additional protection for the operator during impact with the ground during a machine roll-over

NOTE For verification of stiff points, see 6.1.5.

**3.5**
**cab riser**
any spacer that increases the height of the seat index point (SIP), as defined in ISO 5353, greater than 250 mm relative to normal configuration

**3.6**
**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, definition 3.1.

**3.7**
**deflection of ROPS**
**deflection**
movement of the ROPS, mounting system and frame section, as measured at the load application point, excluding the effect of any movement of the test fixture(s)

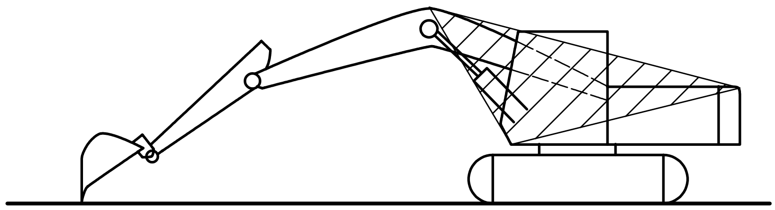
**3.8**
**equipment**
set of components mounted onto the base machine that allows an attachment to perform the primary design function of the machine

**3.9**
**ground reference plane**
**GRP**
pre-established plane representing a hard, flat surface on which the machine might come to rest

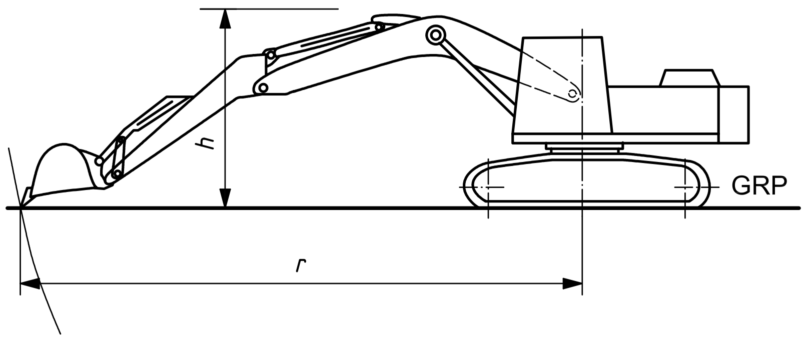
**3.10**
**lateral boundary simulated ground plane**
**LBSGP**
plane defined by the machine LH (left-hand) side three stiff portions (e.g. boom side highest portion, machine cab supporting frame LH front-most portion, counterweight LH side upper portion), when the machine comes to rest on its side, with the machine equipment and attachment at minimum boom height as specified by the manufacturer, and at maximum reach at GRP position

See Figure 1.

NOTE LBSGP contains three stiff points, for example, the LH counterweight edge, the LH highest point of boom when equipment and attachment are in the position of maximum reach above ground, and the LH front part of the deckframe.



**a) LBSGP**




**b) Minimum boom height**

**Key**

*h* minimum boom height

*r* maximum reach on the ground

GRP ground reference plane

**Figure 1 — Lateral boundary simulated ground plane (LBSGP)**

**3.11**
**lateral simulated ground plane**
**LSGP**
plane defined where the machine comes to rest on its side

See Figure 2.

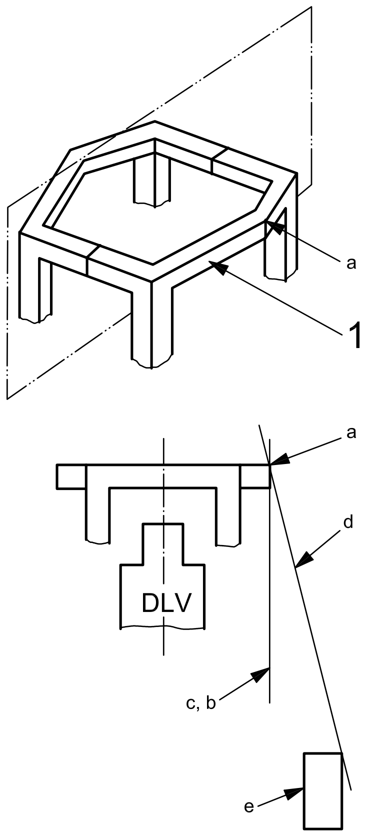
NOTE 1 This plane is pre-established by rotating a vertical plane parallel to the machine's longitudinal centreline, creating a new plane passing through the outermost point of the upper ROPS structural member, to which the lateral load is applied, and a second lower point on the machine.

NOTE 2 Each of the two hard points, noted as a and e in Figure 2, are capable of supporting one half of the machine mass.

NOTE 3 The LSGP is established on an unloaded ROPS and moves with the ROPS member to which the load is applied while maintaining its pre-established angle with respect to the vertical.

NOTE 4 The LSGP applies to conditions where the machine comes to rest on two hard points. If a third hard point is to be considered, then LBSGP can be applicable.




**Key**

1 upper ROPS frame member to which the lateral load is applied

a Outermost point from the end view of frame member.

b Vertical line through the outermost point from the end view of frame member.

c Vertical plane parallel to the machine longitudinal centreline through line b.

d LSGP.

e Certain high rigidity portion of a machine used to establish LSGP.

**Figure 2 — Lateral simulated ground plane (LSGP)**

**3.12**
**load application point**
**LAP**
point on the ROPS structure at which the test load force, $F$, is applied

**3.13**
**load distribution device**
**LDD**
device used to prevent localized penetration of the ROPS members at the load application point

**3.14**
**one- or two-post ROPS**
one- or two-post ROPS formed or fabricated having cantilevered load-carrying structural member(s)

**3.15**
**operating mass**
**OM**
mass of the base machine, with equipment and empty attachment in the most usual configuration as specified by the manufacturer, and with the operator (75 kg), full fuel tank and all fluid systems (i.e. hydraulic oil, transmission oil, engine oil, engine coolant) at the levels specified by the manufacturer and, when applicable, with sprinkler water tank(s) half-full

NOTE 1 The mass of an operator is not included for non-riding machines.

NOTE 2 Ballast mass at delivery can be included if specified by the manufacturer.

[ISO 6016:—, definition 3.2.1]

NOTE 3 Soil, mud, rocks, branches, debris, etc. that commonly adhere to, or lie on, the machine in use are not considered 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.

**3.16**
**operator protective guards**
**OPG**
system consisting of a top guard and a front guard to provide object protection to the operator station of the excavator

NOTE Adapted from ISO 10262:1998, definition 3.1.

**3.17**
**representative specimen**
ROPS, mounting hardware and machine frame (complete or partial) used for test purposes that is within the range of material and manufacturing variances designated to the manufacturer's production specifications

NOTE The intent is that all the ROPS manufactured to these specifications are capable of meeting or exceeding the stated levels of performance.

**3.18**
**rollbar ROPS**
one- or two-post ROPS without FOPS or any cantilevered load-carrying structural members

[ISO 3471]

**3.19**
**roll-over protective structure**
**ROPS**
system of mainly metallic structural members whose primary purpose is to provide a seated operator, held by a seat restraint system, with reasonable protection in the event of a machine overturning (roll-over)

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

**3.20**
**ROPS structural member**
member designed to withstand applied force or absorb energy

EXAMPLE Sub-frame, bracket, mounting, socket, bolt, pin, suspension, flexible shock absorber.

**3.21**
**seat belt system**
seat belt assembly with anchorages

NOTE Adapted from ISO 6683:2005, definition 3.3.

**3.22**
**socket**
**S**
device that reduces restriction point loading of the load distribution device (LDD)

**3.23**
**stiff point**
point on a rigid structural member which has adequate strength to support the induced loads during a roll-over resulting in predictable deformation

NOTE Stiff points are established in the following manner:

a) a load perpendicular to the BSGP is applied at each point equivalent to the standard machine mass;

b) deflection is measured at each stiff point to establish a modified BSGP (deflection measured at each point represents penetration of members into the ground plus deformation of members themselves — this procedure can be calculated);

c) all physical tests are done using the BSGP established in the above manner.

**3.24**
**revolving frame**
structural member(s) of the machine to which the ROPS is permanently attached during normal operation

NOTE For the purposes of this part of ISO 12117, all bolt-on and normally detachable components are permitted to be removed from the machinery frame. This frame need only constitute a replication of the machine frame, as it attaches to the top of the revolving bearing.

**3.25**
**vertical boundary simulated ground plane**
**VBSGP**
top plane established by the upper ROPS members for a machine coming to rest upside down

NOTE 1 The plane is also defined by machine upper stiff portions (e.g. the boom top portion and the counterweight top portion) when it comes to rest upside down, with the machine equipment and attachment at minimum boom height, as specified by the manufacturer, and at maximum reach at GRP position.

NOTE 2 VBSGP contains three stiff points, for example, the highest point(s) of the boom when equipment and attachment are in the position of maximum reach above ground, and the rear top line of the counterweight.

**3.26**
**vertical projection of the DLV**
area formed by the vertical projection of the outside corners of the DLV excluding the foot section

## 4 Symbols and abbreviated terms

For the purposes of this document, the following symbols apply.

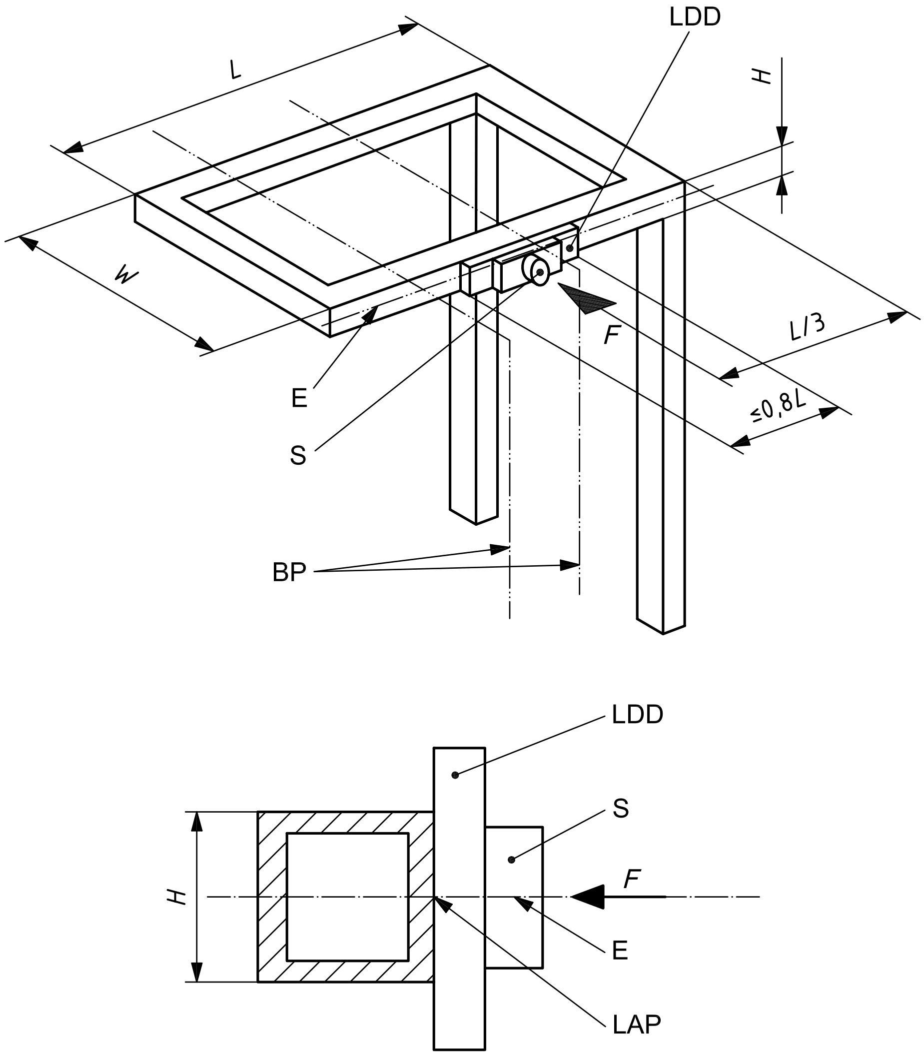
$U$ energy, expressed in joules, absorbed by the structure, related to the machine mass

$F$ force, expressed in newtons

*M* maximum operating mass of the machine according to the manufacturer's specifications, expressed in kilograms, including attachments in operating condition with tools and the ROPS

*L* length of the ROPS, expressed in millimetres, defined as follows:

a) for a one- or two-post ROPS, *L* is defined at the top of the ROPS, from the outside face of the ROPS post(s) to the far end of the farthest cantilevered load-carrying members (see Figure 3).




**Key**

E vertical midpoint of the upper ROPS structural member

*F* load force

*H* height of the upper ROPS structural member

*L* length of ROPS

*W* width of ROPS

LDD load distribution device

LAP load application point

BP boundary planes of DLV

S socket

The LDD may extend beyond the dimension, *H*.

**Figure 3 — Two-post ROPS lateral load application point**

b) for multiple-post rectangular shaped ROPS, $L$ is the greatest total longitudinal distance between the outsides of the front and rear posts (see Figure 4).

NOTE It is not necessary for the ROPS structural members to cover the complete vertical projection of the DLV.

c) for ROPS with curved structural members, $L$ is defined by the intersection plane of the tangent point at the midpoint of the curved segment of the front and rear members (see Figures 5 and 6).

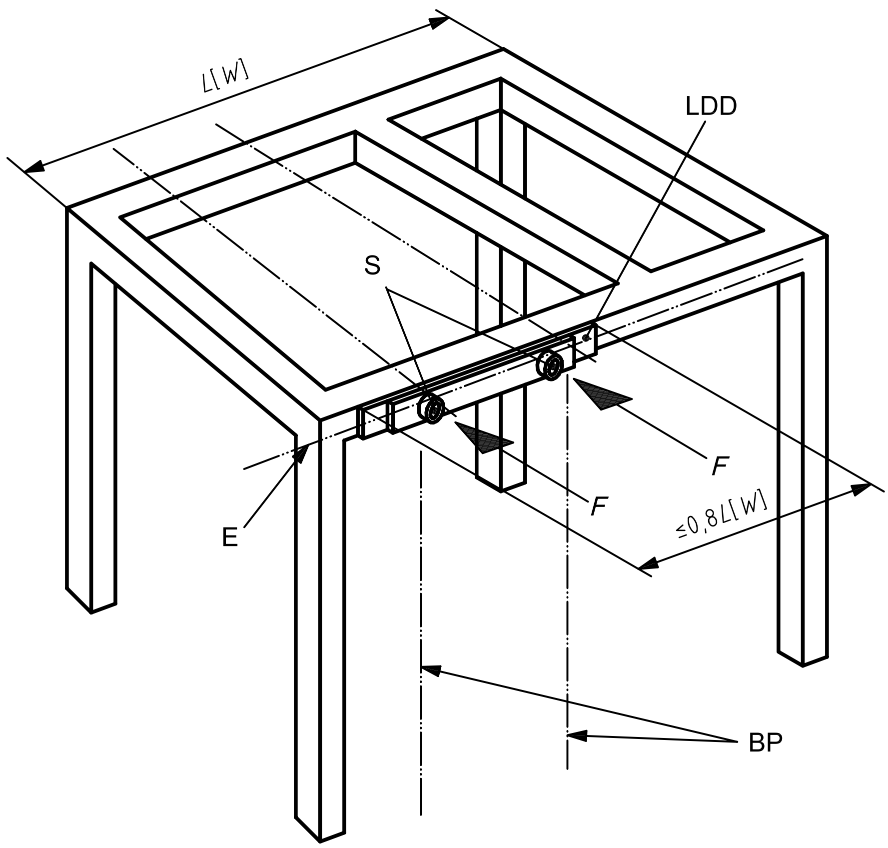
d) For a rollbar ROPS, $L$ does not apply.

e) For ROPS with shaped structural members, $L$ is defined as shown in Figure 5 c):

— $H$ is defined as three times the height (vertical width) of the top member,

— define the horizontal plane lowered by $H$ from the uppermost point of said top member, then

— define the ends of $L$ by its intersections of the front and rear members.



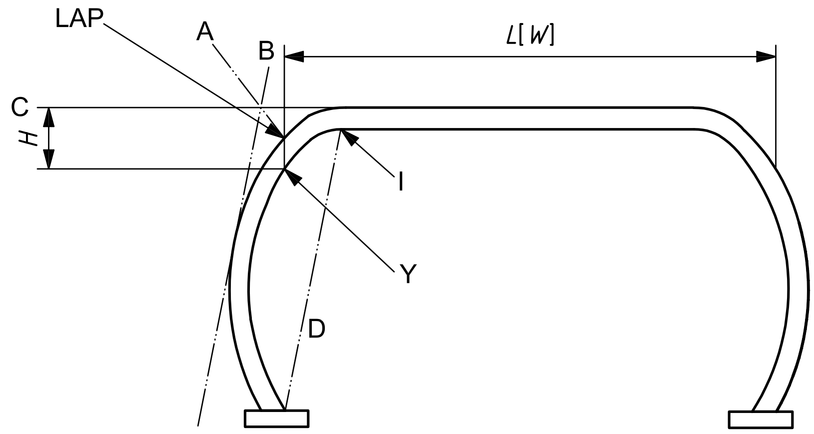

**Key**

BP boundary planes of the DLV
E vertical midpoint of the upper ROPS structural member
$F$ load force
$L$ [$W$] length or width of the ROPS
LDD load distribution device
S socket

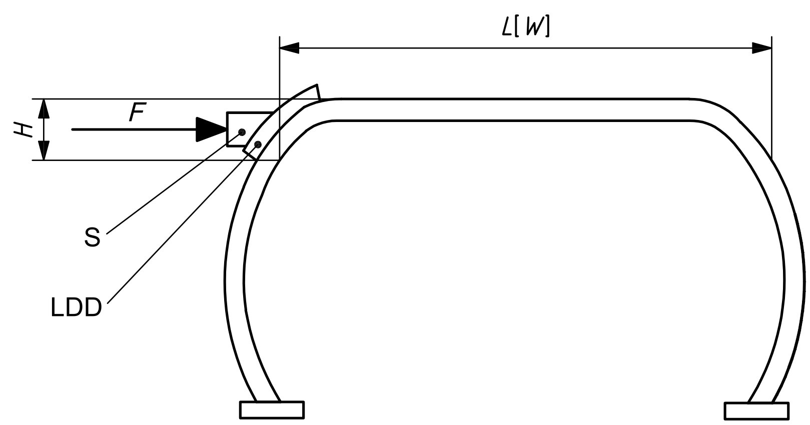
NOTE See Figure 3 for an example of details of the LAP and LDD. Two sockets are shown in this example to illustrate that more than one socket may be used simultaneously to apply the required force. Equal levels of force must be applied so as to not restrict rotation of the ROPS during loading.

**Figure 4 — Four-post ROPS lateral load application point**

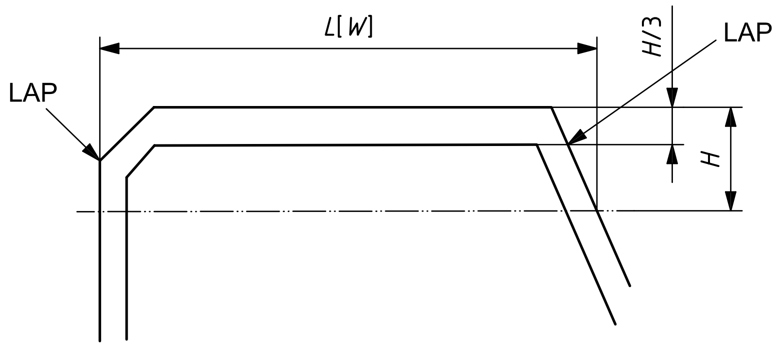
 




**a) Example of curved structural member (curved post) showing $L$ or $W$ and $H$ dimensioning**

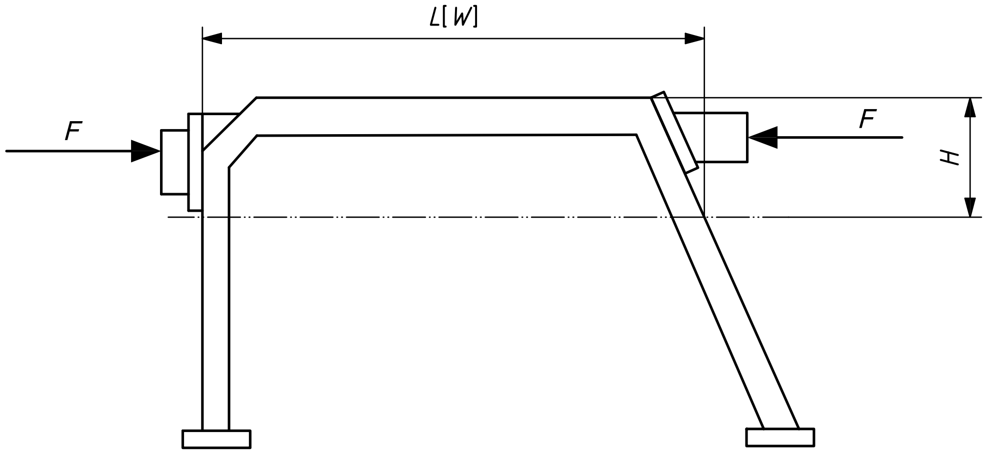



**b) Example of curved structural member (curved post) showing load application**




**c) Example of shaped structural member showing $H$ and $L$ or $W$, and dimensioning**

**Figure 5** (*continued*)




**d) Example of shaped structural member showing load application**

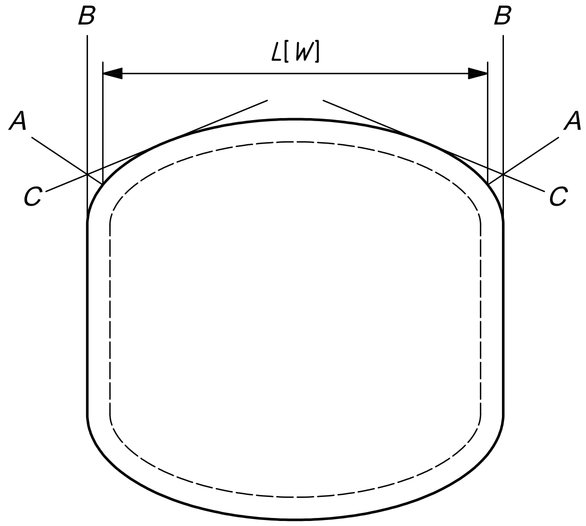
**Key**

A angle bisector of two tangent lines (B and C)
B tangent line parallel to D on the outer surface of the curved ROPS structural member
C projection of the top surface of the upper ROPS structural member
D straight line intersecting the ends of the curved ROPS structural member with mating members
*F* load force
I intersection of curved surface with flat surface
*H* height of load application zone
LDD load distribution device
*L* [*W*] length or width on ROPS for LAP determination
S socket
LAP load application point
Y intersection of a vertical line from LAP to the inner surface of the vertical member

NOTE 1 The angle between A and B is equal to the angle between A and C.

NOTE 2 See Figure 3 for an example of details of the LAP and LDD.

**Figure 5 — Example of curved or shaped structural member**




**Key**

A angle bisector of two tangent lines B and C

B projection of the side surface of the upper (LH and RH) ROPS structural member

C tangent line at midpoint of arc segment of side (LH as shown) ROPS member

*L* length of ROPS for load point determination

**Figure 6 — Another example of curved structural member (plan view)**

*W* width of the ROPS, in millimetres, as follows:

a) for rollbar ROPS, *W* is to the outermost points of the structural member(s);

b) for a one- or two-post ROPS, *W* is that portion of the cantilevered load-carrying members (see Figures 1, 4 and 5) that covers at least the vertical projection of the width of the DLV as measured at the top of the ROPS, from the outside faces of the cantilevered load-carrying members;

c) for all other ROPS, *W* is the greatest total width between the outsides of the left and right ROPS posts as measured at the top of the ROPS, from the outside faces of the load-carrying members (see Figure 5);

d) for ROPS with shaped structural members, *W* is the vertical projection of *H* with the outer surface of the structural members, [see Figure 5 c)];

e) for ROPS with curved structural members, *W* is defined by the intersection of plane A with the outer surface of the vertical member at X, where plane A is the bisector of the angle formed by the intersection of planes B and C, plane B is the tangent line at the outer surface parallel to plane D, plane D is the plane intersecting the intersections of the curved ROPS members with the adjacent members, and plane C is the projection of the top surface of the upper ROPS structural member. [see Figure 5 a)];

$\Delta$ deflection of ROPS, expressed in millimetres;

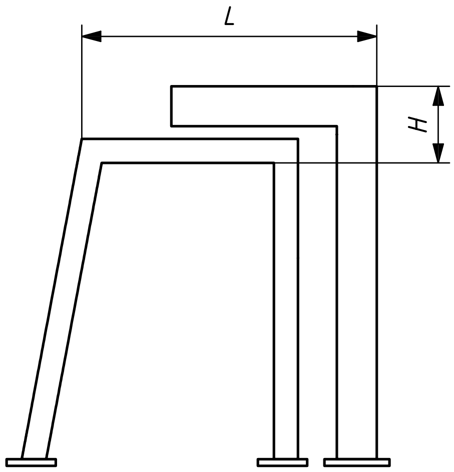
*H* height of the load application zone:

a) for a straight member, *H* is the distance from the top to the bottom of the member as shown in Figure 3;

b) for a curved member, *H* is the vertical distance from the top of the member to the vertical plane at the end of *L* where it intersects the inner surface of the curved member at *Y* as shown in Figure 5 a);

c) for a shaped member, *H* is three times the vertical width of the top member as shown in Figure 5 c);

d) for a ROPS consisting of separate structures, $H$ is the height from the lowest point of the upper member of the lower structural members, within the relative $L$ or $W$, to the highest portion of the upper structural members (see Figure 7) — each structure shall fulfil the material requirements of Clause 7.




NOTE $H$ is the full height of the uppermost ROPS structural member(s) referenced to determine the height of the LDD.

**Figure 7 — Height of load application zone of ROPS with separate upper structural members**

# 5 Test method and facilities

## 5.1 General

The requirements are force resistance in the lateral and vertical directions, and energy absorption in the lateral and longitudinal directions. There are limitations on deflection of ROPS under lateral, longitudinal and vertical loadings. The force and energy requirements plus limitations on deflection under these loadings are intended to ensure that the ROPS will not significantly deform as a result of impact during roll-over.

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 with the attachment, equipment and the machine frame to which it is attached. Therefore, it is expected that minimum crush protection for a seat-belted operator will be ensured under at least the following conditions:

— a 360° roll about the longitudinal axis of the machine's revolving frame without loss of contact with the slope;

— with the attachment and equipment as defined by the manufacturer in the test position as defined in 5.4.4;

— on a hard clay surface of 30° maximum slope.

## 5.2 Instrumentation

Systems used to measure mass, force and deflection shall be in accordance with ISO 9248, except that the force and deflection measurement capability shall be within ± 5 % of maximum values.

## 5.3 Test facilities

Fixtures shall be adequate to secure the ROPS/revolving frame assembly with the equipment and attachments at the maximum reach ground configuration to a bedplate and to apply the required lateral, longitudinal and vertical loads as determined by the formulas given in Tables 2 and 3.

## 5.4 ROPS-revolving frame assembly and attachment to bedplate

**5.4.1** The ROPS shall be attached to the revolving frame as it would be on an operating machine (see Figure 8). A complete revolving frame is not required for the evaluation. However, the revolving 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 do not influence the results of the ROPS evaluation. Non-ROPS elements (e.g. suspension systems and bearings) with structural attributes that contribute to the performance of the ROPS structure may be included or simulated.

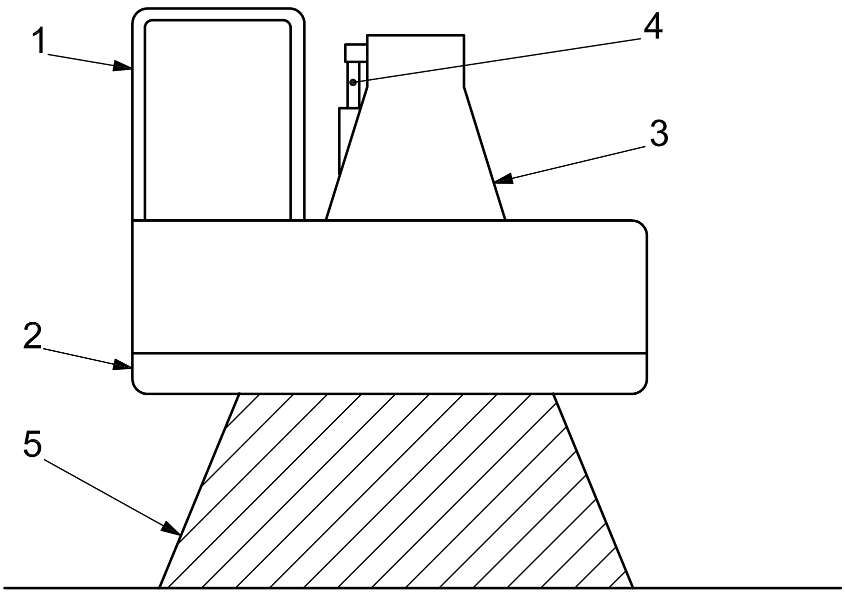
**5.4.2** The ROPS-revolving frame assembly shall be secured to the bedplate so that the members connecting the assembly and bedplate experience minimal deflection during testing. The ROPS-revolving frame assembly shall not receive any support from the bedplate, other than that due to the initial attachment.

**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** The equipment and attachment, including actuators such as boom or arm cylinders, shall be at minimum boom height as specified by the manufacturer at maximum reach at GRP position (see Figure 1).

Equipment, attachments, or other devices (e.g. boom or arm cylinders) that could interfere with the ROPS as it is being deflected under load shall be included or simulated in the test to determine their effect on the deformed ROPS structure.

The equipment and attachment may be actual or of equivalent size, stiffness and position.




**Key**

1 ROPS
2 revolving frame
3 boom
4 boom cylinder
5 bedplate

**Figure 8 — Anchorage of revolving frame**

# 6 Test loading procedure

## 6.1 General

**6.1.1** The test loading sequence shall be first lateral, second longitudinal and third vertical. All tests shall be conducted on the same representative specimen (see Tables 2 and 3 for formulas for the determination of energy and force requirements). If the load must be stopped and then re-applied for any reason, only the additional energy summed after reaching the maximum deflection of the first loading may be added to the sum.

**6.1.2** All load application points and planes, and the longitudinal centreline shall be identified and marked on the structure before any loading is applied.

**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.

**6.1.5** Loading as specified in 6.2 and/or 6.4 can be terminated upon reaching the LBSGP and/or VBSGP before the energy or force levels given in Tables 2 and 3 are met. For this condition to be used during a test, the stiff portion of the machine system must be pre-established. The deflection of the stiff portions shall be verified as follows:

a) apply a load perpendicular to the LBSGP and/or VBSGP at each point equivalent to the standard machine mass (considering deflection of stiff points as well as penetration of ROPS beam/pillars into the ground);

b) measure deflection at each stiff point to establish a modified LBSGP and/or VBSGP;

c) carry out all physical tests using the LBSGP and/or VBSGP established in the above manner.

NOTE The manufacturer has the choice of applying LBSGP and/or VBSGP according to 6.2 and/or 6.4; where not applied, the verification specified in a) to c) above is not needed.

**6.1.6** All structural members that are part of the test, and designed as members to withstand applied force and/or absorb energy, shall meet the material provisions of Clause 7.

## 6.2 Lateral loading

**6.2.1** The lateral load shall be applied to the upper structural member(s) of the ROPS.

The height of the load distribution device shall be less than or equal to the full height of the uppermost ROPS structural member(s) (see $H$ in Clause 4).

The load distribution device may be formed to contact the contour of the load application section(s) of the ROPS.

**6.2.2** The load application point shall be dictated by the length, $L$, and the vertical projections of the front and rear boundary planes of the DLV. The load application point shall not be within $L/3$ from the one- or two-post ROPS structure. Should the $L/3$ point be between the vertical projection of DLV and the one- or two-post ROPS structure, the load application point shall be moved away from the structure until it enters the vertical projection of the DLV (see Figure 3).

The load shall be applied to that side of the ROPS where the centreline of the DLV is the greatest distance from the machine centreline.

**6.2.3** For ROPS with more than two posts, the load application point shall be located between vertical projections of the front and rear boundary planes of the DLV (see Figure 4).

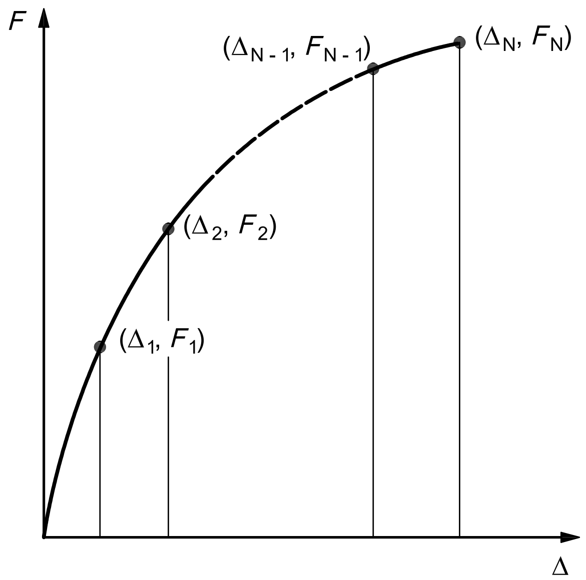
 

**6.2.4** Where the operator's seat is not located on the revolving frame longitudinal centreline, the lateral loading shall be applied against the outermost side nearest the seat.

**6.2.5** The lateral load shall be applied against the outermost side which is furthest from the equipment and attachment.

**6.2.6** The initial direction of the loading shall be horizontal and perpendicular to a vertical plane through the revolving frame longitudinal centreline. As loading continues, ROPS/revolving 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 can be considered static. The rate of load application can be considered static provided the rate of deflection at the load application point is not greater than 5 mm/s. Force and deflection at deflection increments no greater than 15 mm, measured at the point of application of the load, shall be recorded. Loading shall continue until the ROPS has achieved both the force and energy requirements, or the ROPS load application point has reached the LBSGP as defined by the machine side stiff portions. See Figure 9 for the method of calculating the energy, $U$. The deflection used in calculating $U$ is that of the ROPS along the line of action of the force. Any deflection of members used to support the load application devices shall not be included in the total deflection.




Energy, $U$:

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

**Key**

$F$ force

$\Delta$ deflection

**Figure 9 — Force–deflection curve for loading test**

## 6.3 Longitudinal loading for ROPS

**6.3.1** After removal of the lateral loading, a longitudinal load from the machine rear side shall be applied to the upper structural member of ROPS along the longitudinal centreline of the ROPS. The load distribution device should distribute the load over the width, $W$, so that it is still possible to continue loading onto the deformed ROPS (see Figures 5 and 10).

**6.3.2** The longitudinal load shall be applied at a location consistent with Figure 10, established prior to lateral loading.

The load distribution device shall span the whole width (see Figure 10).

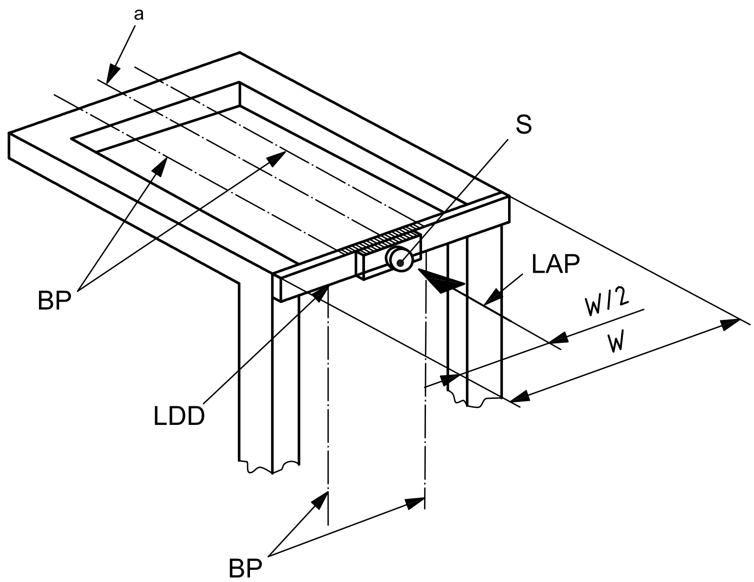
**6.3.3** The longitudinal load shall be applied at a location consistent with Figure 3, established prior to loading. The load distribution device shall span the width in cases where there is no rear (front) cross-member that would be capable of transferring the load without buckling. In all other cases, the device shall not distribute the load over a length greater than 80 % of the width, $W$, of the ROPS (see Figure 3).

**6.3.4** For all machines the direction of loading (fore or aft) shall be selected to place the severest requirements on the ROPS/machine frame assembly. The initial direction of loading shall be horizontal, parallel to the original longitudinal centreline of the machine. Some factors to be considered in deciding the direction to apply the longitudinal load are

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

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

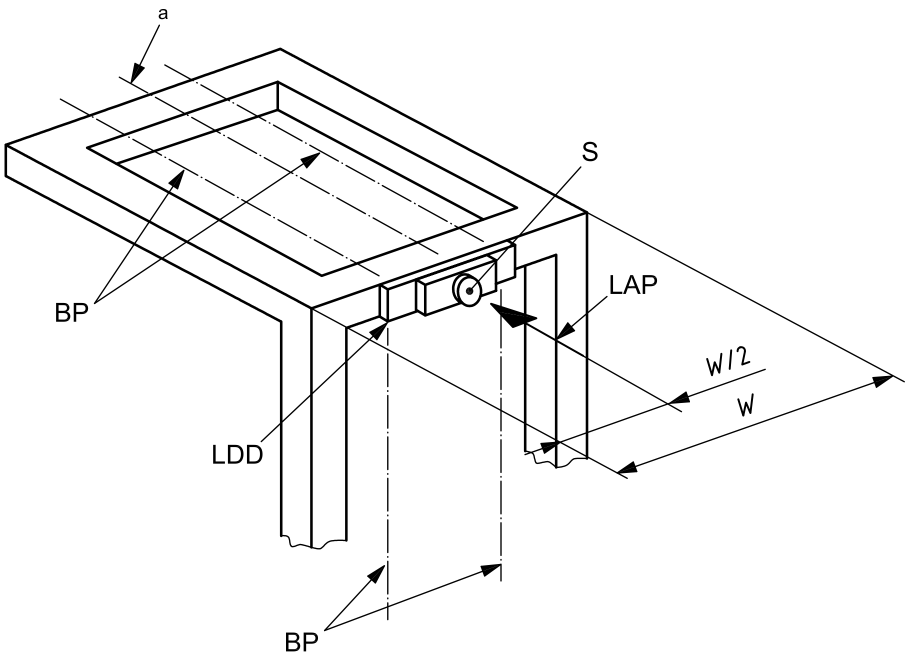
c) any experience indicating the possibility of longitudinal tipping or the tendency of a particular classification of machine to skew as it rotates about a longitudinal axis during an actual roll-over.




**a) Longitudinal load distribution device where no rear cross-member exists capable of transferring the load without buckling**

**Figure 10** (*continued*)




**b) Longitudinal load distribution device in other cases**

**Key**

BP boundary plane

LAP load application point

LDD load distribution device

S socket

LDW width of load distribution device (= width of ROPS where no rear cross-member exists; maximum 0,8 *W* in other cases)

*W* width of ROPS

[a] Parallel to longitudinal centreline of machine.

**Figure 10 — Longitudinal load distribution device**

**6.3.5** The longitudinal rear load shall be applied to the upper structural members of the ROPS along the longitudinal centreline of the ROPS, in order to cover the possibility of a machine roll-over when the machine's upper structure is in a position of clockwise rotation of between 0° to 90°, in respect of the lower structure. A longitudinal energy requirement applies (see 6.2.7 for guidance and Clause 8 for acceptance criteria).

**6.3.6** The rate of deflection shall be such that the loading may be considered static (see 6.2.7).

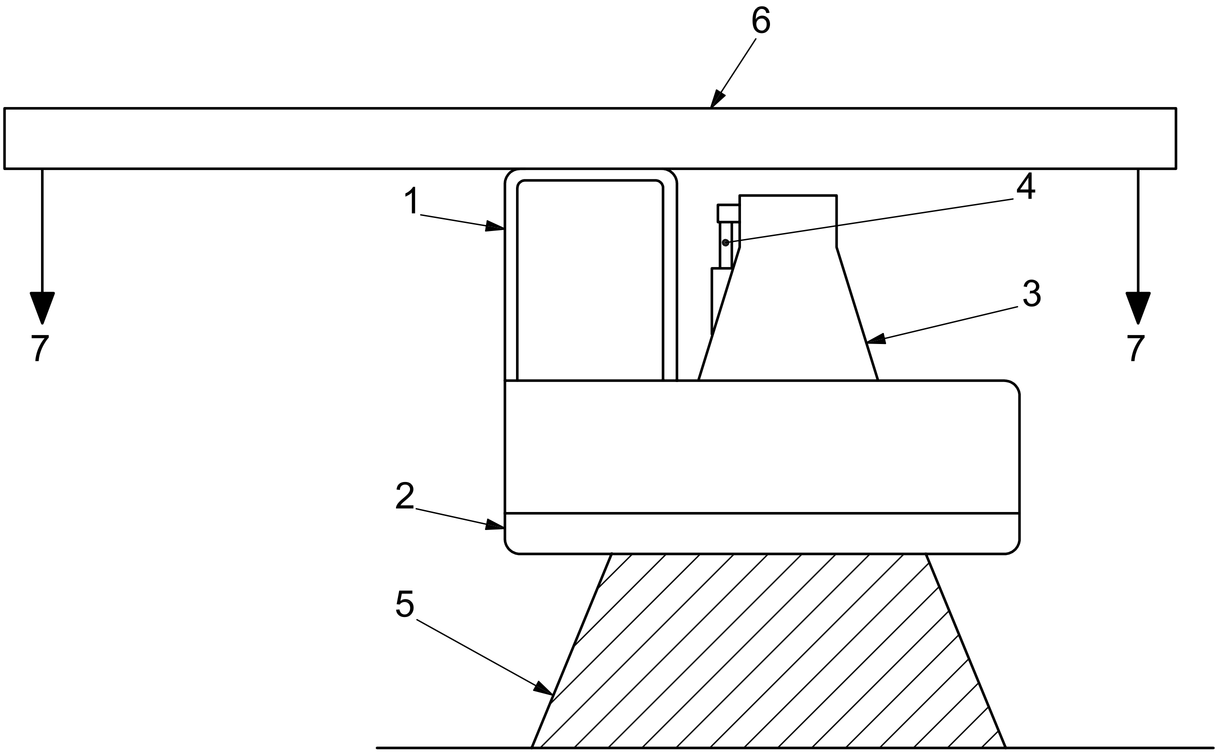
This loading is to continue until the ROPS has achieved the longitudinal energy requirement, or the ROPS deformation reaches the LBSGP/VBSGP as defined by the machine upper stiff portions.

## 6.4 Vertical loading onto ROPS

**6.4.1** After completion of the lateral and longitudinal loading, a vertical load shall be applied to the top of the ROPS.

**6.4.2** For all ROPS, the centre of the vertical load shall be applied in the same vertical plane, perpendicular to the longitudinal centreline of the ROPS structure, as for the lateral loading according to 6.2, defined on the structure before deformation.

**6.4.3** The load on the ROPS is applied without limitation on the manner of distribution, provided it is applied symmetrically with the longitudinal centreline (in accordance with the marked application point in 6.1.2) of the deformed ROPS structure. Figure 11 shows an example of vertical load application.




**Key**

1 ROPS
2 revolving frame
3 boom
4 boom cylinder
5 bedplate
6 vertical loading fixture
7 vertical loads

**Figure 11 — Vertical loading**

**6.4.4** 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 force level specified in Table 1 has been reached, or the ROPS deformation reaches the VBSGP as defined by the machine upper stiff portions.

The structure shall support this load for a period of 5 min or until any deformation has ceased, whichever is shorter.

## 7 Material temperature 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 may be met by applying the static loadings with all structural members at, or below −18 °C provided the materials in subsequently manufactured ROPS will have toughness characteristics equal to or greater than those in the tested representative specimen. Alternatively, the requirement may be met by applying the loading at a higher temperature provided all ROPS structural members are fabricated from materials that meet the mechanical requirements in 7.2 to 7.4.

**7.2** Bolts used structurally should be metric property class 8.8, 9.8 or 10.9, according to ISO 898-1. Nuts used structurally should be metric property class 8 or 10, according to ISO 898-2.

NOTE 1 In those countries using the inch system, it is important that the bolts and nuts used be of an equivalent grade.

NOTE 2 Use of bolts larger than 10.9 property class or nuts larger than property class 10 can require finer quality control to avoid brittle and delayed failure.

**7.3** Structural members of the ROPS and the mounts which attach the ROPS to the machine frame shall be made of steels that meet or exceed one of the Charpy V-notch (CVN) impact strengths shown in Table 1 or meet criteria of 7.4. (The Charpy V-notch evaluation is primarily a quality control check and the indicated temperature does not directly relate to operating conditions.)

**Table 1 — Minimum Charpy V-notch impact strengths**

| Specimen size<br>mm | Energy at −30 °C[a]<br>J | Energy at −20 °C[a]<br>J | Specimen size<br>mm | Energy at −30 °C[a]<br>J | Energy at −20 °C[a]<br>J |
|---|---|---|---|---|---|
| 10 × 10[b] | 11 | 27,5 | 10 × 6 | 8 | 20 |
| 10 × 9 | 10 | 25 | 10 × 5[b] | 7,5 | 19 |
| 10 × 8 | 9,5 | 24 | 10 × 4 | 7 | 17,5 |
| 10 × 7,5[b] | 9,5 | 24 | 10 × 3,3 | 6 | 15 |
| 10 × 7 | 9 | 22,5 | 10 × 3 | 6 | 15 |
| 10 × 6,7 | 8,5 | 21 | 10 × 2,5[b] | 5,5 | 14 |

[a] The energy requirement 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.

[b] Indicates preferred size. Specimen size shall be no less than the largest preferred size that the material will permit.

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 148-1).

**7.4** The following shall be considered to meet the Charpy V-notch requirements:

a) steel less than 2,5 mm in thickness with a maximum carbon content of 0,20 %;

b) fully killed fine grained steel of 2,5 mm to 4,0 mm thickness, with a maximum carbon content of 0,20 %.

## 8 Acceptance criteria

**8.1** The specific lateral force, energy, longitudinal energy and vertical load-carrying capacity shall be met or exceeded in the testing of a single representative specimen.

The formulas given in Table 2 shall be used to determine the values for machines without cab riser.

The formulas given in Table 3 can be used to determine the values for machines with fixed cab riser.

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.

The applied loading to the ROPS or cab structure can be terminated upon reaching the LBSGP and/or VBSGP before the energy or force levels given in Tables 2 and 3 are met.

**Table 2 — Formulas for determining energy and force in accordance with this part of ISO 12117 — Machines without cab riser**

| | |
|---|---|
| **Lateral load energy** $U_s$ (J) | $13\,000 \cdot (M/10\,000)^{1,25}$ |
| **Lateral load force** $F_s$ (N) | $35\,000 \cdot (M/10\,000)^{1,2}$ |
| **Longitudinal load energy** $U_f$ (J) | $4\,300 \cdot (M/10\,000)^{1,25}$ |
| **Vertical load force** $F_V$ (N) | $12,75M$ |

**Table 3 — Formulas for determining energy and force — Machines with fixed cab riser**

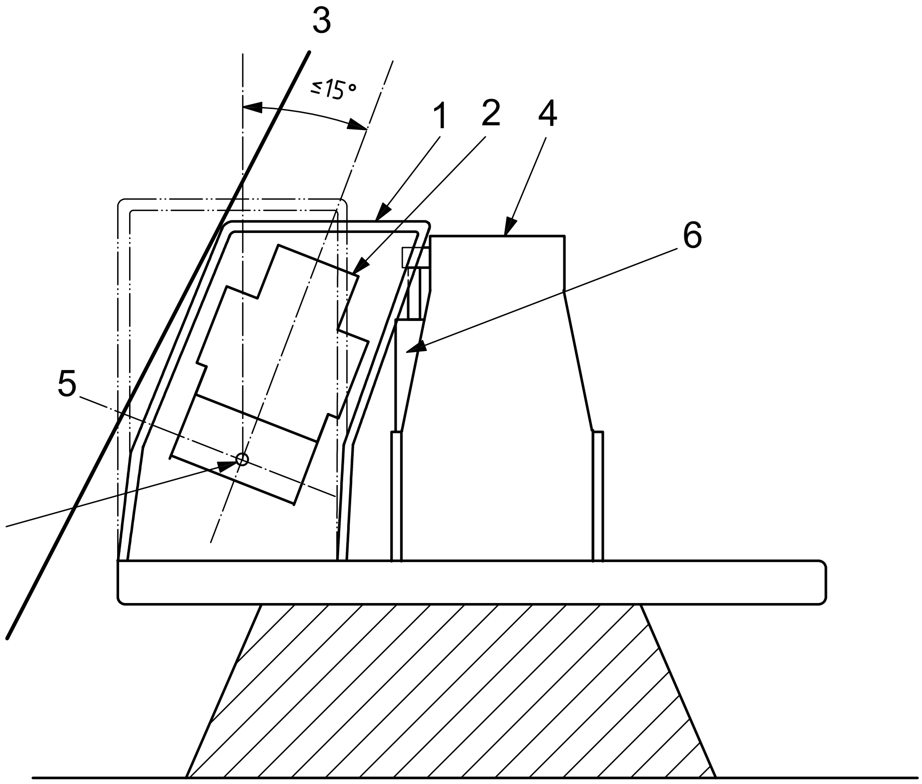
| | **With low cab riser less than or equal to 500 mm** | **With medium height greater than 500 mm and up to 1 300 mm cab riser** | **With greater than 1 300 mm high cab riser (TOPS)** |
|---|---|---|---|
| **Lateral load energy** $U_s$ (J) | $13\,000 \cdot (M/10\,000)^{1,25}$ | $13\,000 \cdot (M/10\,000)^{1,25}$ | $13\,000 \cdot (M/10\,000)^{1,25}$ |
| **Lateral load force** $F_s$ (N) | $35\,000 \cdot (M/10\,000)^{1,2}$ | $50\,000 \cdot (M/10\,000)^{1,2}$ | $50\,000 \cdot (M/10\,000)^{1,2}$ |
| **Longitudinal load energy** $U_f$ (J) | $4\,300 \cdot (M/10\,000)^{1,25}$ | $4\,300 \cdot (M/10\,000)^{1,25}$ | $4\,300 \cdot (M/10\,000)^{1,25}$ |
| **Vertical load force** $F_V$ (N) | $12,75M$ | $19,61M$ | $7M$ |
| NOTE Roll-over behaviour of excavators with cab risers needs more study. Manufacturers should consider the risks and determine the protection required versus the cab riser height based on good engineering practise and knowledge. | | | |

**8.2** The limitations on the deflections are absolute; no part of the ROPS shall enter the DLV upper portion above its LA (locating axis, see ISO 3164) at any time during the lateral loading phase of the test. The exception to this is that the loading may be limited based on its displacement reaching the LBSGP, verified according to 6.1.5. DLV inclination is also allowed, as specified in 8.5.

**8.3** No part of the ROPS shall enter the DLV at any time during the longitudinal loading phase of the test. DLV inclination is allowed as specified in 8.6.

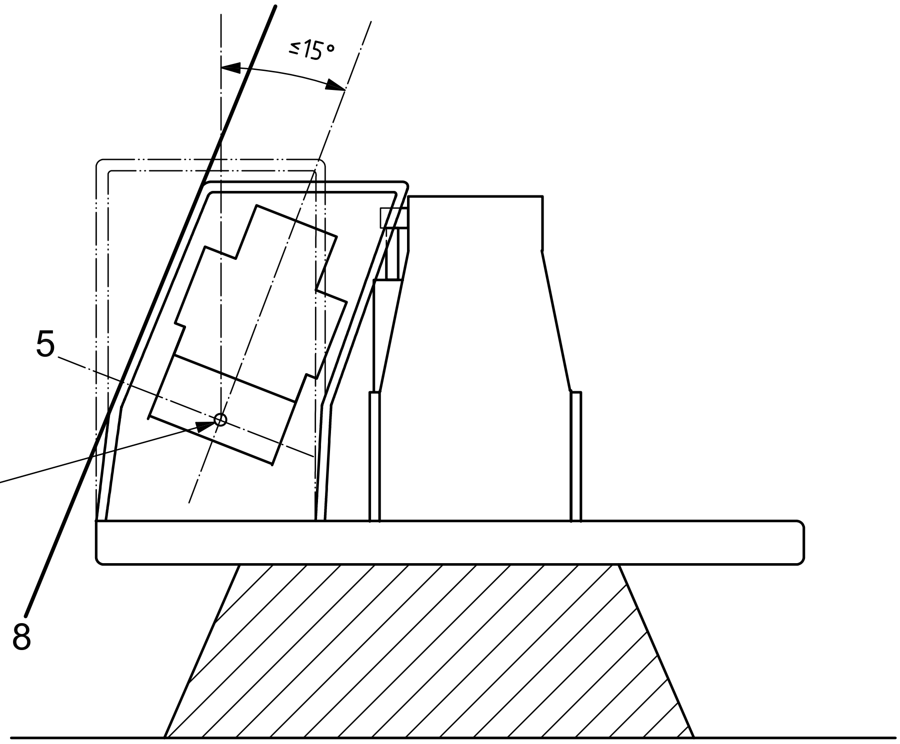
**8.4** No part of the ROPS shall enter the DLV at any time during the vertical loading phase of the test. The exception to this is that the loading may be limited based on its displacement reaching the VBSGP as verified [see Figure 13 b)] according to 6.1.5. DLV inclination is also allowed, as specified in 8.5 and 8.6.

**8.5** During lateral loading, it is permissible for the upper portion of the DLV to be rotated sideways up to 15° about the SIP (see ISO 5353). Sideways rotation of the DLV shall be limited to less than 15° if there were interference with any machine components or controls at a lesser angle (see Figure 12). Upper-portion additional rotation due to deformation of the floor on which the DLV is mounted, is allowed.




**a) ROPS with machine revolving frame including boom and boom cylinder for test loading**

**Figure 12** (*continued*)




**b) ROPS and LBSGP**

**Key**

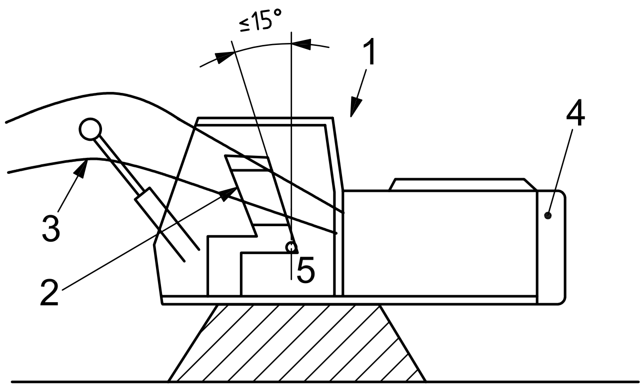
1 ROPS
2 DLV
3 LSGP
4 boom
5 LA
6 boom cylinder
7 SIP
8 LBSGP

NOTE After removal of the lateral loading, longitudinal and vertical loading may cause additional ROPS deformation other than that shown above and the ROPS should be verified with such deformation for longitudinal then vertical acceptance criteria.

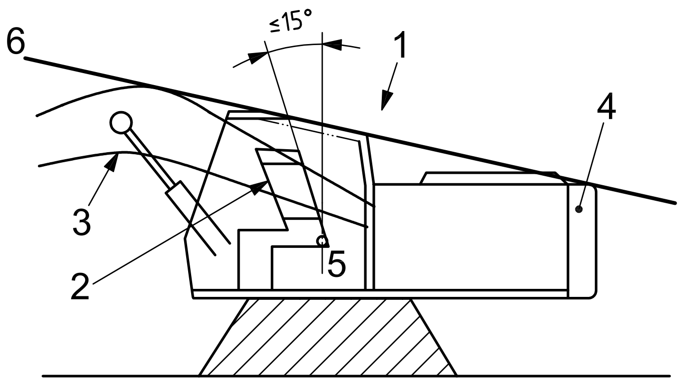
**Figure 12 — Inclination of the upper DLV**

**8.6** During longitudinal loading, it is also permissible for the upper portion of the DLV to be inclined forward up to 15° about its LA (as defined in ISO 3164) to prevent intrusion of ROPS members. Forward inclination of the DLV shall be limited to less than 15° if there were interference with any machine components or controls at a lesser angle.




**a) ROPS with machine upper structure including equipment and attachment for test loading**




**b) ROPS and VBSGP**

**Key**

1 ROPS
2 DLV
3 boom
4 counterweight
5 LA, SIP
6 VBSGP

**Figure 13 — Forward inclination of the DLV under vertical loading**

**8.7** The ROPS shall not break away from the machine revolving frame due to separation of the ROPS, its mounting system or the machine revolving frame. In the event of a partial separation, the ROPS shall demonstrate the capability of preventing total separation from the machine at the required force and energy levels.

# 9 Labelling of the ROPS

## 9.1 General

ROPS meeting the requirements of this part of ISO 12117 shall be labelled according to 9.2 and 9.3.

Information about the OPG (see ISO 10262), or FOPS (falling-object protective structures) may be included on the label.

### 9.2 Label specifications

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

**9.2.2** The label shall be located on the structure so as to be easily read and to be protected from defacing by weather.

### 9.3 Label content

The label shall indicate the following:

a) ROPS model and identification number, if any;

b) model(s), or series number(s) of the machines that the ROPS is designed to fit;

c) International Standard number(s) for which the structure meets all of the performance requirements and the level being met (national and/or regional standards/regulations may be included.);

d) other information included by the manufacturer as deemed appropriate (for example, installation, repair or replacement details).

## 10 Reported results

The results of the test shall be presented using the information given in Annex A.

## 11 Operator's manual

The machine manufacturer shall clearly describe in the operator's manual the application of the ROPS complying with this part of ISO 12117, specification of the base machine, equipment and attachments (including their derivatives if applicable) for which the ROPS can be certified as the protection structure, in the operation manual.

# Annex A
(normative)

# Test report for ROPS conforming to ISO 12117-2

## A.1 Identification

### A.1.1 Machine

Type: ..................................................................................................................................................

Manufacturer: ........................................................................................................................................

Model: .................................................................................................................................................

Serial number, if applicable: ...................................................................................................................

Revolving frame part number: .................................................................................................................

### A.1.2 ROPS

Manufacturer: ........................................................................................................................................

Type and model: ....................................................................................................................................

Serial number: .......................................................................................................................................

ROPS part number, if applicable: ............................................................................................................

## A.2 Information supplied by the manufacturer(s)

### A.2.1 ROPS

Maximum operating mass of the ROPS applicable members ........................................................................ kg

Testing machine mass; ............................................................................................................................ kg

Geometrical data; ....................................................................................................................................

Location of the DLV: ................................................................................................................................

### A.2.2 Loading conditions

Lateral boundary simulated ground plane (LBSGP) three-dimensional geometrical data: .................................

Vertical boundary simulated ground plane (VBSGP) three-dimensional geometrical data: ................................

## A.3 Criteria

Lateral load force .................................................................................................................................... N

Lateral load energy: .................................................................................................................................. J

Longitudinal load energy ........................................................................................................................... J

Vertical load force ...................................................................................................................................... N

## A.4 Tests results

### A.4.1 Lateral boundary simulated ground plane (LBSGP) and vertical boundary simulated ground plane (VBSGP) location

Lateral boundary simulated ground plane (LBSGP) geometrical data, if applicable: ..........................................

Vertical boundary simulated ground plane (VBSGP) geometrical data, if applicable: ........................................

### A.4.2 Lateral loading

The following force and/or energy level was achieved or exceeded with no penetration by the ROPS structural member into the DLV.

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

Absorbed energy attained: ........................................................................................................................ J

or,

the loading reaches the condition as noted in 8.1.2.

Reached load force: ................................................................................................................................. N

Reached load energy: ............................................................................................................................... J

The lateral forces applied onto the stiff portion of the machine side: ............................................................... N

Clearance between the DLV and the ROPS: ......................................................................................... mm

### A.4.3 Longitudinal loading

The following energy level was achieved or exceeded with no penetration by the ROPS structural member into the DLV.

The maximum energy attained: ................................................................................................................. J

Clearance between the DLV and the ROPS: ......................................................................................... mm

### A.4.4 Vertical loading

The following vertical load force was achieved or exceeded with no penetration by the ROPS structural member into the DLV.

Maximum load force: ............................................................................................................................... N or,

Reached load force: ........................................................................................................................ N

Vertical forces applied onto the top stiff portion of the machine: ....................................................................... N

Clearance between the DLV and the ROPS: ...................................................................................... mm

### A.4.5 Temperature and material

**A.4.5.1** The test was performed with ROPS and revolving frame members at ....................................... °C.

**A.4.5.2** (To be completed if the temperature in A.4.5.1 is over −18 °C.)

The Charpy V-notch impact strength requirements for ROPS structural metallic members were tested on specimen size ............... mm × ...................... mm.

The absorbed energy was: .......................................................................................................................... J

Nut property class: ............................................................................................................................................

Bolt property class: ...........................................................................................................................................

## A.5 Attestation statement

The minimum performance requirements of ISO 12117-2 were met in this test for a maximum machine mass of ....................................................................................................................................................... kg

ROPS model, if applicable: ..............................................................................................................................

Excavator model to which the tested ROPS is fitted: ..........................................................................................

Date of test: .........................................................................................................................................................

Name and address of test facility: ....................................................................................................................

Test engineer: .......................................................................................................................................................

Date of test report: ...............................................................................................................................................

# Annex B
(informative)

# Design changes, physical testing and alterations

## B.1 Design changes

Any changes to the design of the ROPS or machine frame require physical testing unless

a) it can be determined that this is a minor change to an existing design which was physically tested, or

b) the changes have no adverse effect on the performance of the ROPS and machine frame.

## B.2 Alterations or repairs

Any ROPS structure which has discernible deformation is not reused.

No alterations or repairs to a protective structure are permitted except where authorized by the manufacturer. Structures which have been altered or repaired without proper authorization are not in compliance with this part of ISO 12117.

## B.3 Alternatives to physical testing

Theoretical performance analysis of major new design ROPS is not permitted as an alternative to physical testing.

# Annex C
(informative)

# Rationale — ROPS performance requirements

## C.1 General

This annex provides explanations of how the criteria were developed.

The points discussed are whether the specific features of excavators listed below may necessitate specifying different ROPS criteria from ROPS for other earth-moving machinery ROPS:

— possible protection by the boom and other stiff portions in case of tip- or roll-over;

— relatively large equipment and attachment (boom, arm and bucket) and the resulting wide working range of the machine,

— upper structure with 360° rotation,

The main technical basis of this part of ISO 12117 is:

— global accident analysis;

— actual roll-over tests;

— simulation analysis done in the USA and Japan, using ADAMS and PAM/CRASH software;

— additional simulation analysis made by a Japanese expert;

— actual compact excavator tip-over tests.

The above are reflected in C.2 to C.5.

## C.2 Boundary simulated ground plane (BSGP)

It is generally understood that the boom of an excavator may provide certain protection for the operator in the event of an excavator tip- or roll-over. For example, a report on 38 cases of tipping over, rolling over or falling from high places in public works in Japan from 1996 to 1999, shows that in 31 out of 38 cases the cab deformation is limited and the DLV is basically maintained. The concept of BSGP is developed for the purpose of taking such protection into account.

In the event of an excavator roll-over (event 1), provided a plane passing though three points of a machine (the highest part of boom, the front-left part of the deck-frame and the upper-left part of the counterweight) touches the ground and provided an operator's space (represented as DLV) does not touch the structural members of ROPS or the ground, the operator in the cab is considered effectively protected. In the event of the machine turning upside down (event 2), provided the plane passing through the boom top and the counterweight rear top touches the ground while the DLV does not touch the structural members of ROPS or the ground, the operator in the cab is also considered protected.

In this part of ISO 12117, BSGP (as in LBSGP and VBSGP) is used to avoid confusion with LSGP and VSGP (vertical simulated ground plane) defined and used in ISO 3471, and the plane in event 1 is defined as LBSGP (lateral boundary simulated ground plane) and the plane in event 2 is defined as VBSGP (vertical boundary simulated ground plane).

### C.2.1 Stiff points of BSGP

LBSGP contains three stiff points: the left-hand side counterweight edge, the left-hand side highest point of the boom and the left-hand side front part of the deck-frame.

VBSGP contains three stiff points: highest point(s) of the boom and rear top line of the counterweight.

### C.2.2 Verification of the stiff points

To verify that the point is stiff enough, it is considered appropriate to apply the load of machine mass under the gravity acceleration to each stiff point and to take resulting displacement into account for establishing LBSGP and/or VBSGP. If it is decided to apply LBSGP and/or VBSGP criteria for ROPS evaluation purpose, verification procedures are needed as specified in 6.1.5.

NOTE The stiff point verification procedure given in 6.1.5 is optional. The manufacturer has a choice of designing ROPS to meet the loading requirements given in Tables 2 and 3 or designing machine stiff portions adequately for lateral loading to LBSGP and/or vertical loading to VBSGP that will not cause the ROPS to penetrate the DLV. In the latter case, verification procedures are required.

### C.2.3 Necessity of physical test(s) on the ROPS in cases applying LBSGP and/or VBSGP criteria

Application of LBSGP and/or VBSGP criteria does not mean omitting lateral, longitudinal and vertical loading tests of the ROPS. LBSGP criteria is applied within the lateral loading test and replaces lateral load energy/force requirements in Tables 2 and 3. Also VBSGP criteria are applied within the vertical loading test and replace vertical force requirement in Tables 2 and 3.

## C.3 Longitudinal energy

The roll-over tests were carried out with the upper structures and undercarriages of machines set in parallel. In this case, the presumption was that longitudinal energy on the ROPS would be none, or minimal enough so as to be ignored. However, a simulation analysis conducted in the USA revealed that there are cases in which significant energy could be applied in the longitudinal direction in case the rolling machine upper structure is at certain angles in relation to the undercarriage.

When rolling with the upper structure at the anticlockwise (counter-clockwise) position to the lower structure, a portion of energy applies in the longitudinal direction to the left-hand front part of the cab. But it is considered that machines in such a posture rarely overturn, and if they do, there would only be slight damage to the cab, this being limited by the LBSGP. Thus operator protection would be ensured.

NOTE One additional Japanese simulation analysis showed that it is difficult for a machine to roll from its upper structure anticlockwise (counter-clockwise) position with its equipment and attachment at maximum reach on the ground position. Raising the boom from the maximum reach position may allow the machine to start rolling but this raised position may cause further limitation in cab deformation due to LBSGP.

In a posture with the upper structure rotated clockwise, it is considered that a certain load is applied from the rear direction. Additional Japanese simulation analysis shows that the longitudinal load force is 1,47 M (0,15 W) for the upper structure parallel position and 1,37 M (0,14 W) for the clockwise position. Considering that the value is rather small, for longitudinal loading, one third energy requirement of the lateral is specified on the text. This one-third loading condition is from the longitudinal loading recommendation for compact excavators TOPS (see ISO 12117-1).

## C.4 Vertical load force

It is considered that an excavator may be mainly supported by its boom top when turned upside down while other earth-moving machinery may be mainly supported by the cab when in an upside-down position. Accordingly, it is considered that other earth-moving machinery ROPS vertical load force requirement of 2 W (19,61 M) may be relaxed. Actual roll-over test results using the 20 t class excavator show that the vertical load force is approximately 1 W (9,8 M) (existence of residual strain ignored) to 0,7 W (7 M) (existence of residual strain taken into account). PAM/CRASH analysis results show that the vertical load force is around 0,9 W (9 M) to 1,2 W (12 M).

Based on these results, the value of 1,3 W was derived as average plus deviation.

NOTE Additional Japanese simulation analysis showed that the vertical load force onto the ROPS is 11,6 M (1,18 W) for the upper structure parallel position and 11,3 M (1,16 W) for the clockwise position.

## C.5 Worst case loading at laboratory

The testing for verification of the ROPS compliance with this part of ISO 12117 should be performed taking worst case loading into consideration. For example, when providing lateral loads onto the ROPS, the boom and/or the cylinder may come into contact with the ROPS at its welding joint, which may be the weakest point, and this may affect the performance of the ROPS.

## C.6 Lateral load force

For the purposes of deciding lateral load force criteria, analysis to calculate load forces on the excavator ROPS and also on the tractor-dozer ROPS in roll-over cases was carried out. Comparison of lateral load forces on the ROPS at their maximum displacement show that the relative (to the machine mass) load force on the excavator ROPS is half of that on the tractor-dozer ROPS. Accordingly, excavator ROPS lateral load force criteria is introduced as half of that for tractor-dozer ROPS.

## C.7 DLV inclination

The DLV upper portion rotation of up to 15° around the SIP (LA) is allowed considering that an excavator cab is relatively narrow This is derived from the acceptance conditions for compact excavators TOPS (see ISO 12117-1).

# Bibliography

[1] ISO 148-1, *Metallic materials — Charpy pendulum impact test — Part 1: Test method*

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

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

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

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

[6] ISO 6016:—, *Earth-moving machinery — Methods of measuring the masses of whole machines, their equipment and components*

[7] ISO 6683:2005, *Earth-moving machinery — Seat belts and seat belt anchorages — Performance requirements and tests*

[8] ISO 10262:1998, *Earth-moving machinery — Hydraulic excavators — Laboratory tests and performance requirements for operator protective guards*

[9] ISO 12117-1, *Earth-moving machinery — Tip-over protection structure (TOPS) for compact excavators — Laboratory tests and performance requirements*

[10] EN 13510, *Earth-moving machinery — Roll-over protective structures — Laboratory tests and performance requirements*

ICS 53.100
Price based on 32 pages