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Tractors for agriculture and forestry — Roll-over protective structures on narrow tractors —

Part 2: Rear-mounted ROPS

Tracteurs agricoles et forestiers — Structures de protection contre le retournement (ROPS) pour tracteurs à voie étroite —

Partie 2: ROPS montées à l'arrière

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry,* Subcommittee SC 2, *Common tests.*

This third edition cancels and replaces the second edition (ISO 12003-2:2008), which has been technically revised.

The main changes compared to the previous edition are as follows:

— the main title has been changed, referencing type of tractor, from “Agricultural and forestry tractors” to “Tractors for agriculture and forestry”;

— the seat anchorage test procedures of OECD have been added as an optional test;

— the ergonomic folding ROPS test procedures of OECD have been added as an optional test;

— definitions for unballasted mass, plane, track width and maximum permissible mass have been added;

— tractor mass limits for unballasted tractor has been specified;

— the allowable mass ratio (1,75) has been specified;

— reference mass limits have been added;

— tractor lashings method of lashing has been changed;

— seat position during test has been updated to include seats with adjustable backrest,

— clearance zone has been updated for clarity and information for reversible seat has been added;

— Figure 17 has been updated to be harmonize with OECD Code 6; specifically, the key “g” has been added to indicate failure at any stage when load drops below $0{,}8F_{max}$;

— cold weather embrittlement test has been added;

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— reversible seat operator seat zones has been updated to harmonize with OECD code 7.

A list of all parts in the ISO 12003 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

Testing of roll-over protective structures (ROPS) for narrow tractors for agriculture and forestry intends to minimize the likelihood of driver injury resulting from accidental overturning during normal operation (e.g. field work) of the tractor. The strength of the roll-over protective structure is tested by applying loads to simulate actual loads which can be imposed on the cab or frame when the tractor overturns either to the rear or to the side without free fall. The tests allow observations to be made on the strength of the structure and the attachment brackets to the tractor and also of the tractor parts that may be affected by the load imposed on the structure. This document also includes optional testing for seat anchorage points and folding efforts of rear-mounted roll-over protective structure designed to fold.

The tests are made using special rigs that are intended to simulate such loads as are imposed on a protective structure, when the tractor overturns. These tests enable observations to be made on the strength of the protective structure and any brackets attaching it to the tractor and any parts of the tractor which transmit the test load.

Provision is made to cover both tractors with the conventional forward-facing driving position only and those with a reversible driving position, which is in agreement with the relevant OECD test code practice (see Reference[4]). For tractors with a reversible driving position, a clearance zone is defined to be the combined clearance zones for the two driving positions.

It is recognized that there can be designs of tractors, such as lawn-mowers, and certain forestry machines such as forwarders, for which this document is not appropriate.

NOTE For regular tractors, see ISO 3463[2] (dynamic test) and ISO 5700[3] (static test).

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Tractors for agriculture and forestry — Roll-over protective structures on narrow tractors —

Part 2: Rear-mounted ROPS

1 Scope

This document specifies procedures for both the static and dynamic strength testing of roll-over protective structures (ROPS) rear-mounted on narrow tractors. It defines the clearance zone and acceptance conditions for rigid or tiltable, rear, two-post roll bar, frame and cab ROPS, and is applicable to tractors so equipped having the following characteristics:

— a ground clearance of not more than 600 mm beneath the lowest points of the front- and rear-axle housings (not considering lower points on the axle differential);

— a fixed or adjustable minimum track width of one of the two axles of less than 1 150 mm and with the overall width of the other axle being less than that of the first axle, including where the two axles are fitted with rims and tyres of the same size;

— a fixed driving position and a mass greater than 400 kg, unballasted, including the ROPS and tyres of the largest size recommended by the manufacturer;

— a reversible driving position (reversible seat and steering wheel), with a mass greater than 400 kg, unballasted, including the ROPS and tyres of the largest size recommended by the manufacturer and maximum unballasted mass less than 3 500 kg and maximum permissible mass less than 5 250 kg;

— a mass ratio less than 1,75;

— a ROPS of the rollbar, frame or cab type, mounted partly or entirely behind the seat index point and having a zone of clearance whose upper limit is (810 + a_v) mm above the seat index point in order to provide a sufficiently large area or unobstructed space for the protection of the driver.

This document also specifies optional testing procedures for both seat anchorage points and folding efforts of rear-mounted ROPS designed to fold.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 630-1, *Structural steels — Part 1: General technical delivery conditions for hot-rolled products*

ISO 630-2, *Structural steels — Part 2: Technical delivery conditions for structural steels for general purposes*

ISO 630-3, *Structural steels — Part 3: Technical delivery conditions for fine-grain structural steels*

ISO 630-4, *Structural steels — Part 4: Technical delivery conditions for high yield strength quenched and tempered structural steel plates and wide flats*

ISO 2408, *Steel wire ropes — Requirements*

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

ISO 13854:2017, *Safety of machinery — Minimum gaps to avoid crushing of parts of the human body*

ISO 12003-1:2021, *Tractors for agriculture and forestry — Roll-over protective structures on narrow tractors — Part 1: Front-mounted ROPS*

ISO 12934, *Tractors and machinery for agriculture and forestry — Basic types — Vocabulary*

ISO 80000-1, *Quantities and units — Part 1: General*

ASTM A370, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 12934 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
roll-over protective structure
ROPS
framework protecting drivers of *agricultural tractors* (3.15), which minimizes the likelihood of driver injury resulting from accidental overturning during normal field work

Note 1 to entry: The ROPS is characterized by the provision of space for a clearance zone, either inside the envelope of the structure or within a space bounded by a series of straight lines from the outer edges of the structure to any part of the tractor that might come into contact with the ground; it is capable of supporting the tractor in an overturned position.

3.2
rear-mounted ROPS
two-post, roll-bar-type, *roll-over protective structure* (3.1) mounted on the tractor rearwards of the driving seat, or a frame or cab

Note 1 to entry: Compare with front-mounted ROPS described in ISO 12003-1.

3.3
unballasted mass
mass of the tractor in working order with tanks and radiators full, *roll-over protective structure* (3.1) with cladding and any track equipment or additional front-wheel drive components required for normal use

Note 1 to entry: Not included are the operator, optional ballast weights, additional wheel equipment, special equipment and loads.

[SOURCE: ISO 5700:2013, 3.2]

3.4
maximum permissible mass
m_{max}
maximum mass of the tractor stated by the manufacturer to be technically permissible and declared on the vehicle's identification plate and/or in the operator's handbook

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3.5
reference mass
m_t
mass, not less than the maximum *unballasted mass* (3.3), selected by the manufacturer for calculation of the energy inputs to be used in the tests

3.6
mass ratio
m_r
ratio of

$$m_r = \frac{m_{max}}{m_t}$$

3.7
reference plane
vertical plane, generally longitudinal to the tractor and passing through the seat index point and the steering-wheel centre

Note 1 to entry: Normally, this reference plane coincides with the *longitudinal median plane* (3.8) of the tractor.

3.8
longitudinal median plane
median longitudinal plane
symmetric longitudinal plane
vertical plane Y passing through the mid-points of AB, perpendicular to AB, A and B being such that

— for each wheel, the vertical plane passing through its axis cuts the mid-plane of the wheel following a straight line Δ which meets the supporting surface of the vehicle at one point, and

— A and B are two points thus defined which correspond to two wheels, both of which are either steering or powered wheels, situated respectively at the two ends of the same real or imaginary axle

Note 1 to entry: The mid-plane of the dual wheels being equidistant from the inner edge of one wheel and the outer edge of the other, the straight line Δ is, in this particular case, the intersection of the mid-plane of the dual wheels and the vertical plane passing through the axis of the axle pin.

Note 2 to entry: Adapted from ISO 612:1978, Clause 5[1].

Note 3 to entry: The longitudinal median plane may also be applied to track-laying tractors.

Note 4 to entry: See Figure 1.

[SOURCE: ISO 5700:2013, 3.8]

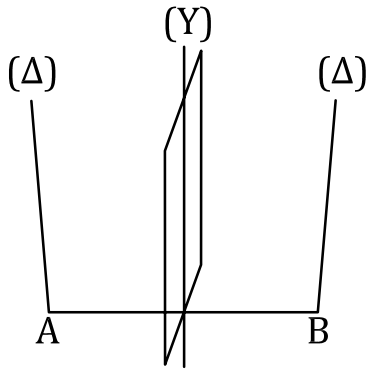

Figure 1 — Longitudinal median plane

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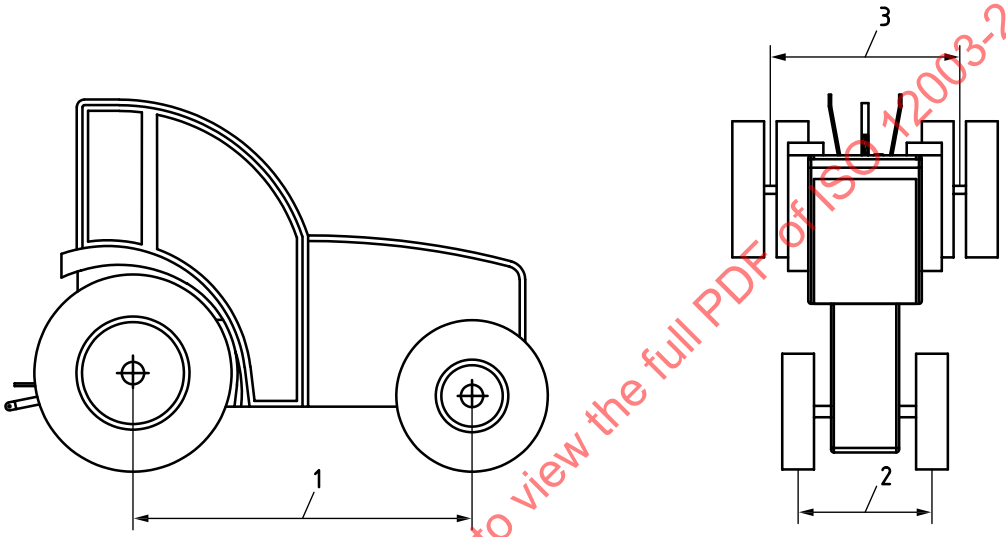
3.9
track
tread
distance at ground level between two vertical planes passing through the centreline of ground contact of the tires parallel to the *longitudinal median plane* (3.8) of the tractor with the wheels in the straight-ahead position

Note 1 to entry: In the case of dual wheels, it is the distance at ground level between two planes passing through the centerline of the dual wheels. In the case of track-laying tractors, it is the distance between the two vertical planes passing through the centerline of ground contact of the tracks.

Note 2 to entry: See Figure 2.

[SOURCE: ISO 789-13:2018, 3.3]



Key
1 wheel base
2 track
3 track (dual wheels)

Figure 2 — Track and wheelbase of wheeled tractor

3.10
wheelbase
distance at ground level between two vertical planes passing through the centres of the front wheels and the rear wheels with tractor and wheels in the same straight ahead position

Note 1 to entry: See Figure 2.

[SOURCE: ISO 789-13:2018, 3.2]

3.11
horizontal loading test
application of a horizontal load to the rear, front and side of the *roll-over protective structure* (3.1)

3.12
crushing test
application of a vertical static load through a beam placed laterally across the uppermost members of the *rear-mounted ROPS* (3.2)

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3.13
impact test
application of a dynamic load produced by a block acting as a pendulum

3.14
foldable ROPS
two-post *roll-over protective structure* (3.1) with hand raising/lowering directly managed by the operator (with or without partial assistance)

3.15
agricultural tractor
self-propelled agricultural vehicle having at least two axles and wheels, or endless tracks, particularly designed to pull agricultural trailers and pull, push, carry and operate implements used for agricultural work (including forestry work), which may be provided with a detachable loading platform

Note 1 to entry: The agricultural vehicle has a maximum design speed of not less than 6 km/h and may be equipped with one or more seats.

[SOURCE: ISO 12934:2013, 3.1]

3.16
hand-operated foldable ROPS
rear-mounted dual pillar protective structure with hand raising/lowering directly managed by the operator (with or without partial assistance)

3.17
automated foldable ROPS
rear-mounted dual pillar protective structure with full assisted raising/lowering operations

3.18
locking system
device fitted to lock, by hand or automatically, the ROPS in the raised or lowered positions

3.19
grasping area
portion of the ROPS and/or additional handle fitted to the ROPS where the operator is allowed to carry out the raising/lowering operations

3.20
accessible part of the grasping area
area where the ROPS is handled by the operator during the raising/lowering operations

Note 1 to entry: This area shall be defined with regard to the geometric centre of cross sections of the grasping area.

3.21
accessible zone
volume where a standing operator can apply a force in order to raise/lower the ROPS

3.22
pinching
dangerous point where parts move in relation to each other or to fixed parts in such a way as may cause persons or certain parts of their bodies to be pinched

3.23
shear
dangerous point where parts move along each other or along other parts in such a way as may cause persons or certain parts of their bodies to be pinched or shorn

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3.24
place to stand
place on the tractor platform accessible from the driving position main access with sufficient space for a standing operator

3.25
static friction
force that resists initiation of movement of one surface sliding over another surface

Note 1 to entry: The force required to initiate movement is equal to that which resists initiation of movement.

[SOURCE: ISO 15359:1999, 3.2]

3.26
dynamic friction
force that resists maintained sliding of one surface over another surface

Note 1 to entry: The force required to maintain sliding is equal to that which resists the maintenance of sliding.

[SOURCE: ISO 15359:1999, 3.4, modified — The original term was "kinetic friction".]

4 Symbols

For the purposes of this document, the symbols in Table 1 apply.

Table 1 — Symbols

Symbol	Description	Unit
a_h	Half of the horizontal seat adjustment	mm
a_v	Half of the vertical seat adjustment	mm
B	Minimum overall width of the tractor	mm
B_b	Maximum outer width of the rear-mounted ROPS	mm
D	Deflection of the ROPS for the calculated basic energy at the point of impact (dynamic test) or at the point of, and in line with, the load application (static test)	mm
D_p	Permanent deformation	mm
D_e	Elastic deformation	mm
E_{il}	Energy to be absorbed during horizontal loading	J
E_{is}	Energy to be absorbed during side loading	J
F	Static load force	N
F_{max}	Maximum static load force occurring during loading, with the exception of overload	N
F_v	Vertical crushing force	N
H	Falling height of the pendulum block's centre of gravity	mm
I	Moment of inertia about rear axle, whatever the mass of the rear wheels may be	$kg{\cdot}m^2$
L	Tractor reference wheelbase	mm
m	Tractor unballasted mass (see 3.3)	kg
m_t	Reference mass (see 3.5)	kg
W	Overall width of the upper part of the protective structure	mm
m_{max}	Tractor maximum permissible mass	kg
m_r	Mass ratio of the maximum permissible mass (m_{max}) to the reference mass (m_t) (see 3.6)	Kg/kg

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5 Test apparatus and equipment

5.1 Apparatus for both dynamic and static testing

5.1.1 Clearance zone framework

Means to prove that the clearance zone has not been entered during the test: a measuring rig conforming with Figures 11 and 12 may be used.

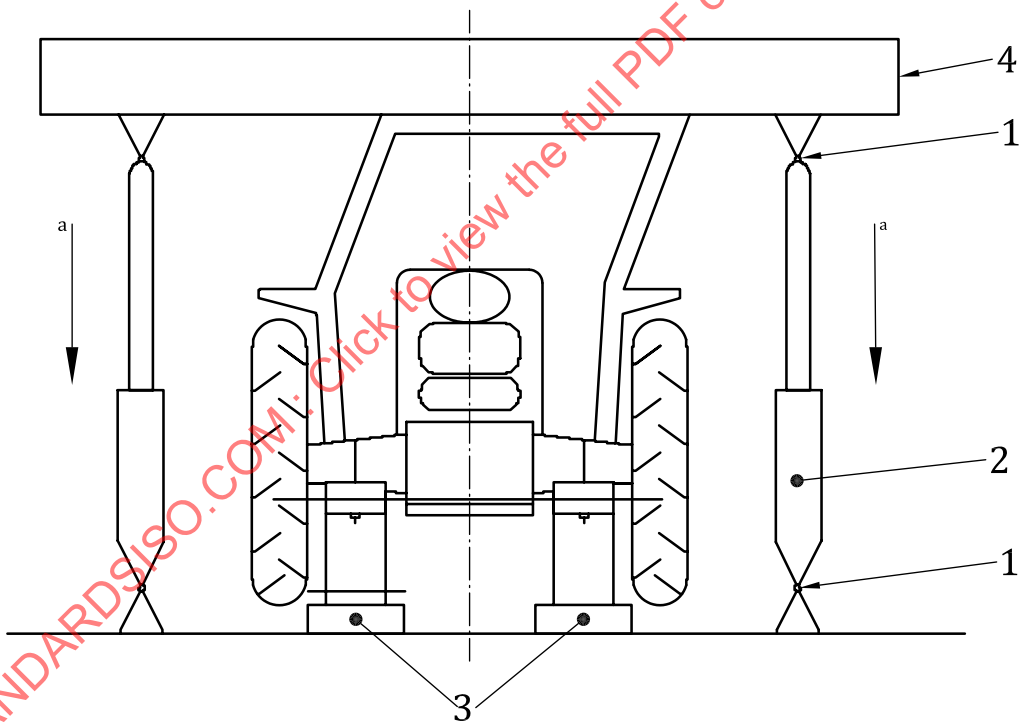
5.1.2 Apparatus for crushing tests

The crushing tests shall be carried out by means of the elements described in 5.1.2.1 and 5.1.2.3.

5.1.2.1 Means to apply downward force on the protective structure, such as that shown in Figure 3, including a stiff beam with a width of 250 mm.

5.1.2.2 Equipment to measure total vertical force applied.

5.1.2.3 Suitable axle supports shall be provided so that the tractor tyres do not bear the crushing force.



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Key

1 universal pin joints
2 hydraulic cylinder
3 axle supports
4 stiff beam
[a] Direction of force.

Figure 3 — Crushing test — Example

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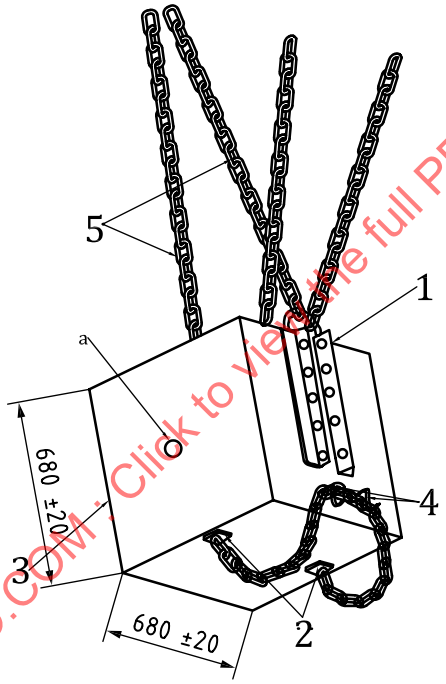
5.2 Apparatus for dynamic testing

5.2.1 Device to strike a blow against the protective structure

A pendulum block with a mass of 2 000 kg shall be used. The pendulum block mass does not include the mass of the chains or wire ropes. The maximum chain mass shall be 100 kg. The block shall be suspended from two chains or wire ropes from pivot points 6 m or more above ground level as shown in Figure 4. The pendulum block centre of gravity shall be constant and coincide with its geometric centre. The pendulum block centre of gravity shall pass through the contact point of the protective structure. Means shall be provided for independently adjusting the height of the pendulum block and the angle between the pendulum block and the supporting chains or wire ropes.

The parallelepiped shall be connected to the system which pulls it backwards by an instantaneous release mechanism which is so designed and located as to enable the pendulum block to be released without causing the parallelepiped to oscillate about its horizontal axis perpendicular to the pendulum's plane of oscillation.

Dimensions in millimetres



Key

1 attachment for release mechanism
2 height adjustment
3 impact face
4 hooks to hold spare chain
5 pendulum chains or wire ropes
a Axis of centre of gravity.

Figure 4 — Illustration of pendulum block

5.2.2 Pendulum supports

The pendulum pivot points shall be rigidly fixed such that their displacement in any direction does not exceed 1 % of the height of fall.

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5.2.3 Means to lash the tractor to the ground

5.2.3.1 Anchoring rails with the requisite track width and covering the necessary area for lashing the tractor shall be rigidly attached to a non-yielding base beneath the pendulum.

5.2.3.2 The tractor shall be lashed to the rails by means of steel cable of construction Class 6 x 19, Grade 1 770, with nominal diameter 13 mm according to ISO 2408. There shall be two lashings on each axle, one on each side of the median plane of the tractor. The lashings shall be anchored in the area immediately below the pivot points and extending for approximately 9 m along the pendulum block axis and approximately 1 800 mm to either side. The points of attachment of the lashings shall be sufficiently long to have an angle of 30° between the ground and lashing. Details of the lashing means are given in Figures 5, 6 and 7.

The front and rear wheels are not required to be in line if this is more convenient for attaching appropriate ropes.

5.2.4 Wheel beam

A softwood beam, of cross-section 150 mm × 150 mm, to restrain the rear wheels when striking from the front or rear, and to clamp against the side of the front and rear wheels when striking from the side, as shown in Figures 5, 6, and 7. It may be necessary to use two beams if the outer sides of the front and rear tyres are not in the same vertical plane.

5.2.5 Wheel prop

Wooden prop to restrain the opposite rear wheel when striking from the side as shown in Figure 7. Its length shall be 20 to 25 times its thickness and its width 2 to 3 times its thickness. The prop shall then be placed against the rim of the most heavily loaded wheel opposite to the point of impact, pushed firmly against the rim and then fixed at its base.

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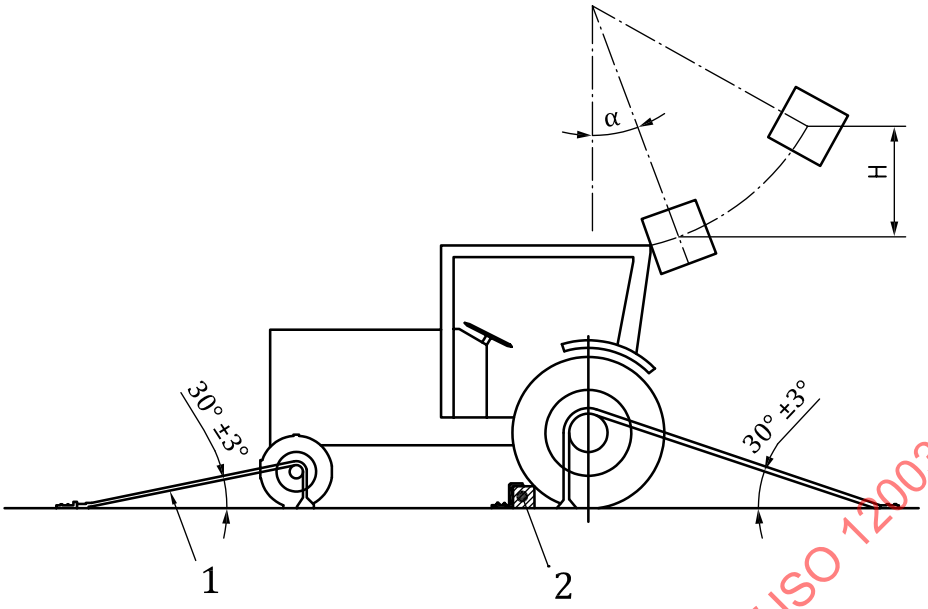
Dimensions in millimetres



Key

1 lashing

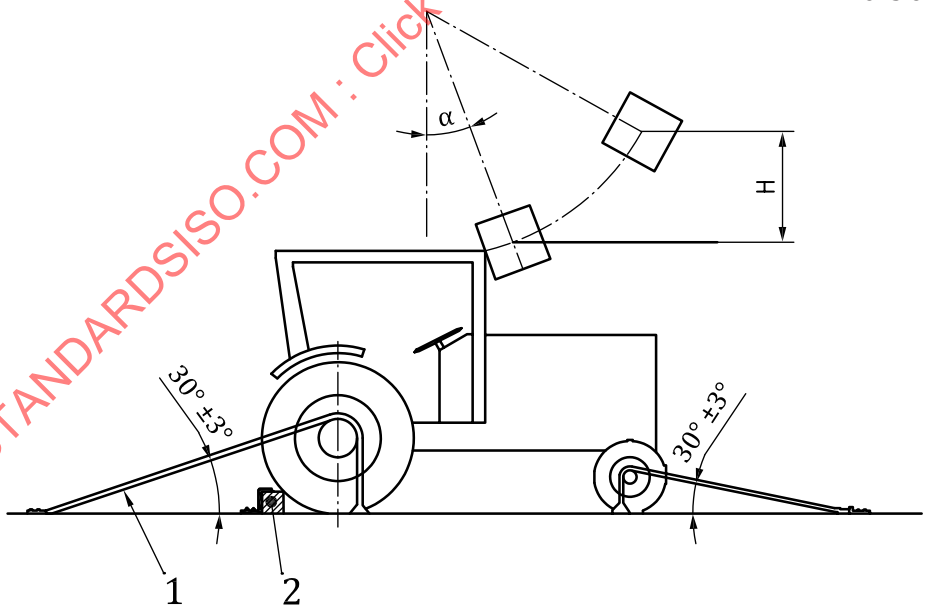
2 wheel beam

H height of fall of pendulum block centre of gravity

$\alpha = m_t / 100$ with a 20° maximum

Figure 5 — Example of lashing method — Impact from rear

Dimensions in millimetres



Key

1 lashing

2 wheel beam

H height of fall of pendulum block centre of gravity

$\alpha = m_t / 100$ with a 20° maximum

Figure 6 — Example of lashing method — Impact from front

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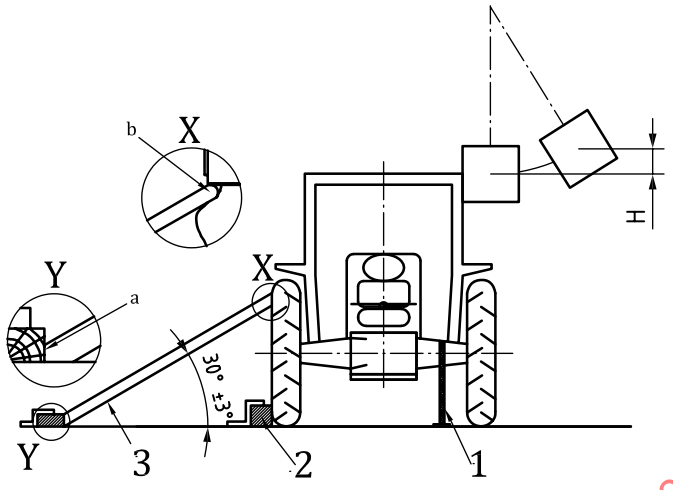
Dimensions in millimetres



Key

1 lashing
2 wheel beam
3 wheel prop
H height of fall of pendulum block centre of gravity
a Chamfered.
b Rounded to secure contact against rim.

Figure 7 — Example of lashing method — Impact from side

5.2.6 Props and lashings for articulated tractors

The central pivot of an articulated tractor shall be supported and lashed down as appropriate for all test procedures. For the side impact test procedure, the pivot shall also be propped from the side opposite the impact.

5.2.7 Tyre pressures and deflection

The tractor tyres shall not be liquid-ballasted and shall be inflated to the pressures prescribed by the tractor manufacturer for field work. The lashings shall be tensioned in each particular case such that the tyres undergo a deflection equal to 12 % of the tyre wall height (distance between the ground and the lowest point of the rim) before tensioning.

5.2.8 Device to measure elastic deflection

Device to measure elastic deflection, such as that shown in Figure 8, in a horizontal plane that coincides with the upper limiting surface of the clearance zone.

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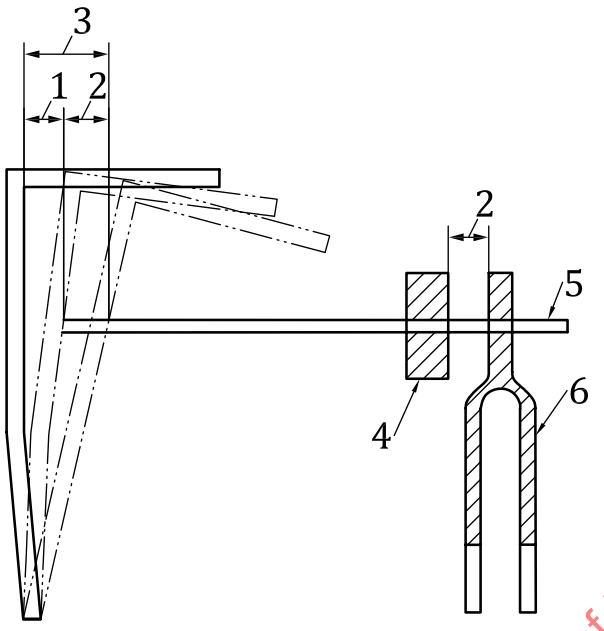
Dimensions in millimetres



Key

1 permanent deflection
2 elastic deflection
3 total (permanent + elastic) deflection
4 friction collar
5 horizontal rod attached to ROPS
6 vertical bar attached to tractor chassis

Figure 8 — Apparatus for measuring elastic deflection — Example

5.3 Apparatus for static testing

5.3.1 Material, equipment and attachment means to ensure that the tractor chassis is firmly fixed to the ground (and supported) independently of the tyres.

5.3.2 Means to apply a horizontal force to the ROPS, such as shown in Figures 9 and 10, conforming with the requirements of 5.3.2.1 to 5.3.2.5.

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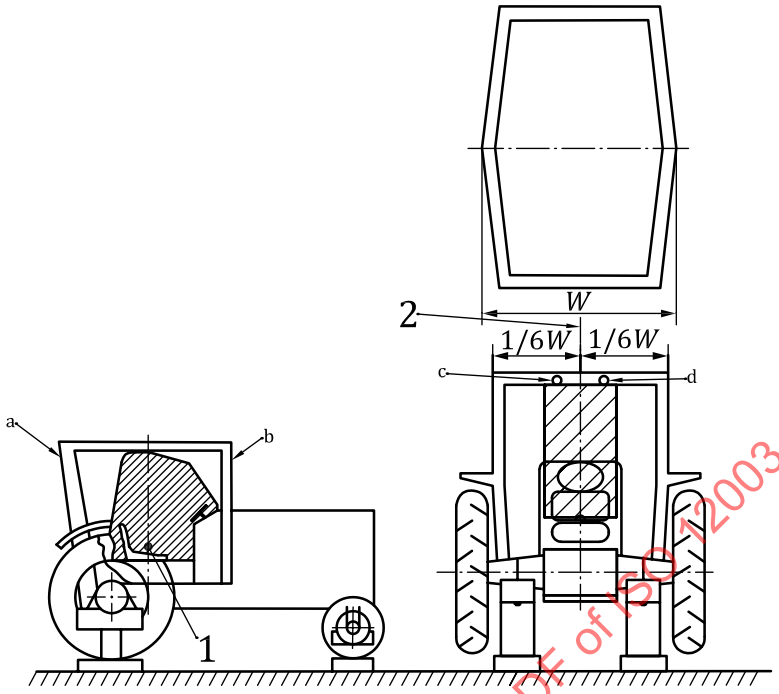
Dimensions in millimetres



Key

1 seat index point

2 seat index point, longitudinal median plane

a Rear load.

b Front load.

c Second horizontal load, front or rear.

d Horizontal load, rear or front.

Figure 9 — Front and rear horizontal load application

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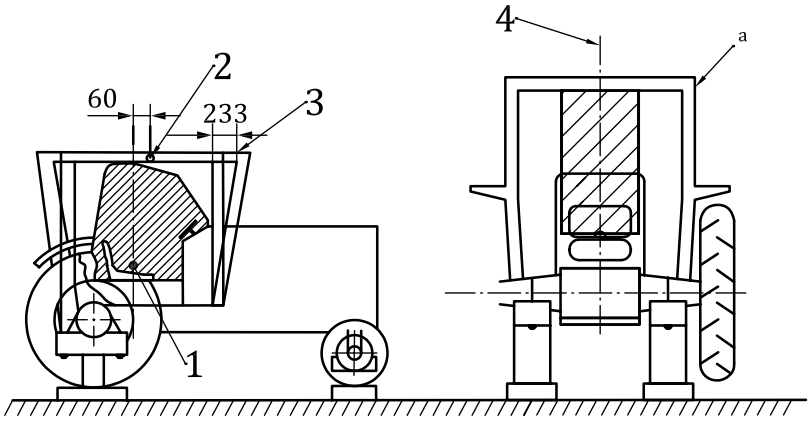
Dimensions in millimetres



Key

1 seat index point
2 point of side load application (see 7.5.5)
3 deflection due to rear horizontal loading
4 seat index point, longitudinal median plane
a Load.

Figure 10 — Side load application

5.3.2.1 It shall be ensured that the load can be uniformly distributed normal to the direction of loading and along a beam of length between 250 mm and 700 mm in an exact multiple of 50 mm. The beam shall have a vertical face of 150 mm.

5.3.2.2 The edges of the beam in contact with the ROPS shall be curved with a maximum radius of 50 mm.

5.3.2.3 Universal joints, or the equivalent, shall be incorporated to ensure that the loading device does not constrain the structure in rotation or translation in any direction other than the loading direction.

5.3.2.4 The pad shall be capable of being adjusted to any angle in relation to the load direction, in order to be able to follow the angular variations of the structure's load-bearing surface as the structure deflects.

5.3.2.5 The direction of the force (deviation from horizontal and vertical) shall be:

— at the start of test, under zero load: ±2°;

— during test, under load: 10° above and 20° below the horizontal; these variations shall be kept to a minimum.

5.3.2.6 Where the roll-over protective structure length, covered by the appropriate load-applying beam, does not constitute a straight line normal to the direction of load application, the space shall be packed so as to distribute the load over this length.

5.3.3 Equipment to measure force and deflection along the direction of application of the force and relative to the tractor chassis. To ensure accuracy, measurements shall be taken as continuous recordings. The measuring devices shall be located so as to record the force and deflection at the point of, and along the line of, loading.

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6 Preparation of tractor and ROPS for testing

6.1 The protective structure may be manufactured either by the tractor manufacturer or by an independent firm. In either case, a test is only valid for the model of tractor on which it is carried out.

6.2 The protective structure shall be retested for each model of tractor to which it is to be fitted. However, the entity may certify that the strength tests are also valid for tractor models derived from the original model by modifications to the engine, transmission and steering and front suspension. More than one protective structure may be tested for any one model of tractor.

6.3 The rear-mounted ROPS shall be manufactured to production specifications and shall be fitted to the appropriate tractor model chassis in accordance with the manufacturer's declared attachment method to form the assembly.

NOTE A complete tractor is not required for the static strength test; however, the protective structure and part of the tractor to which it is attached represent an operating installation; hereinafter referred to as "the assembly".

6.4 This assembly shall be secured to the bedplate so that the members connecting the assembly and the bedplate do not deflect significantly in relation to the ROPS under loading. The assembly shall not receive any support under loading other than that due to the initial attachment.

6.5 A track width setting for the rear wheels, if present, shall be chosen such that there is no interference with the ROPS during testing.

6.6 The assembly shall be supported and secured or modified so that all the test energy is absorbed by the roll-over protective structure and its attachment to the tractor rigid components.

6.7 Deflection of the chassis integral components is permissible during the ROPS test. Any members that absorb energy during the ROPS test should be noted in the test report.

6.8 All windows, panels and removable non-structural fittings shall be removed so that they do not contribute to the strength of the ROPS.

In cases where it is possible to fix doors and windows open or remove them during work, they shall be either removed or fixed open for the test, so that they do not add to the strength of the ROPS. It shall be noted, whether, in this position, they would create a hazard for the driver in the event of overturning.

6.9 Any component of the tractor contributing to the strength of the protective structure, such as mudguards, which has been reinforced by the manufacturer, shall be described and its measurements given in the test report.

6.10 Where a "tandem" tractor (e.g. articulated tractor) is concerned, the mass of the standard version of that part to which the ROPS is fitted shall be used.

6.11 The ROPS shall be instrumented with the necessary equipment to obtain the required force deflection data.

6.12 Components which may create a hazard in the clearance zone shall also be fitted on the tractor (or the assembly) so that they may be shown to fulfil requirements of the acceptance conditions of Clause 11 have been fulfilled.

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7 ROPS deflection test procedures

CAUTION — Take adequate protection to protect personnel during tests. Some of the tests specified in this document involve the use of processes which can lead to a hazardous situation.

7.1 General requirements

7.1.1 If, during any test, any part of the tractor restraining equipment breaks or moves, the test shall be restarted.

7.1.2 No repairs or adjustments to the tractor or rear-mounted ROPS may be carried out during the tests.

7.1.3 The tractor gear box shall be in neutral and the brakes off during testing.

7.1.4 If the tractor is fitted with a suspension system between the tractor body and the wheels, it shall be blocked during testing.

7.1.5 The side chosen for application of the first impact (dynamic test) or the first load (static test) on the rear of the structure shall be the one that will result in the application of the series of impacts or loads under the most unfavourable conditions for the rear-mounted ROPS. The side impact or load and rear impact or load-shall be-applied on both sides of the longitudinal median plane of the rear-mounted ROPS. The front impact or load shall be on the same side of the longitudinal median plane of the rear-mounted ROPS as the side impact or load.

7.1.6 For tractors with a reversible driver's position (reversible seat and steering wheel) the maximum permissible mass is less than 5 250 kg.

7.1.7 The mass ratio (m_r) shall not be greater than 1,75.

7.2 Test methods

Tests shall be performed in accordance with either the dynamic test procedure or the static test procedure. The two methods are determined to be equivalent. The crushing test procedure is common to both test methods.

7.3 Test sequence

The sequence of tests, without prejudice to the additional tests mentioned in 7.4.4, 7.7 and 11.6 is as follows:

a) impact (dynamic test procedure) or horizontal loading (static test procedure) applied at the rear of the structure (see 7.4.1 or 7.5.3);

b) vertical crushing (dynamic and static test procedure) applied at the rear of the structure (see 7.6);

c) impact (dynamic test procedure) or horizontal loading (static test procedure) applied at the front of the structure (see 7.4.2 or 7.5.4);

d) impact (dynamic test procedure) or horizontal loading (static test procedure) applied at the the side of the structure (see 7.4.3 or 7.5.5);

e) vertical crushing (dynamic and static test procedure) applied at the front of the structure (see 7.6).

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7.4 Dynamic (impact) test procedures for rear-mounted ROPS

7.4.1 Rear impact test procedure

7.4.1.1 The tractor shall be positioned in relation to the pendulum block such that the block will strike the rear-mounted ROPS when the impact face of the block and the supporting chains or wire ropes are at an angle with the vertical plane, α, equal to $m_t/100$ with a 20° maximum, unless, during deflection, the rear-mounted ROPS at the point of contact forms a greater angle to the vertical. In that case, the impact face of the block shall be adjusted by means of an additional support such that it is parallel to the rear-mounted ROPS at the point of impact at the moment of maximum deflection, the supporting chains or wire ropes remaining at the angle defined above.

The suspended height of the pendulum block shall be adjusted and any necessary steps taken to prevent the block from turning about the point of impact.

The point of impact is that part of the rear-mounted ROPS likely to hit the ground first in a rearward overturning accident, normally the upper edge. The position of the centre of gravity of the block shall be one-sixth the width of the top of the rear-mounted ROPS, inwards from a vertical plane parallel to the median plane of the tractor touching the outside extremity of the top of the rear-mounted ROPS.

lf the rear-mounted ROPS is curved or protruding at this point, wedges enabling the impact to be applied thereon shall be added without thereby reinforcing the rear-mounted ROPS.

7.4.1.2 The tractor shall be lashed to the ground as prescribed in 5.2.3 to 5.2.6 as shown in Figure 5. The spacing between the front and rear lashing points shall be such that the wire ropes make an angle of less than 30° with the ground. The rear lashings shall, in addition, be so arranged that the point of convergence of the two wire ropes is located in the vertical plane in which the centre of gravity of the pendulum block travels.

The wire ropes shall be tensioned so that the tyres undergo the deflections given in 5.2.7. With the wire ropes tensioned, the wheel beam shall be placed in front of and tight against the rear wheels and then fixed to the ground.

7.4.1.3 lf the tractor is of the articulated type, its pivot shall be additionally supported by a wooden block at least 100 mm square and firmly lashed to the ground.

7.4.1.4 The pendulum block shall be pulled back to achieve the height, H, of its centre of gravity as given by Formula (1) or Formula (2):

$$H = 2{,}165\times10^{-8}\, m_t \times L^2 \tag{1}$$

or

$$H = 5{,}73\times10^{-2}\, m_t \times I \tag{2}$$

7.4.1.5 For tractors with a reversible seat position, one of the preceding formulae [Formula (1) or Formula (2)] or one of the following formulae [Formula (3) or Formula (4)] shall be used, whichever gives the greater result.

— For tractors with a reference mass of less than 2 000 kg:

$$H = 25 + 0{,}07\, m_t \tag{3}$$

— For tractors with a reference mass of 2 000 kg or more:

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$$H = 125 + 0{,}02 m_t \quad (4)$$

7.4.1.6 The pendulum block shall be released so that it strikes the rear-mounted ROPS.

7.4.2 Front impact test procedure

7.4.2.1 The tractor shall be positioned in relation to the pendulum block such that the block will strike the rear-mounted ROPS when the impact face of the block and the supporting chains or wire ropes are at an angle with the vertical plane, α, equal to $m_t/100$ with a 20° maximum, unless, during deflection, the rear-mounted ROPS at the point of contact forms a greater angle to the vertical. In that case, the impact face of the block shall be adjusted by means of an additional support such that it is parallel to the rear-mounted ROPS at the point of impact at the moment of maximum deflection, with the supporting chains or wire ropes remaining at the angle defined above.

The suspended height of the pendulum block shall be adjusted and any necessary steps taken to prevent the block from turning about the point of impact.

The point of impact is that part of the rear-mounted ROPS likely to hit the ground first if the tractor overturned sideways while travelling forward, normally the upper edge. The position of the centre of gravity of the block shall be one-sixth the width of the top of the rear-mounted ROPS, inwards from a vertical plane parallel to the median plane of the tractor touching the outside extremity of the top of the rear-mounted ROPS.

If the rear-mounted ROPS is curved or protruding at this point, wedges enabling the impact to be applied thereon shall be added without thereby reinforcing the rear-mounted ROPS.

7.4.2.2 The tractor shall be lashed to the ground as prescribed in 5.2.3 to 5.2.6 as shown in Figure 6. The spacing between the front and rear lashing points shall be such that the wire ropes make an angle of less than 30° with the ground. The rear lashings shall, in addition, be so arranged that the point of convergence of the two wire ropes is located in the vertical plane in which the centre of gravity of the pendulum block travels.

The wire ropes shall be tensioned so that the tyres undergo the deflection given in 5.2.7. With the wire ropes tensioned, the wheel beam shall be placed in front of and tight against the rear wheels and then fixed to the ground.

7.4.2.3 If the tractor is of the articulated type, its pivot shall be additionally supported by a wooden block at least 100 mm square and firmly lashed to the ground.

7.4.2.4 The pendulum block shall be pulled back to achieve the height, H, as given by either Formula (3) or Formula (4).

7.4.2.5 For tractors with a reversible seat position and a rear, two-post roll bar, Formula (3) or Formula (4) shall be used.

For tractors with a reversible seat position and any other type of rear-mounted ROPS, one of Formulae (1), (2), (3) or (4) shall be used, whichever gives the greater result.

7.4.2.6 Release the pendulum block so that it strikes the rear-mounted ROPS.

7.4.3 Side impact test procedure

7.4.3.1 The tractor shall be positioned in relation to the pendulum block such that the block will strike the rear-mounted ROPS when the impact face of the block and the supporting chains or wire ropes are vertical, unless, during deflection, the rear-mounted ROPS at the point of contact forms an angle of

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less than 20° to the vertical. In this case, the impact face of the block shall be adjusted by means of an additional support such that it is parallel to the rear-mounted ROPS at the point of impact at the moment of maximum deflection, with the supporting chains or wire ropes remaining vertical on impact.

The suspended height of the pendulum block shall be adjusted and any necessary steps taken to prevent the block from turning about the point of impact.

The point of impact shall be that part of the rear-mounted ROPS likely to hit the ground first in a sideways overturning accident (normally the upper edge). Unless it is certain that another part of this edge would hit the ground first, the point of impact shall be in the plane at right angles to the median plane and passing 60 mm in front of the SIP, the seat being set at the mid position of longitudinal adjustment.

7.4.3.2 For tractors with a reversible driving position (reversible seat and steering wheel), the point of impact shall be in the plane at right angles to the median plane and passing at the midpoint of the segment joining the two seat index points defined by joining the two different positions of the seat. For protective structures having a two-post system, the impact shall be located on one of the two posts.

7.4.3.3 The tractor shall be lashed to the ground as prescribed in 5.2.3 to 5.2.6 as shown in Figure 7. The lashings shall be tensioned to produce the tyre deflection values given in 5.2.7 on the side which is to receive the impact. The wheel beam shall be placed on the ground, pushed tight against the tyres on the side opposite that which is to receive the impact and then fixed to the ground. (It may be necessary to use two wheel beams if the outer sides of the front and rear tyres are not in the same vertical plane.)

The wooden prop shall be placed, as shown in Figure 7, against the rim of the wheel opposite to the impact, pushed firmly against the rim and fixed at its base. The length of the prop shall be chosen such that it makes an angle of 30° ± 3° with the ground when in position against the rim. In addition, its length shall, if possible, be between 20 and 25 times greater than its thickness, and its width between two and three times greater than its thickness. The props shall be shaped at both ends as shown in the details in Figure 7.

7.4.3.4 If the tractor is of the articulated type, its pivot shall, in addition, be supported by a wooden block at least 100 mm square, as well as being laterally supported by a block similar to that specified in 7.4.1 for articulated type tractors against the rear wheel. Lash the point of articulation firmly to the ground.

7.4.3.5 The pendulum block shall be pulled back to achieve the height, H, as given by whichever of the following two formulae [Formula (5) or Formula (6)] is applicable.

— For tractors with a reference mass of less than 2 000 kg:

$$H = 25 + 0{,}20 m_t \tag{5}$$

— For tractors with a reference mass of 2 000 kg or more:

$$H = 125 + 0{,}15 m_t \tag{6}$$

7.4.3.6 For tractors with a reversible driving position (seat position and steering wheel) and a rear, two-post roll bar, one of the preceding formulae or one of the following formulae [Formula (7) or Formula (8)] shall be used, whichever gives the greater result.

— For tractors with a reference mass of less than 2 000 kg:

$$H = \frac{(25 + 0{,}2 m_t)(B_b + B)}{2B} \tag{7}$$

— For tractors with a reference mass of 2 000 kg or more:

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$$H = \frac{(125+0{,}15m_t)(B_b+B)}{2B} \quad (8)$$

For tractors with a reversible driving position (seat position and steering wheel) and other types of rear-mounted ROPS, Formula (5) or Formula (8) shall be used.

7.4.3.7 The pendulum block shall be released so that it strikes the rear-mounted ROPS.

7.4.4 Additional impact tests

If cracks or tears which cannot be considered negligible appear during an impact test, a second, similar test, but with a height of fall shown as Formula (9):

$$H' = (H \times 10^{-1})\,(12 + 4a)\,(1 + 2a)^{-1} \quad (9)$$

shall be performed immediately after the impact tests causing these tears or cracks to appear as shown in Formula (10):

$$a = \frac{D_p}{D_e} \quad (10)$$

as measured at the point of impact. The additional permanent deformation due to the second impact shall not exceed 30 % of the permanent deformation due to the first impact.

In order to be able to carry out the additional test, it is necessary to measure the elastic deformation during all the impact tests.

7.5 Static test procedures for rear-mounted ROPS

7.5.1 Test preparation

7.5.1.1 The tractor shall be prepared as described in 5.2.3. The assembly shall be secured to the bedplate so that the members connecting the assembly and the bedplate do not deflect significantly in relation to the ROPS under loading. The assembly shall not receive any support under loading other than that due to the initial attachment.

7.5.1.2 A track width setting for the rear wheels if present shall be chosen such that no interference exists with the ROPS during the tests.

7.5.1.3 The assembly shall be supported and secured or modified so that all the test energy is absorbed by the ROPS and its attachment to the tractor rigid components. If the tractor or assembly moves, the entire test shall be repeated, unless the system for measuring the deflections taken into account for plotting the force versus deflection curve is connected to the tractor or assembly.

7.5.2 General requirements for horizontal loading test procedures

7.5.2.1 The loads applied to the ROPS shall be distributed by means of a stiff beam, complying with the requirements of 5.3.2, located normal to the direction of load application. The rate of load application shall be such that the rate of deflection does not exceed 5 mm/s. As the load is applied, force and deflection data shall be recorded simultaneously as continuous recordings to ensure accuracy.

7.5.2.2 If the structural member to which the load is to be applied is curved, the requirements of 5.3.2.6 shall be met. The application of the load shall, however, still comply with the requirements of 7.5.2.1 and 5.3.2.

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7.5.3 Rear loading

Apply the load horizontally, in a vertical plane parallel to the tractor's reference plane. The load application point shall be that part of the rear-mounted ROPS likely to hit the ground first in a rearward overturning accident, normally the upper edge. The vertical plane in which the load is applied is located at a distance of one-sixth the external width of the upper part of the rear-mounted ROPS from the longitudinal median plane. lf the rear-mounted ROPS is curved or protruding at this point, wedges enabling the load to be applied to it shall be added, without thereby reinforcing the rear-mounted ROPS.

The tractor or assembly shall be secured to the ground using lashings in accordance with 5.2.3.

The energy absorbed by the rear-mounted ROPS during the test shall be at least as shown in Formula (11):

$$E_{il} = 2{,}165 \times 10^{-7}\, m_t \times L^2 \tag{11}$$

or in Formula (12):

$$E_{il} = 0{,}574 \times I \tag{12}$$

For tractors with a reversible driving position (reversible seat and steering wheel), the energy shall be whichever is the higher of the formula selected above [Formula (11) or Formula (12)] or Formula (13):

$$E_{il} = 500 + 0{,}5 m_t \tag{13}$$

7.5.4 Front loading

Apply the load horizontally, in a vertical plane parallel to the tractor's reference plane and located at a distance of one-sixth the external width of the upper part of the rear-mounted ROPS from the reference plane. The load application point is that part of the rear-mounted ROPS likely to hit the ground first, were the tractor to overturn in a sideways direction while travelling forwards, normally the upper edge. lf the rear-mounted ROPS is curved or protruding at this point, wedges enabling the load to be applied thereon shall be added, without thereby reinforcing the rear-mounted ROPS.

The tractor or assembly shall be lashed to the ground in accordance with 5.2.3.

The energy absorbed by the rear-mounted ROPS during the test shall be at least as shown in Formula (13).

For tractors with a reversible seat position and a rear, two-post roll bar, Formula (13) shall be used.

For tractors with a reversible driving position (reversible seat and steering wheel) and other types of rear-mounted ROPS, either Formula (13) or one of Formulae (11) or (12) shall be used, whichever gives the greater result.

7.5.5 Side loading

Apply the load horizontally, in a vertical plane perpendicular to the tractor's longitudinal median plane, passing 60 mm in front of the SIP (see Figure 10 and Clause 8) with the seat in the longitudinal seat adjustment mid-position. The load application point is that part of the rear-mounted ROPS likely to hit the ground first in a sideways overturning accident, normally the upper edge.

The tractor or assembly shall be secured to the ground in accordance with 5.2.3.

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The energy absorbed by the rear-mounted ROPS during the test shall be at least given by Formula (14):

$$E_{is} = 1{,}75 m_t \tag{14}$$

For tractors with a reversible driving position (reversible seat and steering wheel), the load application point shall be in the plane at right angles to the longitudinal median plane and passing at the midpoint of the segment joining the two seat index points defined by joining the two different positions of the seat. For protective structures having a two-post system, the load shall be located on one of the two posts.

For tractors with a reversible driving position (reversible seat and steering wheel) and a rear, two-post roll bar, either Formula (14) or Formula (15) may be used, whichever gives the greater result:

$$E_{is} = \frac{1{,}75 m_t \left(B_b + B\right)}{2B} \tag{15}$$

For tractors with a reversible driving position (reversible seat and steering wheel) and other types of rear-mounted ROPS, the first of these formulae shall be used.

The load shall be applied in the vertical plane at mid-point between the two SIPs.

7.6 Vertical crushing test procedure

Position the beam across the uppermost structural members of the rear-mounted ROPS, with the resultant crushing forces located in the tractor's longitudinal median plane (see Figure 3).

Apply a vertical crushing force, F_v, of 20 m_t.

Maintain this force for at least 5 s after the cessation of any visually detectable movement of the rear-mounted ROPS. For protective structures having a two-post system, the second crushing force may be at the same point as the first.

Where the rear or front part of the ROPS roof does not sustain the full crushing force, apply the force until the roof is deflected to coincide with the plane joining the upper part of the ROPS with that part of the tractor rear or front capable of supporting the vehicle mass when overturned. Then remove the force and position the tractor or loading force such that the beam is over that point of the ROPS that would then support the tractor rear or front were the tractor to completely overturn and the full force be applied.

7.7 Additional vertical crushing tests

If cracks or tears that cannot be considered as negligible appear during a crushing test, an additional, similar crushing test, but with a force of $1{,}2F_v$, shall be carried out immediately after the crushing test that caused the cracks or tears to appear.

7.8 Observations during testing

7.8.1 Fractures and cracks

After each test, all structural members, joints and fastening systems shall be visually examined for fractures or cracks. Small cracks in unimportant parts and any tears caused by the edges of the pendulum weight may be ignored.

7.8.2 Clearance zone

During each test, an examination shall be made to ascertain whether any part of the rear-mounted ROPS has entered the clearance zone (see Clause 9).

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In addition, an examination shall be made to determine whether any part of the clearance zone is outside the protection of the rear-mounted ROPS, which could be the case were any part of the zone to come into contact with the ground in the event of the tractor overturning in the direction of impact. For this purpose, the front and rear tyres, and track width setting, shall be the smallest specified by the manufacturer.

7.8.3 Recording permanent deflection

After the final crushing test procedure has been carried out, the permanent deflection of the rear-mounted ROPS shall be recorded. For this purpose, before the start of the test procedure, the position of the main rear-mounted ROPS members shall be noted.

8 Determination of seat index point (SIP), seat location and adjustment for test

8.1 General

The seat index point (SIP) shall be determined in accordance with ISO 5353.

After the installation of the seat on the tractor, the seat index point (SIP) becomes a fixed point with respect to the tractor and does not move with the seat through its horizontal and vertical adjustment range.

8.2 Seat location and adjustment for tests

Where the seat position is adjustable, the seat shall be adjusted to its rear uppermost position.

Where the inclination of the backrest is adjustable, it shall be adjusted to the mid position.

Where the position of the seat is adjustable only lengthwise and vertically, the longitudinal axis passing through the seat index point shall be parallel with the vertical longitudinal plane of the tractor passing through the centre of the steering wheel and not more than 100 mm from that plane.

For a suspended seat, the manufacturer's directions for setting the suspension shall be followed if provided. Otherwise, the seat suspension shall be set to the suspension mid-travel point.

9 Clearance zone

9.1 General

The clearance zone is illustrated in Figures 11 and 12. The dimensions are given in Table 2. The zone is defined in relation to the reference plane and the SIP. The reference plane is a vertical plane, generally longitudinal to the tractor and passing through the SIP and the centre of the steering wheel. Normally, the reference plane coincides with the longitudinal median plane of the tractor. This reference plane shall be assumed to move horizontally with the seat and steering wheel during loading but to remain perpendicular to the tractor or the floor of the rear-mounted ROPS. The clearance zone shall be defined on the basis of 9.2 and 9.3.

9.2 Clearance zone for tractors with a non-reversible seat

The clearance zone for tractors with a non-reversible seat is defined in a) to m) below and is bounded by the following planes, the tractor being on a horizontal surface, the seat adjusted and located as specified in 8.2, and, where the steering wheel is adjustable, adjusted to the middle position for seated driving:

a) a horizontal plane (A_1 B_1 B_2 A_2), (810 + a_v) mm above the SIP with line B_1B_2 located (a_h − 10) mm behind the SIP;

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b) an inclined plane (H_1 H_2 G_2 G_1), perpendicular to the reference plane, including both a point 150 mm behind line B_1B_2 and the rearmost point of the seat backrest;

c) a cylindrical surface (A_1 A_2 H_2 H_1), perpendicular to the reference plane, having a radius of 120 mm, tangential to the planes defined in a) and b);

d) a cylindrical surface (B_1 C_1 C_2 B_2), perpendicular to the reference plane, having a radius of 900 mm extending forward for 400 mm and tangential to the plane defined in a) above along line B_1B_2;

e) an inclined plane (C_1 D_1 D_2 C_2), perpendicular to the reference plane, joining the surface defined in d) and passing 40 mm in front of the forward external edge of the steering wheel. In the case of a high steering-wheel position, this plane extends forward from line B_1B_2 tangentially to the surface defined in d);

f) a vertical plane (D_1 K_1 E_1 E_2 K_2 D_2), perpendicular to the reference plane, 40 mm forward of the external edge of the steering wheel;

g) a horizontal plane (E_1 F_1 P_1 N_1 N_2 P_2 F_2 E_2) passing through a point (90 – a_v) mm below the SIP;

h) a surface (G_1 L_1 M_1 N_1 N_2 M_2 L_2 G_2), if necessary curved from the bottom limit of the plane defined in b) to the horizontal plane defined in g), perpendicular to the reference plane, and in contact with the seat backrest throughout its length;

i) two vertical planes (K_1 I_1 F_1 E_1) and (K_2 I_2 F_2 E_2), parallel to the reference plane, 250 mm either side of the reference plane and bounded at the top 300 mm above the plane defined in g);

j) two inclined and parallel planes (A_1 B_1 C_1 D_1 K_1 I_1 L_1 G_1 H_1) and (A_2 B_2 C_2 D_2 K_2 I_2 L_2 G_2 H_2), starting from the upper edge of the planes defined in i) and joining the horizontal plane defined in a) at least 100 mm from the reference plane on the side where loading is applied;

k) two portions of vertical planes (Q_1 P_1 N_1 M_1) and (Q_2 P_2 N_2 M_2), parallel to the reference plane, 200 mm on either side of the reference plane, and bounded toward the top 300 mm above the horizontal plane defined in g);

l) two portions, (I_1 Q_1 P_1 F_1) and (I_2 Q_2 P_2 F_2), of a vertical plane, perpendicular to the reference plane and passing (210 – a_h) mm in front of the SIP;

m) two portions, (I_1 Q_1 M_1 L_1) and (I_2 Q_2 M_2 L_2), of the horizontal plane passing 300 mm above the plane defined in g).

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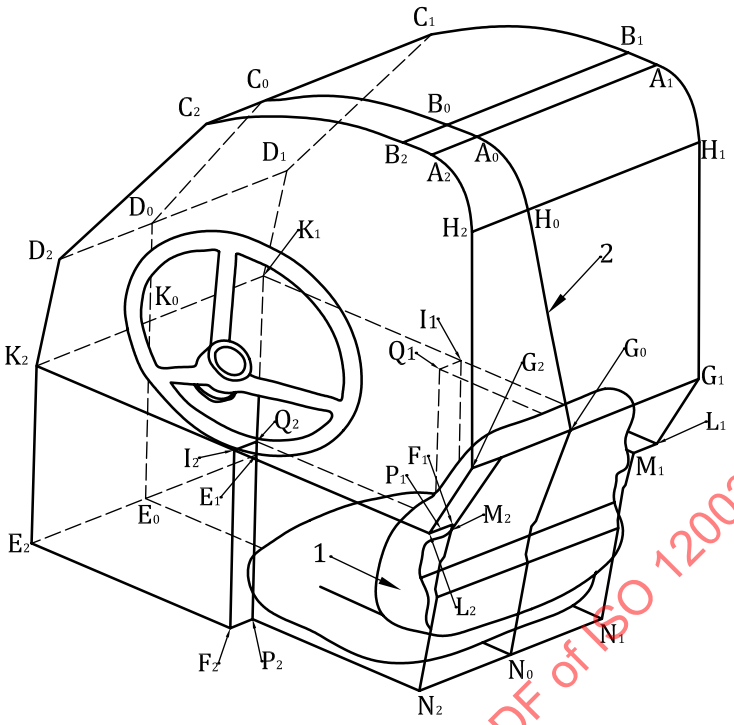

Key

1 seat index point

2 vertical reference plane

Figure 11 — Clearance zone measuring rig

Table 2 — Dimensions for the clearance zone measuring rig shown in Figure 11.

Dimensions mm		Remarks	Dimensions mm		Remarks
A_1 A_0 B_1 B_0	100	Minimum	K_1 K_0 K_2 K_0	250	Minimum or equal to the steering wheel radius plus 40 mm, whichever is greater
A_1 A_2 B_1 B_2 C_1 C_2	500		L_1 L_2	500	
			M_1 M_2 N_1 N_2 Q_1 Q_2	400	
D_1 D_2 E_1 E_2	500	Minimum or equal to the steering wheel radius plus 40 mm, whichever is greater	K_0 E_0	300	
F_1 F_2	500		G_0 N_0	—	
G_1 G_2	400		G_0 H_0	—	Depending on the tractor
H_1 H_2 I_1 I_2	500		C_0 D_0 E_0 N_0	— —	

NOTE For other dimensions, see Figure 12.

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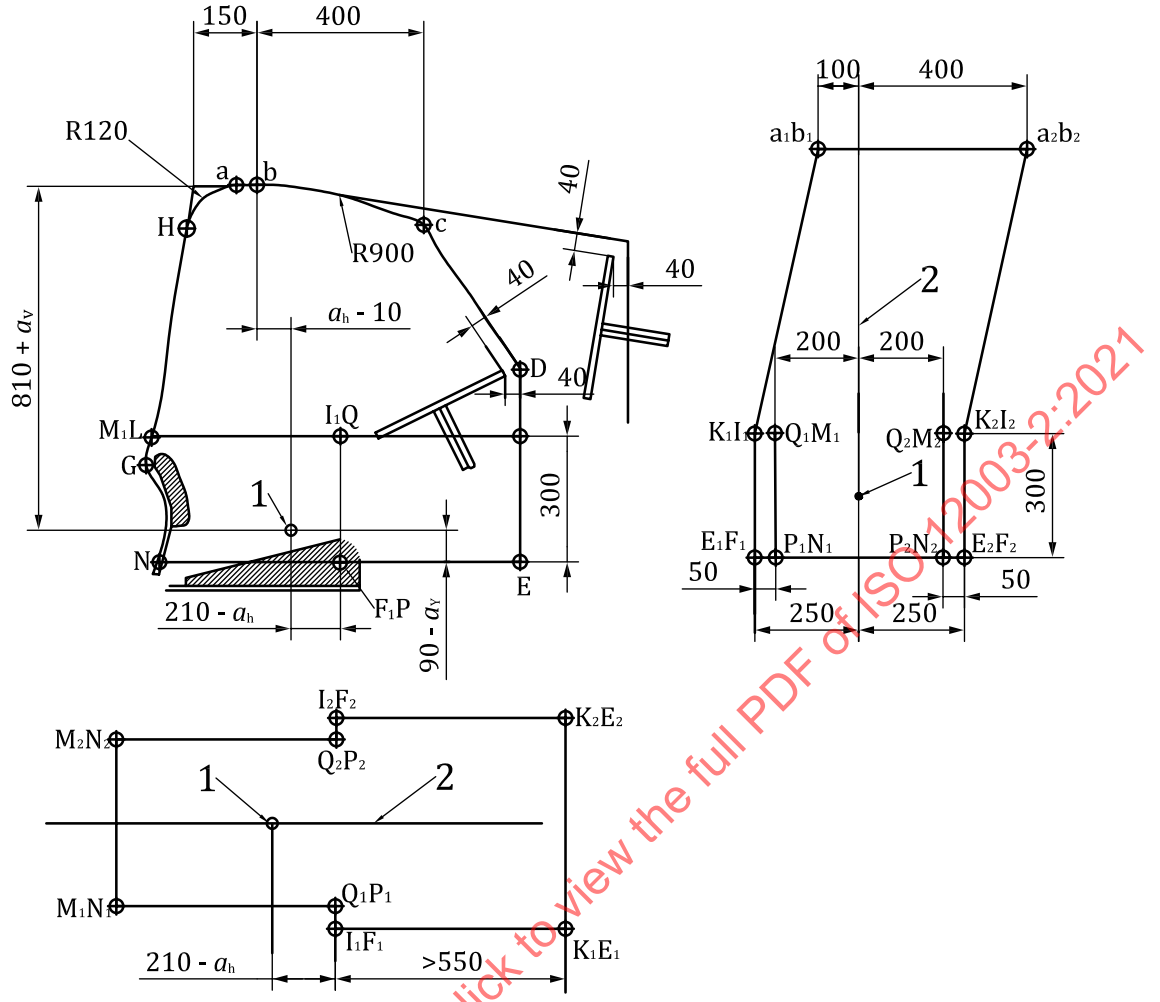
Dimensions in millimetres



Key

1 seat index point

2 vertical reference plane

Figure 12 — Clearance zone

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9.3 Clearance zone for tractors with a reversible driving position

9.3.1 General

For tractors with a reversible driving position (reversible seat and steering wheel), the zone of clearance is the envelope of the two clearance zones defined by the two different positions of the steering wheel and the seat. See Figure 13.

9.3.2 If the protective structure is of a rear two-post type, for each position of the steering wheel and of the seat, the clearance zone shall respectively be defined in accordance with 9.2 and of ISO 12003-1:2021, 10.3 for driving position in reverse position.

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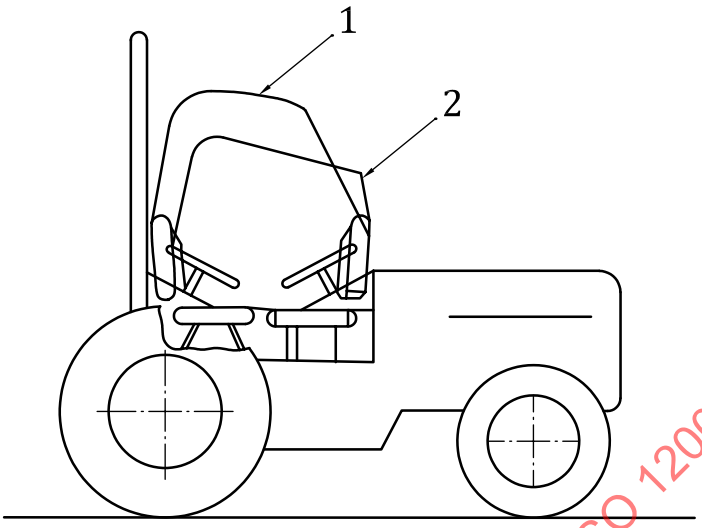
9.3.3 If the ROPS is of another type, for each position of the steering wheel and of the seat, the clearance zone shall be defined on the basis of 9.1 and 9.2. See Figure 14.

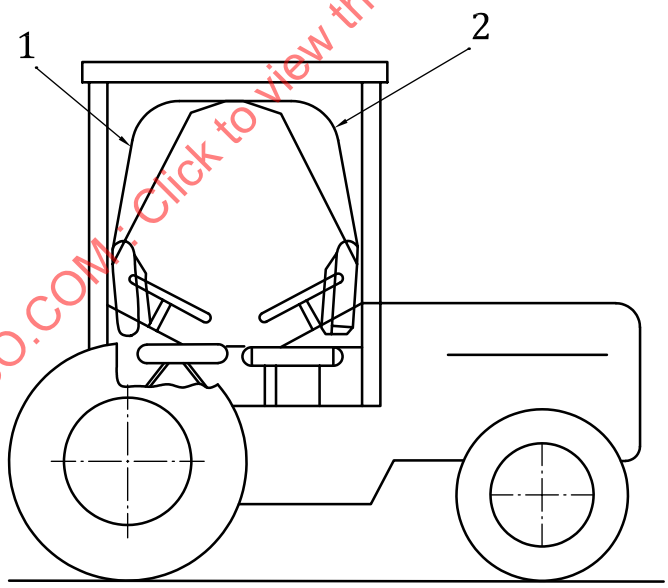


Key

1 clearance zone – forward facing driver

2 clearance zone – rearward facing driver

Figure 13 — Clearance zone for tractors with reversible seat position for two-post rollbar



Key

1 clearance zone – forward facing driver

2 clearance zone – rearward facing driver

Figure 14 — Clearance zone for tractors with reversible seat position for other types of ROPS

9.4 Optional seats

9.4.1 In case of tractors that could be fitted with optional seats, the envelope comprising the seat index points of all options offered shall be used during the tests. The protective structure shall not enter the larger clearance zone which takes account of these different seat index points.

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9.4.2 In the case where a new seat option is offered after the test has been performed, it shall be determined whether the clearance zone around the new SIP falls within the envelope previously established. If it does not, a new test shall be performed.

9.4.3 Optional seat does not include a seat for a person in addition to the driver and from where the tractor cannot be controlled. The SIP shall not be determined because the definition of the clearance zone is in relation to the driver seat.

10 Tolerances

Unless otherwise stated, measurements during the tests shall be made to the following tolerances:

a) time ±0,2 s;

b) linear dimensions ±3 mm except for:

   1) tyre deflection: ±1 mm

   2) structure deflection during horizontal loadings: ±1 mm

   3) height of fall of pendulum block: ±1 mm

c) force ±2 %

d) mass ±1 %

e) angles ±2°

11 Acceptance conditions

11.1 General

11.1.1 In order for the rear-mounted ROPS to be accepted, it shall meet the requirements of this clause both during and after the tests.

11.1.2 For articulated tractors, the clearance zone shall remain protected at any angle of articulation of the tractor when overturned.

11.1.3 The rear-mounted ROPS and the tractor shall be examined for cracks and tears after each test.

11.1.3.1 After each part-test it shall be free from cracks or tears other than those allowed in 7.8.1.

11.1.3.2 If significant cracks or tears appear during one of the tests, an additional test, as defined in 7.4.4 for impact tests or 7.7 for crushing tests, shall be applied immediately after the impact or the crushing test which caused cracks or tears to appear.

11.2 Clearance zone

During the tests other than the overload test, no part of the tractor shall enter the clearance zone (see Clause 9). No part shall strike the seat during the tests. Furthermore, the clearance zone shall not be outside the protection of the rear-mounted ROPS as defined in 3.2. For this purpose, it shall be considered to be outside the ROPS protection if any part of the zone would come into contact with flat ground if the tractor were to overturn in the direction from which the horizontal load was applied. To

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estimate this, the front and rear tyres, and track width setting, shall be the smallest specified by the manufacturer.

NOTE It is the responsibility of the tractor manufacturer to ensure that other components not present during the ROPS test do not present a hazard to the operator in the event of an overturn by entering the clearance zone.

11.3 Seat anchorage performance

If the seat anchorage performance is evaluated, the manufacturer shall give details that shall be included in the report. See Clause 12.

11.4 Folding ROPS performance

If the rear mounted ROPS folding performance is evaluated, the manufacturer shall give details that shall be included in the report. See Clause 13.

11.5 After impact loads

After impact loads have been applied, the following conditions shall be met.

a) There shall be no cracks in structural members, mounting components or tractor parts contributing to the strength of the rear-mounted ROPS, except in accordance with the provisions of c) and e).

b) There shall be no cracks in welds contributing to the strength of the rear-mounted ROPS or its mounting components (spot- or tack-welding used for attaching cladding panels is normally excluded from this requirement).

c) Energy-absorbing tears in sheet-metal rear-mounted ROPS components are acceptable, provided they are judged to have not significantly reduced the resistance to deflection of the rear-mounted ROPS. Tears in sheet metal components caused by the edges of the pendulum block shall normally be ignored.

d) During the side impact test, the elastic deformation shall not exceed 250 mm in a horizontal plane coinciding with the upper limiting surface of the clearance zone.

e) If an additional impact test described in 7.4.4 is required, the additional permanent deflection due to the second impact shall not exceed 30 % of the permanent deflection achieved during the first impact test.

11.6 After static horizontal loads

After static horizontal loads have been applied, the following conditions shall be met.

a) At the point at which the required energy is met in each of the specified horizontal loading tests, the force shall exceed $0{,}8F_{max}$.

b) An overload test to determine the residual strength of the rear-mounted ROPS may be required, after a horizontal loading test which may have caused cracks, tears or buckling, in order to ensure adequate residual strength to resist a potential multiple upset accident. The overload test shall be carried out as follows (see Figures 15 to 17).

   1) An overload test shall be performed if the force drops by more than 3 % over the last 5 % of deflection attained while absorbing the required energy (see Figure 16).

   2) An overload test shall consist of a continuation of the horizontal loading in increments of 5 % of the original required energy up to a total of 20 % additional energy (see Figure 17).

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3) The overload test shall be considered to have been successfully completed, if, after the absorption of 5 %, 10 % or 15 % additional energy, the force drops by less than 3 % for each 5 % increment, and if the force is greater than $0{,}8F_{max}$.

4) The overload test shall be considered to have been successfully completed, if, after the absorption of 20 % additional energy, the force is greater than $0{,}8F_{max}$.

5) Additional cracks and tears and/or entry into the clearance zone or lack of protection of the clearance zone is permitted during the overload test. After removing the load, the rear-mounted ROPS shall not be in the clearance zone and shall protect the clearance zone.

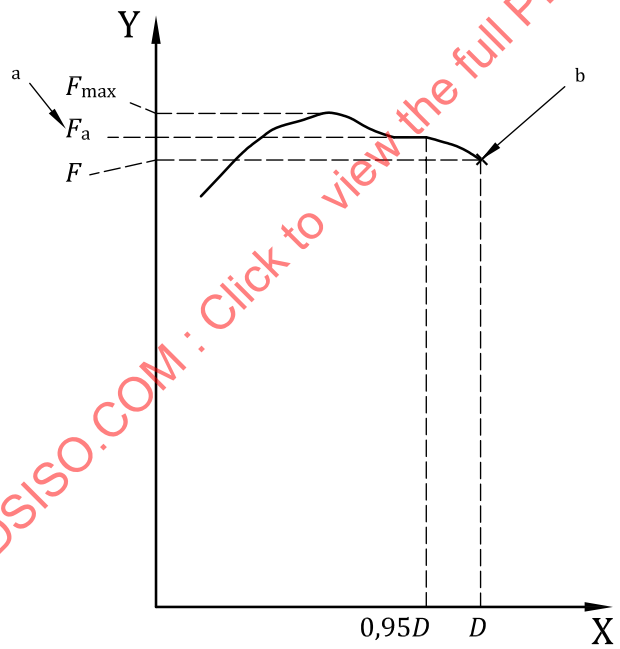
11.7 Additional conditions

11.7.1 The required force shall be sustained in both crushing tests described in 7.3 b) and c).

If an additional crushing test described in 7.7 is required, the required force of 1,2 F_v shall be sustained.

11.7.2 There shall be no protruding member or component which would be likely to cause serious injury during an overturning accident or which, through the deformation occurring, might trap the operator, for example by the leg or foot.

11.7.3 There shall be no other components presenting a serious hazard to the operator.



Key

X deflection

Y static load force

a Locate F_a in relation to 0,95D.

b Overload test not necessary as $F_a \leq 1{,}03F$.

Figure 15 — Static load force — Deflection diagram, overload test not necessary

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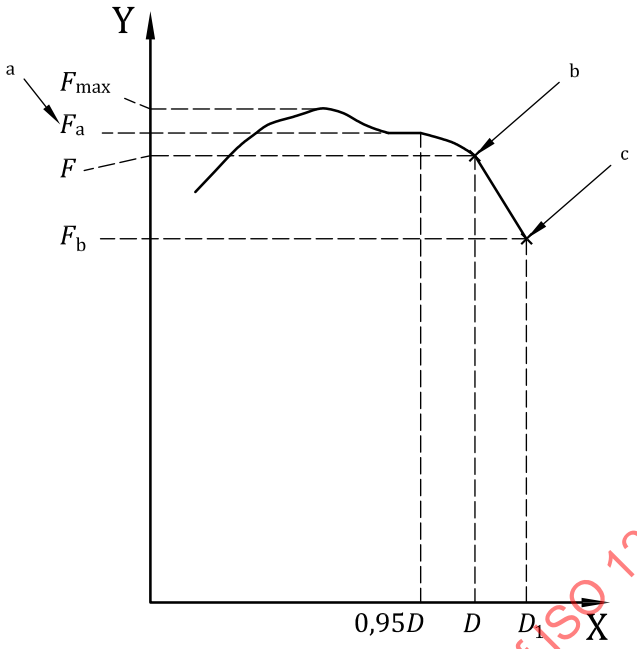

Key

X deflection

Y static load force

a Locate F_a in relation to 0,95D.

b Overload test necessary as $F_a > 1{,}03F$.

c Overload test performance satisfactory as $F_b > 0{,}97F$ and $F_b > 0{,}8F_{max}$.

Figure 16 — Static load force — Deflection diagram, overload test necessary

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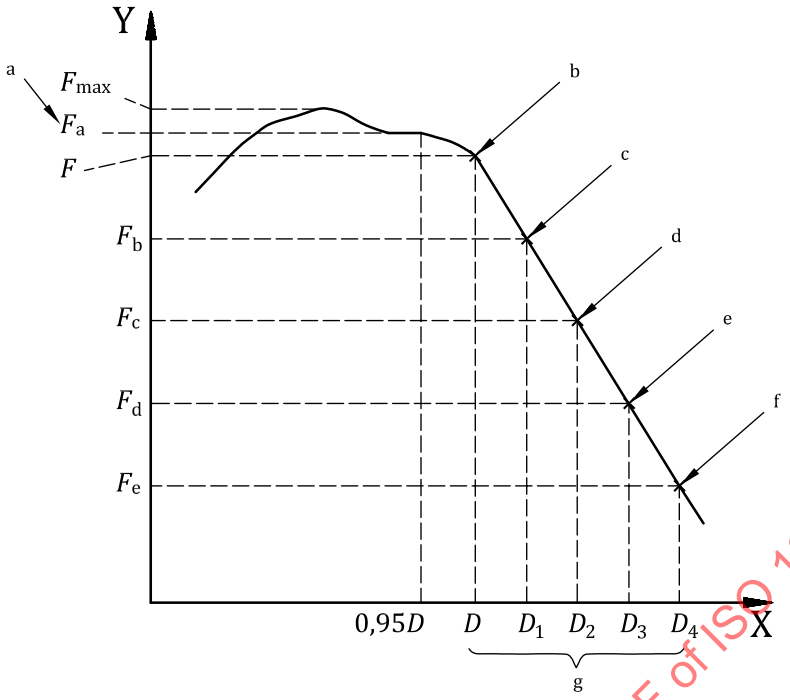

Key

X deflection

Y static load force

a Locate F_a in relation to 0,95D.

b Calculated basic energy. Overload test necessary as $F_a > 1{,}03F$.

c Energy increased by 5 %. $F_b < 0{,}97F$ therefore further overload necessary.

d Energy increased by 10 %. $F_c < 0{,}97F_b$ therefore further overload necessary.

e Energy increased by 15 %. $F_d < 0{,}97F_c$ therefore further overload necessary.

f Energy increased by 20 %. Overload test performance satisfactory, if $F_e > 0{,}8F_{max}$.

g Failure at any stage when load drops below $0{,}8F_{max}$.

Figure 17 — Static load force — Deflection diagram, continuing overload test

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11.8 Cold weather embrittlement

If the rear-mounted ROPS is claimed to have properties resistant to cold weather embrittlement, the manufacturer shall comply with the requirements and procedures in Annex A and shall provide details in the report.

12 Seatbelt anchorage test procedures

Optional procedure for testing seatbelt anchorage, if conducted, shall be in accordance with ISO 3776-2.

NOTE In some countries, seat belts are required with the ROPS protective structure providing a safety system to the operator from accidental overturning during normal operation.

13 Folding ROPS

13.1 Optional procedure for testing folding ROPS described in Annex B.

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13.2 General requirements for folding ROPS.

13.2.1 The device fitted to lock the ROPS in the upright/lowered position shall be designed:

1) to be handled by one standing operator and located in one of the accessible zones;

2) to be attached to the machine (e.g. by means of a tether);

3) to avoid any confusion in the locking operation (the proper location of the pins shall be indicated, if not obvious);

4) fitted with a holding device ensuring positive retention to avoid unintentional removing or losing of parts (e.g. a retaining pin).

If the devices employed to lock the ROPS in the upright/lowered position are pins they shall be inserted or removed freely. If to do so there is a need to apply a force on the ROPS, this shall conform with the requirements of list items 1) and 3) or 4).

13.2.2 All other locking devices shall be designed according to an ergonomic approach for what concerns the shape and the force.

13.2.3 The manual handling to raise or lower the ROPS shall not create shearing, pinching or uncontrollable movement hazards to the operator per safety distances described in ISO 13854:2017, Table 1. The safety distances shall be checked with respect to the mode of handling foreseen by the manufacturer in the operator's manual.

14 Labelling

If a label is required, it shall be durable and permanently attached to the main rear-mounted ROPS such as to be easily read. It shall be protected from damage and contain at least the following information:

a) name and address of the manufacturer or constructor of the rear-mounted ROPS;

b) identification number of the rear-mounted ROPS;

c) make, model(s) or series number(s) of the tractor(s) the rear-mounted ROPS is designed to fit;

d) a reference to this document, i.e. ISO 12003-2:2021, stating conformance with it.

15 Extension to other tractor models

15.1 Administrative extension

If there are changes in the make, denomination or marketing features of the tractor or protective structure tested or listed in the original test report, the entity that has carried out the original test may issue an “administrative extension report”. This extension report shall contain a reference to the original test report.

15.2 Technical extension

15.2.1 General

When technical modifications occur on the tractor or the protective structure, or in the means of attaching the protective structure to the tractor, the entity that has carried out the original test may issue a “technical extension report” as follows.

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15.2.2 Extension of the structural test results to other models of tractors

The loading and crushing tests need not be carried out on each model of tractor, provided that the protective structure and tractor comply with the conditions listed in 15.2.2.1 to 15.2.2.5.

15.2.2.1 The structure shall be identical to the one tested.

15.2.2.2 The required energy shall not exceed the energy calculated for the original test by more than 5 %. This 5 % limit shall also apply to extensions in the case of substituting tracks for wheels on the same tractor.

15.2.2.3 The means of attachment and the tractor components to which the attachment is made shall be identical.

15.2.2.4 Any components such as mudguards and bonnet that may provide support for the protective structure shall be identical.

15.2.2.5 The position and critical dimensions of the seat in the protective structure and the relative position of the protective structure on the tractor shall be such that the clearance zone will have remained within the protection of the deflected structure throughout all tests. [This shall be checked by using the same reference of clearance zone as in the original test report, respective to the seat index point (SIP)].

15.2.3 Extension of the structural test results to modified models of the protective structure

This applies when the provisions of 15.2.1 are not fulfilled, but shall not be used when the means of attaching the protective structure to the tractor do not follow the same principle (e.g. rubber supports replaced by a suspension device):

15.2.3.1 Modifications having no loading on the results of the initial test (e.g. weld attachment of the mounting plate of an accessory in a non-critical location on the structure), addition of seats with different SIP location in the protective structure [subject to checking that the new clearance zone(s) remain(s) within the protection of the deflected structure throughout all tests].

15.2.3.2 Modifications having a possible loading on the results of the original test without calling into question the acceptability of the protective structure (e.g. modification of a structural component, modification of the method of attachment of the protective structure to the tractor), in which case a validation test may be carried out and the test results drafted in the extension report.

15.2.4 Type extension limits

15.2.4.1 Limits for this type extension are fixed and are listed in 15.2.4.1.1 to 15.2.4.1.3.

15.2.4.1.1 No more than five extensions may be accepted without a validation test.

15.2.4.1.2 The results of the validation test will be accepted for extension if all the acceptance conditions of this document are fulfilled and if the force measured when the required energy level has been reached in the various horizontal load tests does not deviate from the force measured when the required energy has been reached in the original test by more than ±7 % and the deflection measured when the required energy level has been reached in the various horizontal load tests does not deviate from the deflection measured when the required energy has been reached in the original test report by more than ±7 %;

15.2.4.1.3 More than one protective structure modification may be included in a single extension report if they represent different options of the same protective structure, but only one validation test shall be accepted in a single extension report and the options not tested shall be described in a specific section of the extension report.

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15.2.5 Increase of the declared reference mass

An increase of the reference mass may be declared by the manufacturer for a protective structure that has already been tested. A revised test report shall state the increased reference mass after having carried out a validation test (the limits of ±7 % specified in 15.2.4.1.2 are not then applicable). The revised test report shall follow C.5.

16 Test report

The test report shall contain at least the information given in Annex C.

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Annex A
(normative)

Requirements for providing resistance to brittle fracture of rear-mounted ROPS at a reduced operation temperature

A.1 The following requirements and procedure are intended to provide strength and resistance to brittle fracture at reduced temperature. The following minimum material requirements shall be met in judging the ROPS suitability at reduced operating temperature in those countries requiring this additional operating protection.

In certain countries, testing for cold weather embrittlement according to this annex is mandatory. A partial listing of these countries is given in Table A.1.

Table A.1 — Countries which testing for cold weather embrittlement using the method described in this annex is mandatory

Country	Country Code
Canada	CA
United States	US

A.2 Bolts and nuts used to attach the ROPS to the machine frame and to connect structural parts of the ROPS shall exhibit suitable controlled reduced temperature toughness properties.

A.3 All welding electrodes used in the fabrication of structural members and mounts shall be compatible with the ROPS material as given in A.4.

A.4 Steel materials for structural members of the rear-mounted ROPS that are expected to absorb energy during ROPS testing shall be of controlled toughness and exhibiting minimum Charpy V-notch impact energy requirements as shown in Table A.2. Steel grade and quality shall be specified in accordance with ISO 630-1, ISO 630-2, ISO 630-3 and ISO 630-4.

NOTE Steel with an as-rolled thickness less than 2,5 mm and with a carbon content less than 0,2 % is considered to meet this requirement.

Structural members of the rear-mounted ROPS made from materials other than steel shall have equivalent low temperature impact resistance. Specimens shall be "longitudinal" and taken from flat stock, or tubular or structural sections before forming or welding for use in the rear-mounted ROPS. Specimens from tubular or structural sections shall be taken from the middle of the biggest side and shall not include welds.

A.5 When testing the Charpy V-Notch impact energy requirements, the specimen size shall be no less than the largest of the sizes stated in Table A.2 that the material permits.

A.6 The Charpy V-notch tests shall be carried out in accordance with the procedure in ASTM A370[1)], except that specimen sizes shall be in accordance with the dimensions given in Table A.2.

1) Reference to ASTM A370 is intended to be replaced as soon as a corresponding International Standard becomes available.

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A.7 One alternative to this procedure is to use killed or semi-killed steel for which a specification shall be provided. Steel grade and quality shall be specified in accordance with ISO 630-1, ISO 630-2, ISO 630-3 and ISO 630-4.

Table A.2 — Minimum Charpy V-notch energy requirements for ROPS material at a specimen temperature of –20 °C and –30 °C

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

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

[b] The energy requirement at the temperature –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.

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Annex B
(informative)

Folding ROPS test procedures

B.1 Optional procedure for testing folding ROPS provides minimum performance and test requirements for rear mounted foldable ROPS that are:

— raised and/or lowered manually by a standing operator (with or without partial assistance);

— locked manually or automatically.

B.2 Hand-operated foldable ROPS

B.2.1 Grasping area

B.2.1.1 The manual handling shall be done by a standing operator grasping a defined area of the ROPS. The area may be grasped from the ground or from a place to stand on the platform (see Figures B.1 and B.2). The operator may grasp the area in parallel with or in front of its trajectory. A multiple step process with multiple operator positions and multiple defined grasping areas is allowed.

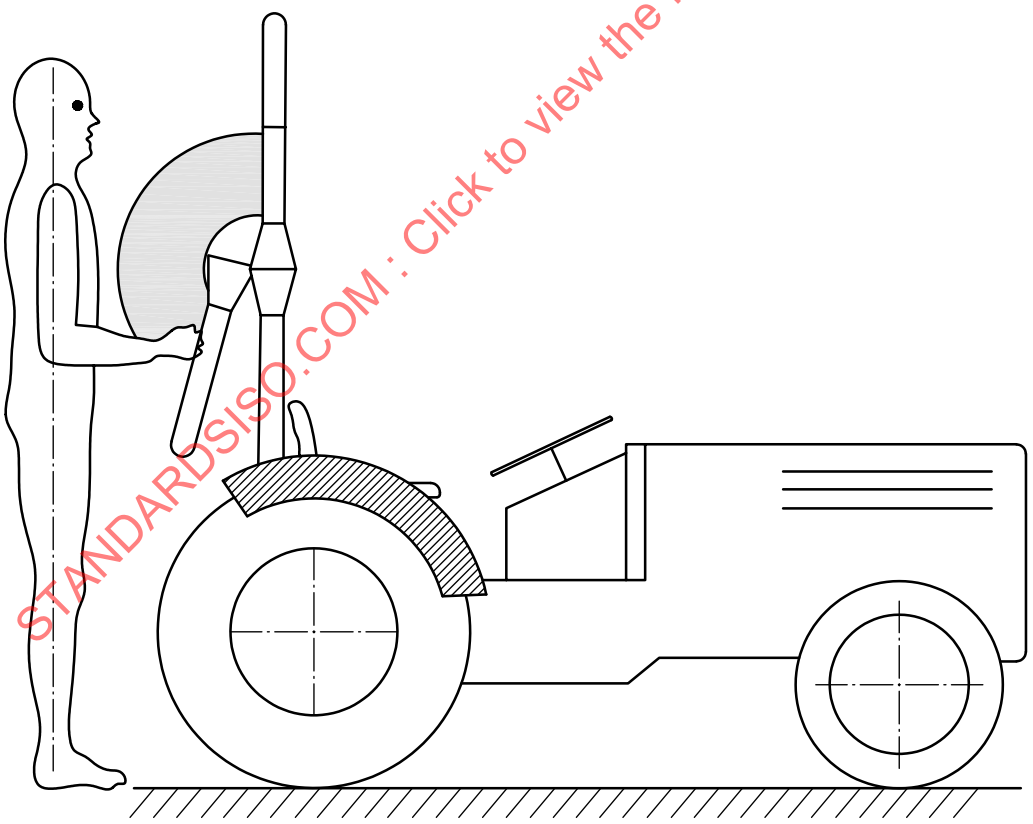

Figure B.1 — Folding from the ground

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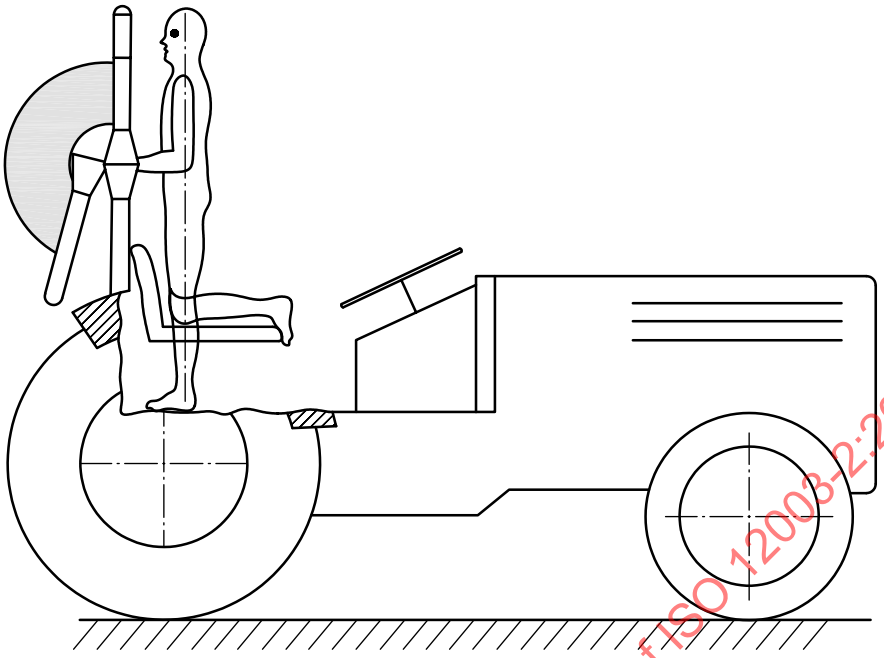

Figure B.2 — Folding from the platform

B.2.1.2 The grasping area shall be clearly and permanently identified by the manufacturer (see Figure B.3). This area shall not have sharp edges, sharp angles and rough surfaces likely to cause injury to the operator. This area may be on one or both sides of the tractor and may be a structural part of the roll-bar or additional handles. The manual handling to raise or lower the roll-bar shall not create shearing, pinching or uncontrollable movement hazards to the operator.

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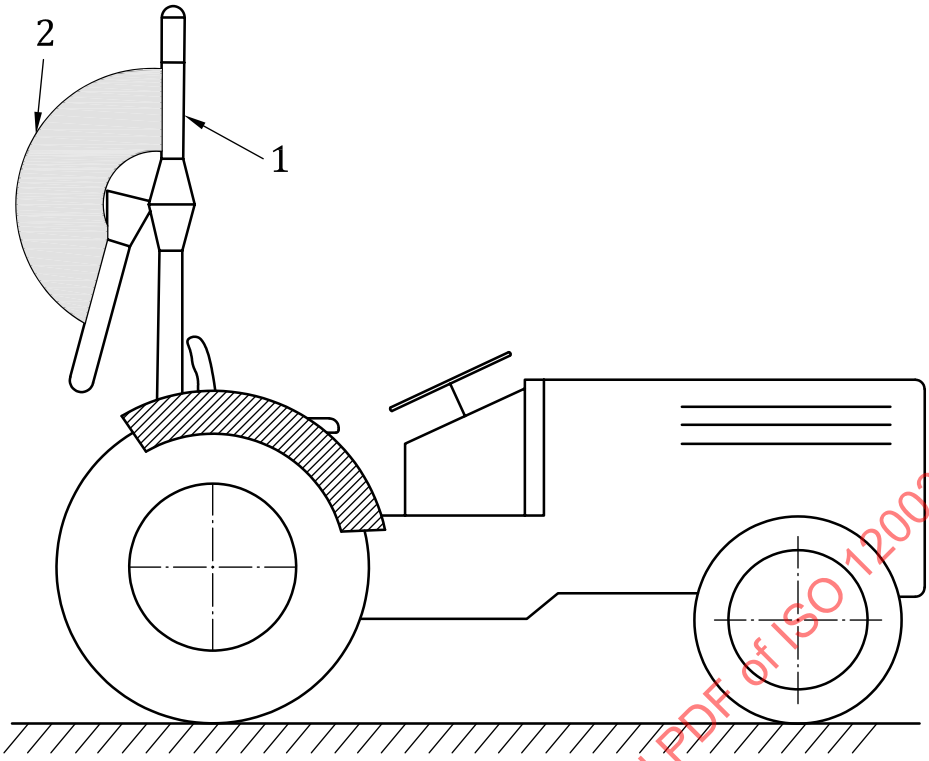

Key

1 grasping area

2 trajectory of grasping area

Figure B.3 — Grasping area

B.2.2 Accessible zones

The grasping area defined in B.2.1 shall be within three accessible zones or the envelope of different accessible zones. Each accessible zone is defined with respect to horizontal plane of the ground and the vertical planes tangent to the outer parts of the tractor that limit the position or the displacement of the operator (see Figure B.4 and Figure B.5). The grasping area is considered accessible when located within the accessible zones or the envelope of different accessible zones (see Figure B.6).

Zone I: comfort zone

Zone II: accessible zone without forward leaning of the body

Zone III: accessible zone with forward leaning of the body

NOTE The accessible zones are fixed in front of the operator and move with the operator. They are not fixed in relation to the ROPS trajectory.

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Dimensions in millimetres

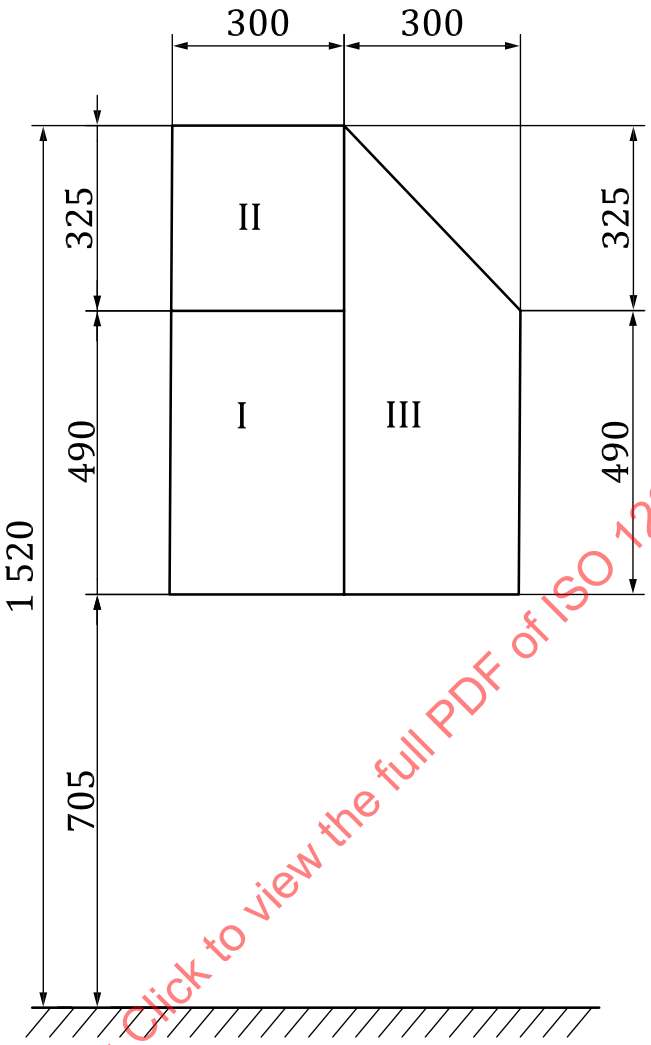

Figure B.4 — side view of accessible zone

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Dimensions in millimetres

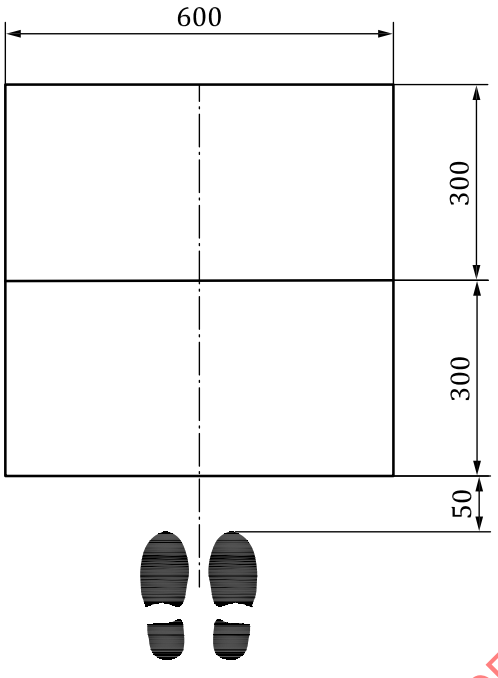
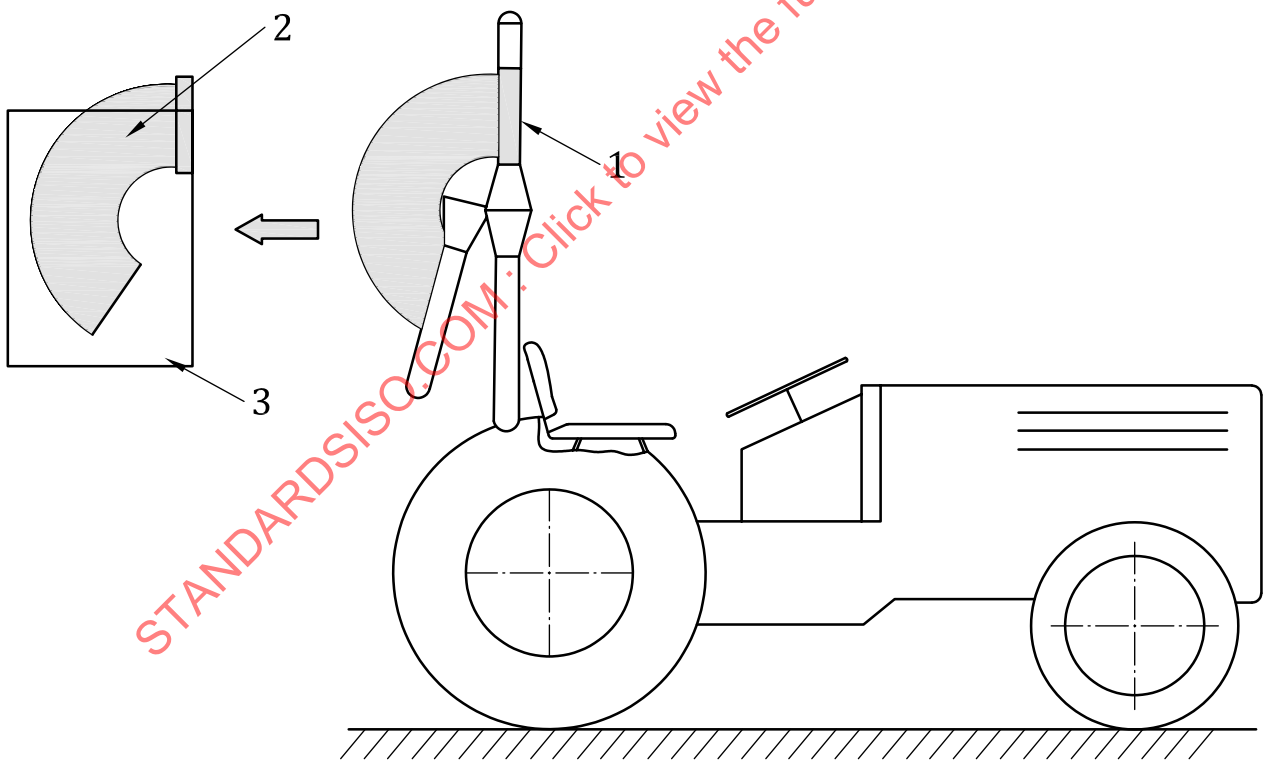


Figure B.5 — Top view of accessible zones



Key

1 trajectory of accessible grasping area
2 accessible part of grasping area
3 accessible zones

Figure B.6 — Example of accessible part of a grasping area

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B.3 Handling of the ROPS in parallel with its trajectory

B.3.1 Parts of the tractor can be obstacles to the position and movement of the operator. The obstacles are defined by the vertical planes tangent to the external edges of the obstacle.

B.3.2 Moving around obstacles while folding the roll-bar is acceptable provided:

a) re-positioning around them does not cause the grasping area to move out of the accessible zones described in B.2.2.

b) folding does not exceed the force requirements described in B.7.

B.4 Handling of the roll-bar from the platform

B.4.1 Extensions of zone II and zone III are acceptable for handling of the roll-bar in front of its trajectory (see Figure B.7) while handling from the platform. The acceptable actuation forces in these extended zones are the same as in zone II and in the zone III respectively.

Dimensions in millimetres

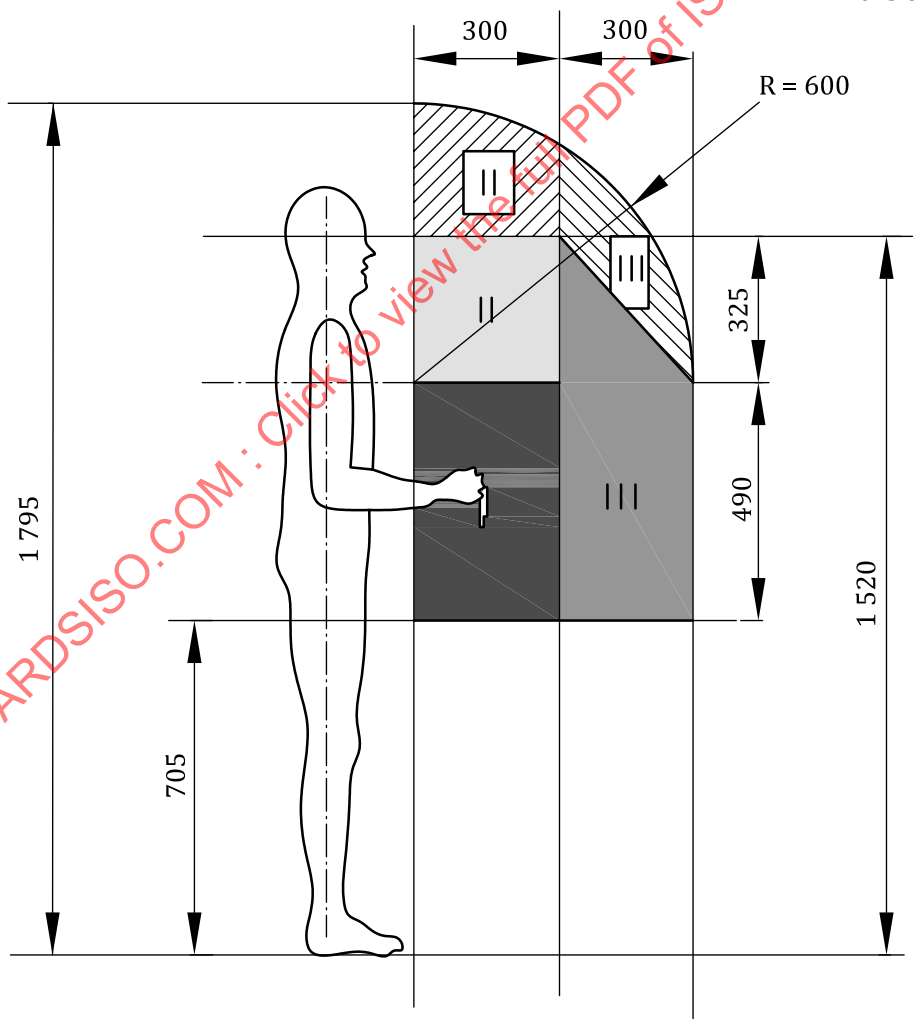

Figure B.7 — Handling of the roll-bar in front of its trajectory — Accessible zones

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B.4.2 If the operator needs to move during the manual handling of the roll-bar it shall be done so by a displacement without any obstacle within a plane parallel to the roll-bar trajectory.

In this case, the accessible area shall be considered as the envelope of the different accessible zones.

B.4.3 Place to stand

B.4.3.1 If the minimum performance and test requirements are designated to be fulfilled from the tractor platform, a location to stand on the platform shall be declared by the manufacturer and shall be accessible from the main access to the driving position and fulfil the following requirements:

— It shall be positioned so the operator can maintain stability. It shall have sufficient space for both of the operator's feet, be flat and have a slip-resistant surface.

— Handhold(s) and/or railings shall be provided in order to allow three-point contact. Parts of the machine may be considered to fulfil this requirement.

— It may consist of two separate surfaces and may use machine components. It shall be positioned so the operator can maintain stability and be on the same height level with a tolerance of ±50 mm.

B.4.3.2 The location to stand requirement may be met by providing sufficient space for one foot on a flat surface and one knee on the seat provided that the first and second bullets of B.4.3.1 are met. See Figure B.2.

NOTE It is considered that a place for standing has sufficient space if its surface is at least a square in cross section of 400 mm per side (see Figure B.8).

Dimensions in millimetres

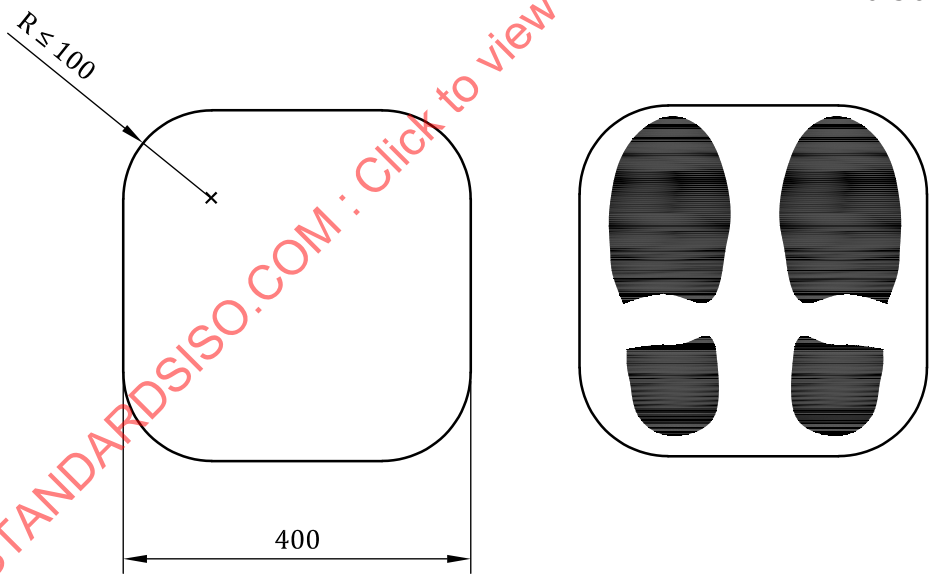

Figure B.8 — Place to stand on the platform

B.5 Folding ROPS Test conditions

The tractor shall be fitted with tyres having the greatest diameter indicated by the manufacturer and the smallest cross-section for tyres of that diameter. The tyres shall be inflated to the pressure recommended for field work. The rear wheels shall be set to the narrowest track width.

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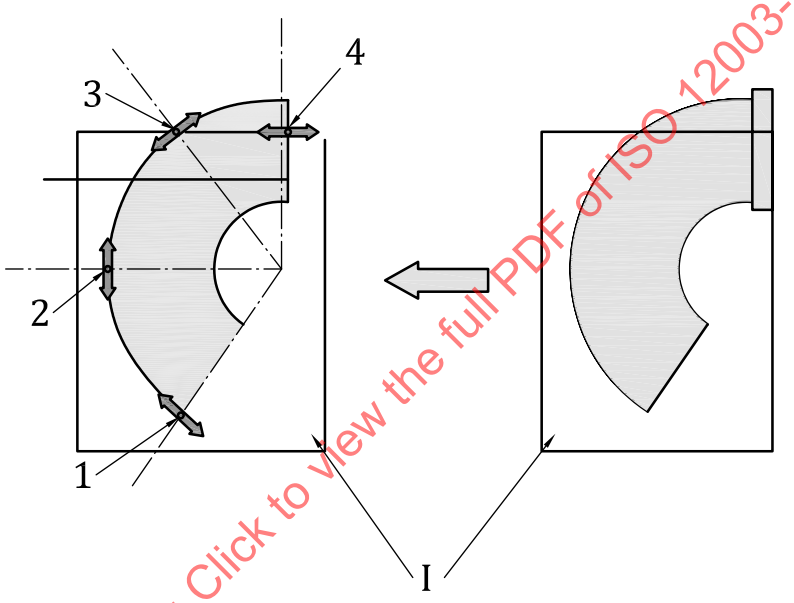
B.6 Folding ROPS Test procedure

B.6.1 The folding test shall be carried out in a slowly moving constant velocity condition sufficient to overcome static friction and achieved at a speed sufficient to provide measurable and reproducible results. Measurements shall be made at a folding speed lower than 20°/s. Each measurement of the force necessary to raise or lower the ROPS shall be made in a direction tangent to the trajectory of the ROPS and passing through the geometric centre of cross sections of the grasping area defined in B.2.1. The measured force will be the sum of dynamic friction and the weight of the ROPS not supported by the hinge.

NOTE The folding test measures the force required to fold the ROPS through its trajectory.

B.6.2 The force necessary to raise and lower the ROPS shall be measured in different points that are within the accessible part of the grasping area (see Figure B.9).



Key

1 point 1
2 point 2
3 point 3
4 point 4
I accessible zone

Figure B.9 — Points where the force requirement shall be measured

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B.6.2.1 The first measurement is carried out at the extremity of the accessible part of the grasping area when the ROPS is fully lowered (Point 1).

B.6.2.2 The second measurement is defined according to the position of Point 1 after rotation up to the point where the perpendicular to the trajectory of the ROPS is vertical (Point 2).

B.6.2.3 The third measurement is carried out after rotation of the ROPS up to the top of the accessible part of the grasping area (Point 3).

B.6.2.4 If in the third measure the roll bar is not fully raised, a point shall be measured at the extremity of the accessible part of the grasping area when the roll bar is fully raised (Point 4).

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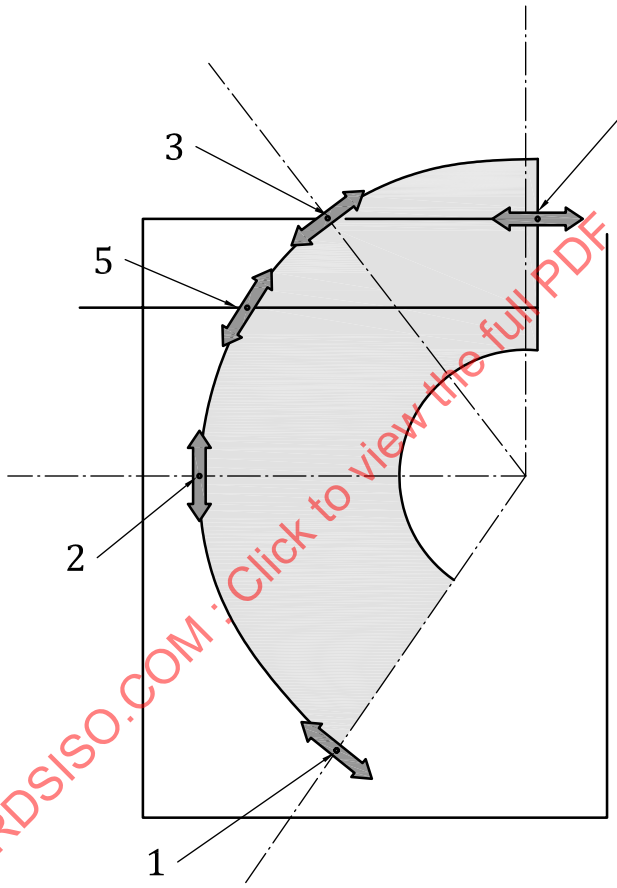
B.6.2.5 If the measurements of B.6.2.1 to B.6.2.4 do not capture the maximum force, an additional measurement shall be carried out to determine the maximum force. This measurement shall be found by slowly moving the ROPS through its trajectory and measuring the force at the grasping area.

B.6.3 If between point 1 and point 3 the trajectory of extremity of the grasping area crosses the horizontal plane between Zone I and Zone II an additional measurement shall be made at this point (see Figure B.9).

B.6.3.1 The maximum forces in these points shall not exceed the acceptable force of the zone (I, II or III).

B.6.4 In order to measure the force in the required points, it is possible either to measure directly the value or to measure the torque needed to raise or lower the ROPS so as to calculate the force.



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Key

1 point 1
2 point 2
3 point 3
4 point 4
5 point 5, additional point

Figure B.10 — Additional point where the force requirement shall be measured

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