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Tractors for agriculture and forestry — Roll-over protective structures (ROPS) — Dynamic test method and acceptance conditions

Tracteurs agricoles et forestiers — Structures de protection contre le retournement (ROPS) — Méthode d'essai dynamique et conditions d'acceptation

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Foreword

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

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 3463 was prepared by Technical Committee ISO/TC 23, *Tractors and machinery for agriculture and forestry*, Subcommittee SC 2, *Common tests*.

This fourth edition cancels and replaces the third edition (ISO 3463:1989), which has been technically revised. It also incorporates the Amendment ISO 3463:1989/Amd 1:1998.

Introduction

Testing of roll-over protective structures (ROPS) for wheeled tractors for agriculture and forestry aims at minimizing the likelihood of driver injury resulting from accidental overturning during normal operation (e.g. field work) of the tractor. The strength of the ROPS is tested by applying dynamic impact loads and a static crushing test 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 could be affected by the load imposed on the structure.

Provision is made to cover both tractors with the conventional forward facing driver's position only, as well as those with a reversible driver's position, which is in agreement with the relevant OECD test code practice. For tractors with a reversible driver's position, a clearance zone is defined to be the combined clearance zones for the two driving positions. The point of application of the side loading is determined as the mid-point between the seat index points measured in the two positions.

It is recognized that there may be designs of tractors — for example, lawn-mowers, narrow vineyard tractors, low profile tractors used in low buildings with limited overhead clearance, orchards, etc., stilt tractors and certain forestry machines such as forwarders — for which this International Standard is not appropriate.

NOTE For narrow-track wheeled tractors, see ISO 12003-1[5] and ISO 12003-2[6].

Tractors for agriculture and forestry — Roll-over protective structures (ROPS) — Dynamic test method and acceptance conditions

1 Scope

This International Standard specifies a dynamic test method and the acceptance conditions for roll-over protective structures (cab or frame) of wheeled tractors for agriculture and forestry.

It is applicable to tractors having at least two axles for wheels mounted with pneumatic tyres, or having tracks instead of wheels, with an unballasted tractor mass of not less than 600 kg, but generally less than 6 000 kg, and with a minimum track width of the rear wheels greater than 1 150 mm.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 630, *Structural steels — Plates, wide flats, bars, sections and profiles*

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

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

3 Terms and definitions

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

3.1
roll-over protective structure
ROPS
framework protecting drivers of agricultural and forestry tractors that minimizes the likelihood of driver injury resulting from accidental overturning during normal operation

NOTE 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 flat ground and that is capable of supporting the tractor in that position if the tractor overturns.

3.2
tractor mass
mass of the unladen tractor in working order with tanks and radiators full, roll-over protective structure with cladding, and any track equipment or additional front-wheel drive components required for normal use

NOTE Not included are the operator, optional ballast weights, additional wheel equipment, special equipment and loads.

3.3
reference mass
m_t
mass, not less than the tractor mass, selected by the manufacturer for calculation of the energy inputs to be used in the tests

3.4
impact test
application of a dynamic load produced by a block acting as a pendulum

3.5
crushing test
application of a vertical load through a beam placed laterally across the uppermost members of the roll-over protective structure.

3.6
longitudinal median plane
longitudinal plane of symmetry
zero Y 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

See Figure 1.

NOTE 1 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 Adapted from ISO 612:1978[1], Clause 5.

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

NOTE Normally, this plane coincides with the longitudinal median plane of the tractor.

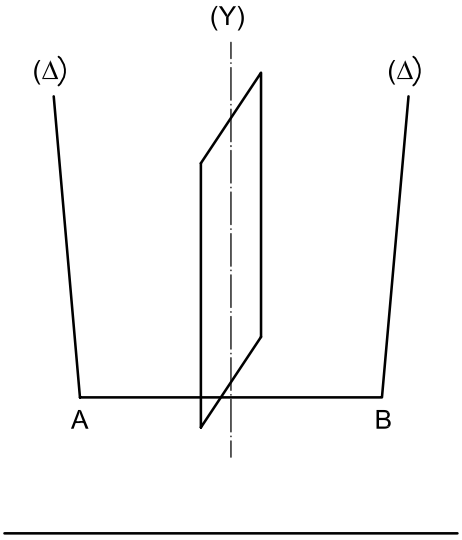


Figure 1 — Longitudinal median plane

4 Symbols and abbreviated terms

For the purposes of this document, the symbols given in Table 1 are used.

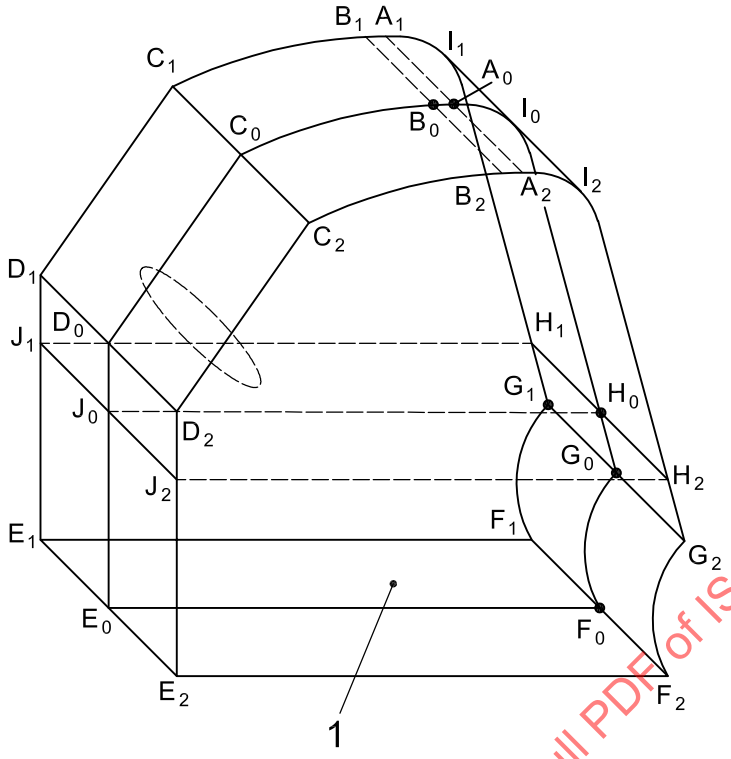
Table 1 — Symbols

Symbol	Description	Unit
a_h	Half of the horizontal seat adjustment	mm
a_v	Half of the vertical seat adjustment	mm
E	Energy input to be absorbed during the test	J
F	Static load force	N
H	Lift height of the pendulum block centre of gravity	mm
I	Moment of inertia about the rear axle excluding the rear wheels	$kg \cdot m^2$
L	Tractor reference wheel base	mm
m_t	Reference mass	kg

5 Apparatus

5.1 Clearance zone framework

Means to prove that the clearance zone has not been entered during the test: a measuring rig in accordance with Figure 2 and Figure 11 a) and b) can be used.



Key

1 seat index point (SIP)

Dimensions	mm	Remarks
A_1A_0 B_1B_0	100	Minimum
A_1A_2 B_1B_2 C_1C_2	500	
D_1D_2 E_1E_2	500	Minimum or equal to the steering-wheel radius plus 40 mm, whichever is greater
F_1F_2 G_1G_2 H_1H_2 I_1I_2 J_1J_2	500	
E_1E_0 E_2E_0	250	Minimum or equal to the steering-wheel radius plus 40 mm, whichever is greater
J_0E_0	300	
F_0G_0 I_0G_0 C_0D_0 E_0F_0	--- --- --- ---	Depending on the tractor

NOTE For other dimensions, see Figure 11 a) and b).

Figure 2 — Clearance zone measuring rig

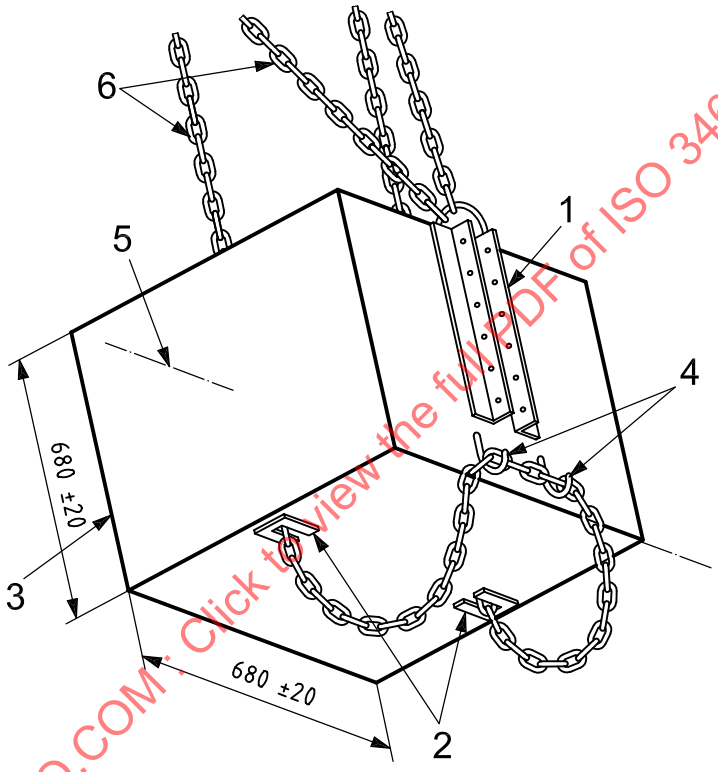
5.2 Impact test

The impact test shall be carried out by means of the elements described in 5.2.1 to 5.2.5.

5.2.1 Device for striking blow against ROPS

A pendulum block of mass of 2 000 kg. The pendulum block mass does not include the mass of the chains. The maximum chain mass shall be 100 kg. The dimensions of the block, which shall be suspended from two chains from pivot points 6 m or more above ground level, shall be as shown in Figure 3. The pendulum block centre of gravity shall coincide with its geometric centre.

Dimensions in millimetres



Key

1 attachment for release mechanism
2 height adjustment
3 impact face
4 hooks to hold spare chain
5 centre of gravity axis
6 pendulum chains

Figure 3 — Illustration of pendulum block

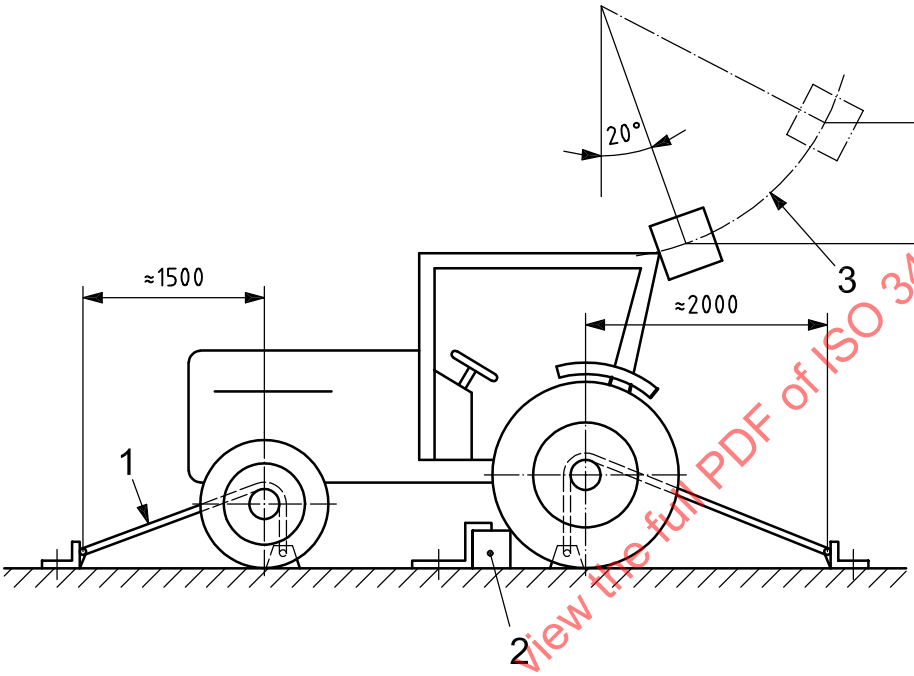
5.2.2 Means to lash the tractor to the ground

The tractor shall be lashed, by means of steel wire ropes incorporating tensioning devices, to ground rails preferably spaced approximately 600 mm apart throughout 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 approximately 2 000 mm behind the rear axle and 1 500 mm in front of the front axle. There shall be two lashings on each axle: one on each side of the median plane of the tractor. The lashings shall be steel cable of from 12,5 to 15 mm diameter, with tensile strength of from 1 100 MPa to 1 260 MPa. Details of the means are given in Figures 4, 5 and 6.

5.2.3 Softwood beam

Softwood beam, of cross-section 150 mm × 150 mm, used to restrain the rear wheels when striking from the front and rear, and to clamp against the side of the front and rear wheels when striking from the side, as shown in Figures 4, 5 and 6.

Dimensions in millimetres

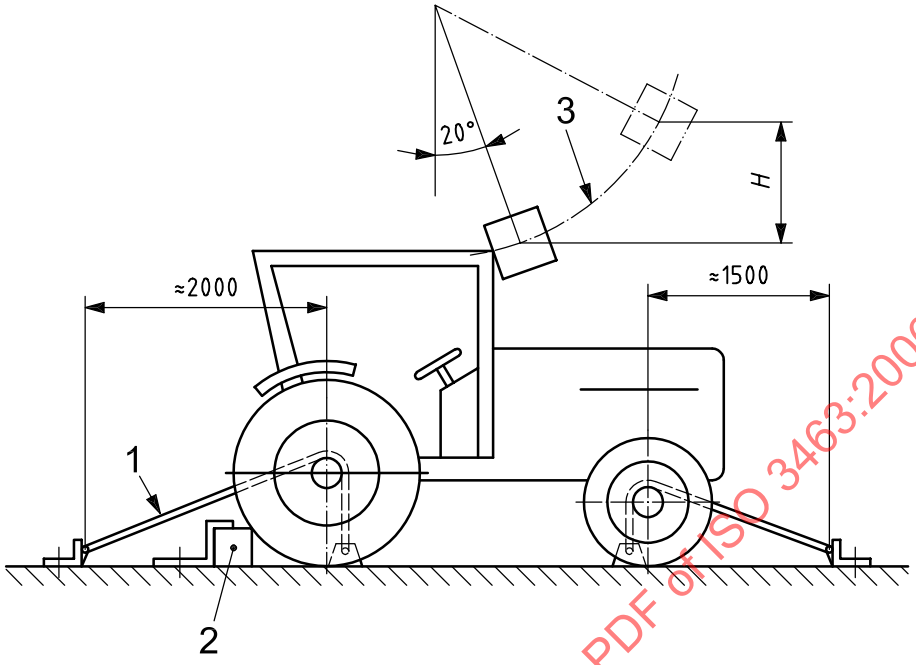


Key

1 positioning tie
2 150 mm square softwood beam clamped behind both rear wheels after anchoring
3 travel arc of pendulum block centre of gravity passing through contact point

Figure 4 — Example of lashing method — Rear impact

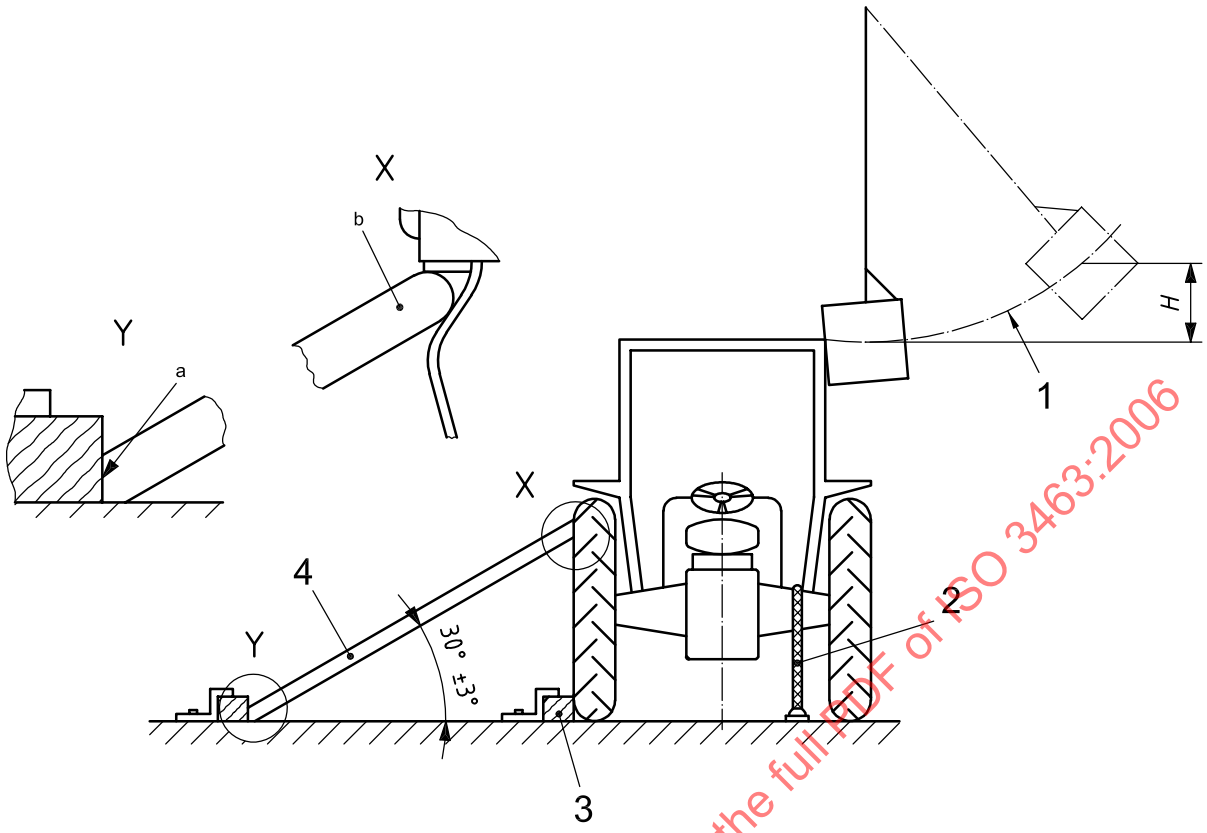
Dimensions in millimetres



Key

1 positioning tie
2 150 mm square softwood beam clamped behind both rear wheels after anchoring
3 travel arc of pendulum block centre of gravity passing through contact point

Figure 5 — Example of lashing method — Front impact



Key

1 travel arc of pendulum block centre of gravity passing through contact point
2 lashing (see 6.2.3)
3 150 mm square softwood beam
4 wooden prop
a Chamfered.
b Rounded to secure contact against rim.

Figure 6 — Example of lashing method — Side impact

5.2.4 Wooden prop

Wooden prop, used to restrain the opposite rear wheel when striking from the side as shown in Figure 6. Its length shall be 20 to 25 times its thickness and its width 2 to 3 times its thickness.

5.2.5 Device for measuring elastic deflection

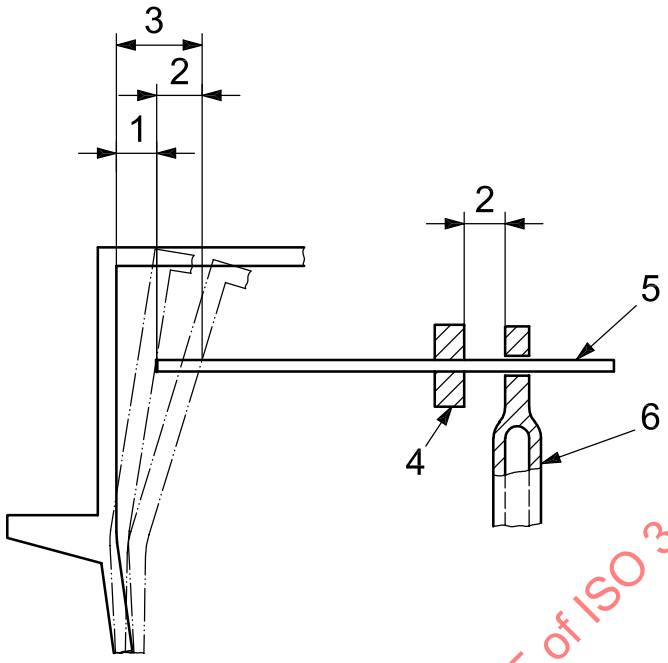
Device used to measure elastic deflection, such as that shown in Figure 7, in a horizontal plane that coincides with the upper limiting surface of the clearance zone.

5.3 Crushing tests

The crushing tests shall be carried out by means of the elements described in 5.3.1 and 5.3.2.

5.3.1 Means of applying downward force on the ROPS, such as that shown in Figure 8, including a stiff beam with a width of 250 mm.

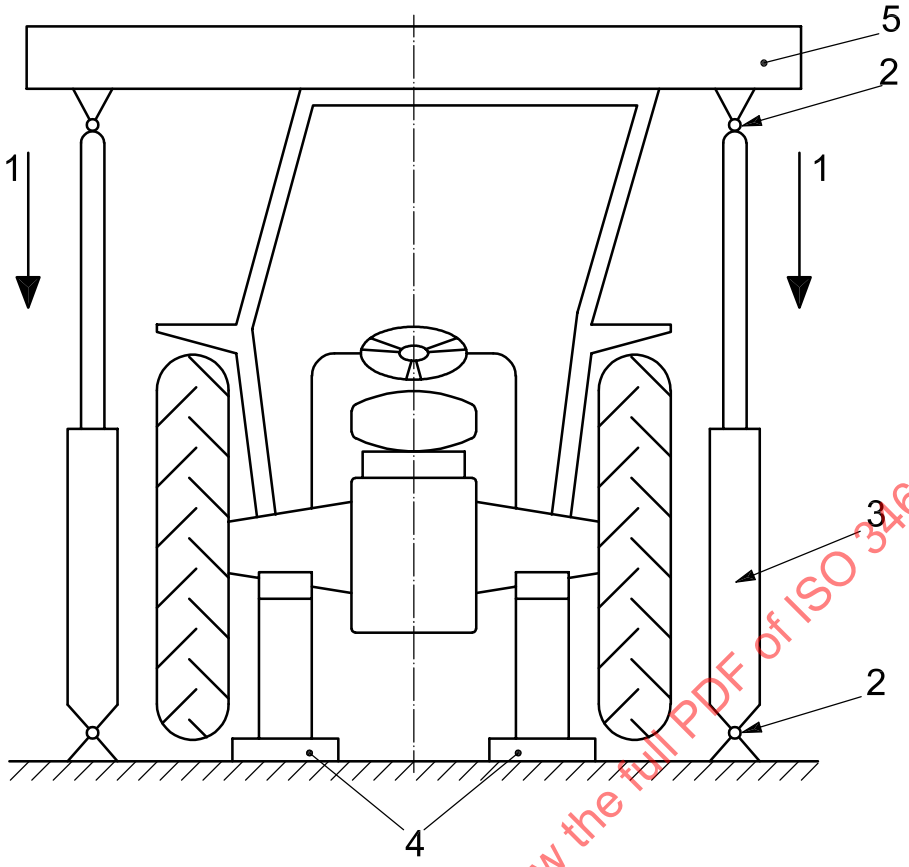
5.3.2 Equipment for measuring the total vertical force applied.



Key

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

Figure 7 — Example of device for measuring elastic deflection



Key

1 force
2 universal pin joints
3 hydraulic cylinder
4 supports under front and rear axles
5 crushing beam

Figure 8 — Example of arrangement for crushing test

6 Preparation of tractor and ROPS for testing

6.1 General

6.1.1 The roll-over protective structure 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.

6.1.2 A track width setting for the rear wheels shall be chosen such that, as far as possible, the ROPS is not supported by tyres during the test.

6.1.3 Cross-ply tyres should preferably be used.

6.1.4 The gear lever shall be in neutral and the hand-brake off.

6.1.5 All detachable 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 either be removed or fixed open for the test, so that they do not add to the strength of the protective structure. It shall be noted whether, in this position, they would create a hazard for the driver in the event of overturning.

6.2 Impact test

6.2.1 General

The position of the block and its supporting chains shall be selected so that the impact point will be at the upper edge of the roll-over protective structure and in line with the travel arc of the block centre of gravity.

The tractor shall be positioned and held securely in the area beneath the pivots so as to be struck appropriately.

The lashing attachment points shall be approximately 2 m behind the rear axle and 1,5 m in front of the front axle.

The tractor tyres shall be inflated according to the different types of tractor (water ballast shall not be used), and the lashing tightened to give deflections appropriate to the tractor type and tyre as shown in Table 2.

Table 2 — Impact tests — Deflection

Tractor type	Tyre pressure kPa	Deflection mm
Four-wheel drive with front and rear wheels of the same size:		
Front	100	25
Rear	100	25
Four-wheel drive with front wheels smaller than rear wheels:		
Front	150	20
Rear	100	25
Two-wheel drive:		
Front	200	15
Rear	100	25

6.2.2 Front and rear impact tests

The lashings shall be one on each side of both axles giving a resultant force in the plane in which the block centre of gravity will swing.

After the lashings have been tightened for the front and rear blows, a beam (see 5.2.3) shall be clamped against the appropriate wheels on the side opposite the pendulum and driven tight against them (see Figures 4 and 5).

6.2.3 Side impact test

The lashing shall be on the side of the axles adjacent to the blow.

A beam (see 5.2.3) shall be clamped against the side of the front and rear wheels opposite the pendulum and driven hard against the tyres. After lashing, a beam (see 5.2.4) shall be placed as a prop against the rear wheel rim and secured to the floor so that it is held tight against the rim during the impact, as shown in Figure 6. The beam length shall be chosen so that when in position against the rim it is at an angle of (30 ± 3)° to the horizontal.

6.3 Crushing tests

When in position for the crushing test, the tractor shall be supported under the axles so that the load applied is not carried on the wheels.

7 Test procedures

CAUTION — Some of the tests specified in this International Standard involve the use of processes which could lead to a hazardous situation.

7.1 Sequence of tests

7.1.1 For tractors with less than 50 % of the tractor mass on the front wheels, the following sequence shall be used (the subclause numbers are those in which the tests are described).

a) impact from the rear (see 7.2.1 and 7.2.2);

b) crushing at the rear (see 7.4.1);

c) impact from the front (see 7.2.1 and 7.2.3);

d) impact from the side (see 7.3);

e) crushing at the front (see 7.4.2).

7.1.2 For tractors with 50 % or more of the tractor mass on the front wheels, the following sequence shall be used (the subclause numbers are those in which the tests are described):

a) impact from the front (see 7.2.1 and 7.2.3);

b) impact from the side (see 7.3);

c) crushing at the rear (see 7.4.1);

d) crushing at the front (see 7.4.2).

7.1.3 For a tractor with a reversible driver's position, the front wheels of the tractor shall be as defined by the manufacturer and the tests shall be carried out in accordance with either 7.1.1 or 7.1.2, as appropriate. However, where the front/rear of the tractor is not clearly defined, the front wheels shall be assumed to be those carrying less than 50 % of the tractor mass and tests shall be carried out in the sequence specified in 7.1.1.

7.1.4 No repairs or straightening of any member shall be carried out between tests.

7.1.5 If a protruding member would present an inadequate area for the pendulum block, a steel plate of appropriate thickness and depth, and about 300 mm in length shall be fastened to the member such that the strength of the protective structure is not affected.

7.1.6 The energy input to be absorbed by the ROPS during the test shall be reported, calculated, in joules, by the formula:

$$E = 19{,}6H$$

7.2 Front and rear impacts

7.2.1 Positioning of tractor

For the impact tests to the rear and front, the tractor shall be positioned so that the supporting chains and the pendulum block face are at an angle of 20° to the vertical when striking the ROPS. If the angle of the roll-over protective structure member at the contact point at maximum deflection during impact is greater than 20° to the vertical, the block angle shall be further adjusted by any convenient means so that the striking face and the ROPS member are parallel at the impact point and maximum deflection, the supporting chains being at 20° to the vertical when the block strikes the roll-over protective structure.

Where the angle is greater than 20°, the adjustment of the pendulum block striking face shall be based on estimated maximum deformation.

7.2.2 Rear impact

The rear impact is not required on tractors having 50 % or more of the tractor mass on the front wheels. The rear blow shall be struck in a vertical plane parallel to the longitudinal median plane on the corner opposite to that on which the side impact (see 7.3) is made and at two-thirds of the distance from the tractor median plane to the vertical plane touching the outside extremity of the roll-over protective structure top. However, if a curve in the back of the roll-over protective structure starts at less than two-thirds of the distance from the centre, the impact shall be at the beginning of that curve, i.e. at the point where this curve is tangential to a line at right angles to the tractor median plane.

The height of the pendulum block lift shall be calculated from either of the following formulae. The choice of formula is at the manufacturer's discretion.

Alternative 1: $H = 2{,}165 \times 10^{-8} m_t L^2$

Alternative 2: $H = 5{,}73 \times 10^{-2} I$

7.2.3 Front impact

The general requirements for this test are similar to those for the rear impact. The blow shall be struck as close to the roll-over protective structure's top corner as is practicable on the same side as that on which the side impact is made (see 7.3). "As close to the corner as practicable" means a maximum of 80 mm from a vertical plane parallel to the tractor longitudinal median plane touching the outside extremity of the ROPS top. However, if a curve in the front of the roll-over protective structure starts at a distance further than 80 mm inside this vertical plane, the impact shall be struck at the beginning of the curve, i.e. at the point where this curve is tangential to a line at right angles to the median plane of the tractor.

The pendulum block lift shall be given by the following formula:

$$H = 125 + 0{,}02 m_t$$

7.3 Impact from either side

7.3.1 Positioning of tractor

For the side impact test the impact direction shall be horizontal.

The tractor shall be positioned so that the supporting chains and the pendulum block striking face are vertical when striking the roll-over protective structure. If the ROPS member angle at the contact point is not vertical, the pendulum block striking face and the ROPS structure members shall be set parallel at the impact point at maximum deflection by one additional support. The supporting chains shall remain vertical at the impact point.

In the case of non-vertical structure members, the adjustment of the pendulum block striking face shall be based on estimated maximum deformation.

7.3.2 Side impact

If it is certain that any particular member will take the initial impact when the tractor overturns sideways, the impact shall be struck against this member. Otherwise, the impact shall be struck against the highest side member and in the vertical plane perpendicular to the longitudinal median plane (see Clause 9) and 60 mm forward of the seat index point; or, for a tractor with a reversible driver's position, midway between the seat index points measured in the two driving positions. In the case where the ROPS has an offset seat and/or non-symmetrical strength, the side blow shall be on the side more likely to enter the clearance zone.

The lift height of the pendulum block shall be calculated from the following formula:

$$H = 125 + 0{,}15 m_t,$$

7.4 Crushing tests

7.4.1 Crushing at rear

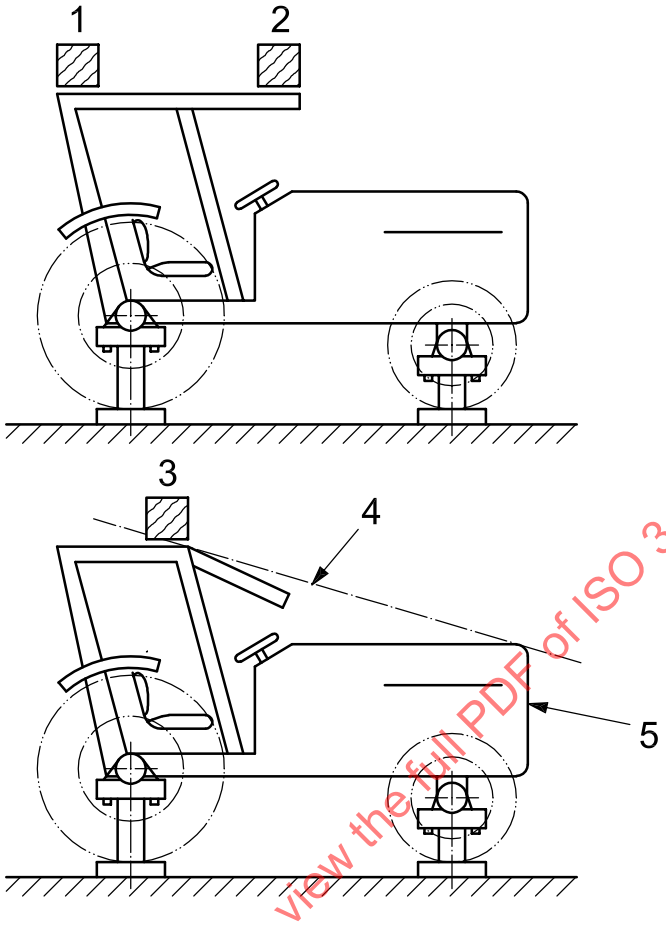
The beam shall be positioned across the rear uppermost structural members and the resultant crushing forces shall be located in the vertical reference plane. The force, F, shall be applied, where F = 20 m_t, in newtons. This force shall be maintained for at least 5 s after the cessation of any visually detectable movement of the ROPS.

Where the rear part of the roll-over protective structure's roof will not sustain the full crushing force, the force shall be applied until the roof is deflected to coincide with the plane joining the upper part of the ROPS to that part of the tractor rear capable of supporting the vehicle mass when overturned. The force shall then be removed and the tractor or loading force repositioned so that the beam is over that point of the ROPS which would then support the tractor front when completely overturned and the full force applied.

7.4.2 Crushing at front

The beam shall be positioned across the front uppermost structural members and the resultant crushing forces shall be located in the vertical reference plane. The force, F, shall be applied, where F = 20 m_t, in newtons. This force shall be maintained for at least 5 s after the cessation of any visually detectable movement of the ROPS.

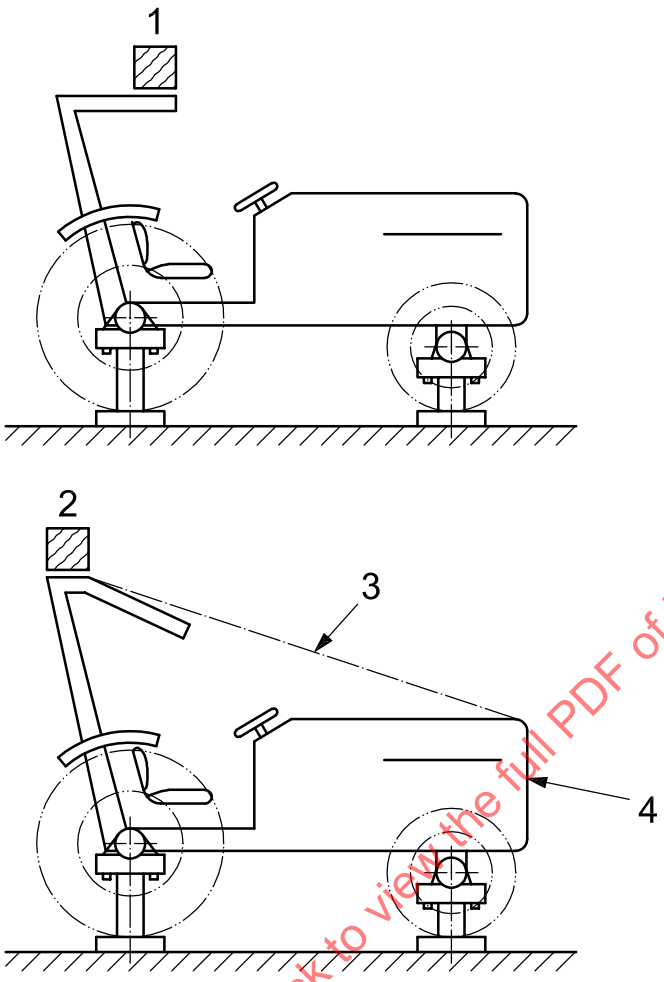
Where the front part of the roll-over protective structure's roof will not sustain the full crushing force, the force shall be applied until the roof is deflected to coincide with the plane joining the upper part of the ROPS to that part of the tractor front capable of supporting the vehicle mass when overturned. The force shall then be removed and the tractor or loading force repositioned so that the beam is over that part of the ROPS which would then support the tractor rear when completely overturned and the full force applied (see Figures 9 and 10).



Key

1 beam positioned for rear crushing test
2 beam positioned for front crushing test
3 second beam positioned for front crushing test when front part of roof will not sustain full crushing force
4 imaginary ground plane
5 part of tractor capable of supporting mass of tractor when overturned

Figure 9 — Beam in position for crushing test — Protective cab



Key

1 beam positioned for front crushing test

2 beam positioned for rear crushing test and second beam positioned for front crushing test when front part of roof will not sustain full crushing force

3 imaginary ground plane

4 part of tractor capable of supporting mass of tractor when overturned

Figure 10 — Beam in position for crushing test — Frame

8 Seat index point

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

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

9 Clearance zone

9.1 The clearance zone is illustrated in Figure 2 and in Figure 11 a) and b). 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 ROPS. The clearance zone shall be defined on the bases of 9.2 and 9.3.

9.2 The clearance zone for tractors with a non-reversible seat is defined and is bounded by the planes listed in a) to j) below; the tractor being on a horizontal surface, the seat, where adjustable, adjusted to its rear uppermost position, and the steering wheel, where adjustable, adjusted to the mid-position for seated driving.

a) A horizontal plane, $A_1B_1B_2A_2$, $(810 + a_v)$ mm above the SIP with line B_1B_2 located $(a_h - 10)$ mm behind the SIP.

b) An inclined plane, $G_1G_2I_2I_1$, 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, $A_1A_2I_2I_1$, perpendicular to the reference plane, having a radius of 120 mm, tangential to the planes defined in a) and b).

d) A cylindrical surface, $B_1C_1C_2B_2$, perpendicular to the reference plane, having a radius of 900 mm extending forward for 400 mm, and tangential to the plane defined in a) along line B_1B_2.

e) An inclined plane, $C_1D_1D_2C_2$, perpendicular to the reference plane, joining the surface defined in d) and passing 40 mm from 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, $D_1E_1E_2D_2$, perpendicular to the reference plane 40 mm forward of the external edge of the steering wheel.

g) A horizontal plane, $E_1F_1F_2E_2$, passing through a point $(90 - a_v)$ mm below the SIP.

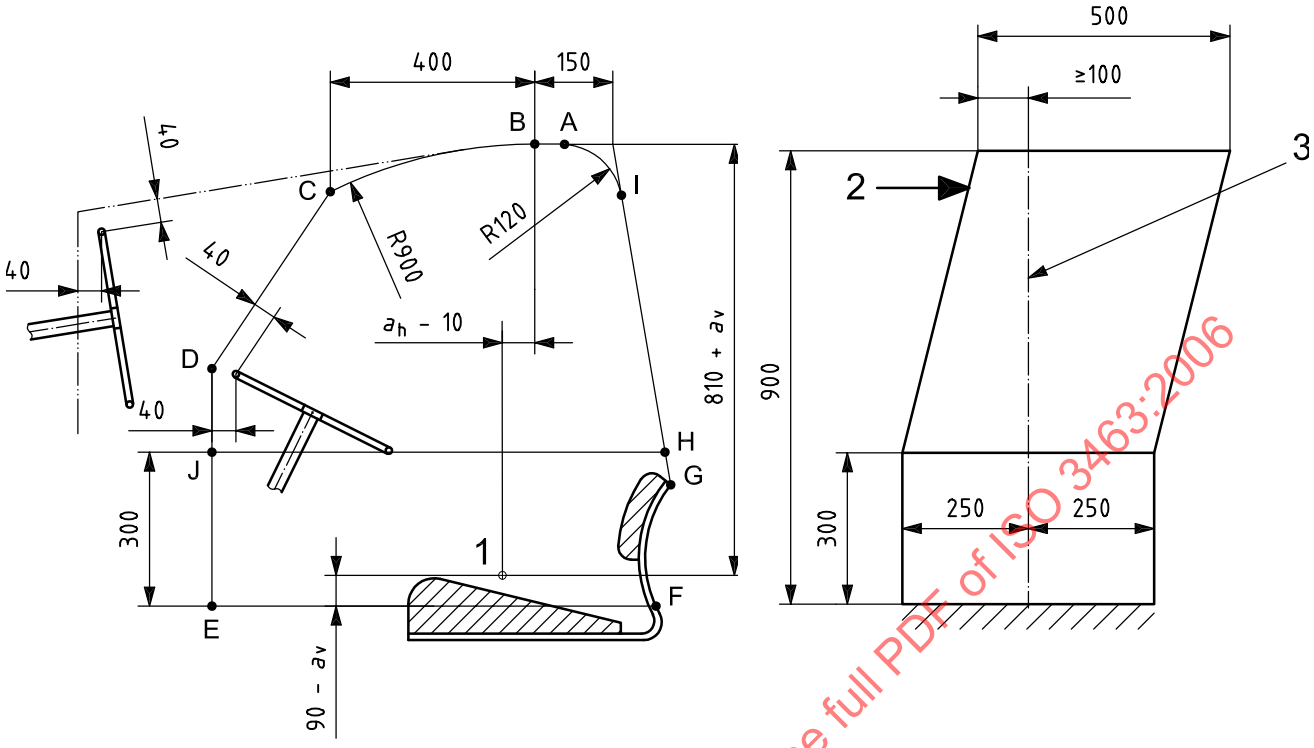
h) A surface, $G_1F_1F_2G_2$, if necessary curved from the bottom limit of the plane defined in b) to the horizontal plane defined in g), perpendicular to the reference plane, and in contact with the seat backrest throughout its length.

i) Vertical planes, $J_1E_1F_1G_1H_1$ and $J_2E_2F_2G_2H_2$. These vertical planes shall extend upwards from plane $E_1F_1F_2E_2$ for 300 mm; the distances E_1E_0 and E_2E_0 shall be 250 mm.

j) Parallel planes, $A_1B_1C_1D_1J_1H_1I_1$ and $A_2B_2C_2D_2J_2H_2I_2$, inclined so that the plane upper edge of the plane on the side on which the force is applied is at least 100 mm from the vertical reference plane.

9.3 For tractors with a reversible driver's 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.

Dimensions in millimetres



a) Section in reference plane **b) Front or rear view**

Key

1 SIP
2 force
3 vertical reference plane

Figure 11 — Clearance zone

10 Tolerances

Measurements during the tests shall be made to the following tolerances:

a) distance ± 0,5 %

b) force ± 1,0 %

c) mass ± 0,5 %

d) pressure ± 5,0 %

e) angle of pendulum block supporting chains at impact point: ± 2°

11 Acceptance conditions

11.1 General

For the ROPS to be accepted, it shall fulfil the conditions in 11.2 to 11.5 during and after the tests. On articulated tractors, the clearance zone shall remain protected at any angle of articulation of the tractor when overturned.

11.2 Clearance zone

No part shall enter the clearance zone as defined in Clause 9. No part may strike the seat during the tests. Furthermore, the clearance zone shall not be outside the protection given by the ROPS (see Note to 3.1). For this purpose, it shall be considered to be outside if any part of it would have come into contact with flat ground if the tractor had overturned towards the direction from which the blow was struck. To estimate this, the tyres and track width setting shall be the smallest standard fitting 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 into the clearance zone.

11.3 Cracks and tears

The ROPS and the tractor shall be visually examined for cracks and tears after each test. 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 ROPS, except as covered by c);

b) there shall be no cracks in welds contributing to the strength of the ROPS or its mounting components; however, spot or tack-welding used for attachment of cladding panels shall normally be excluded from this requirement;

c) energy-absorbing tears in sheet metal structures are acceptable, provided that they are judged by the test office not to have significantly reduced the resistance to deflection of the ROPS; tears in sheet metal components caused by the edge of the pendulum block shall normally be ignored.

11.4 Elastic deformation

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

11.5 Cold weather embrittlement

If the ROPS is claimed to have properties resistant to cold weather embrittlement, the manufacturer shall give details which shall be included in the report (see Clause 14).

Cold weather embrittlement properties may be verified by either performing the tests in accordance with Clause 7 at −18°C or colder, or in accordance with Annex A.

NOTE In some countries, ROPS are required to meet the cold weather embrittlement requirements of Annex A. A partial list of those countries is given in Annex A.

12 Extension to other tractor models

In the case of a ROPS which has fulfilled the conditions required for acceptance and which is designed to be used on other tractor models, the test as specified in Clause 7 need not be carried out on each tractor model, provided that the ROPS and the tractor comply with the following conditions.

a) The tractor mass (3.2) of the new tractor shall not exceed the reference mass (3.3) used in the test by more than 5 %.

b) If the lift height of the pendulum block for the impact from the rear was calculated by alternative formula 1 (see 7.2.2), the maximum wheel base shall not exceed the reference wheel base. If the lift height of the pendulum block for the impact from the rear was calculated by alternative formula 2, the maximum moment of inertia about the rear axle shall not exceed the reference moment of inertia.

c) The attachment method and the tractor components to which the attachment is made shall be identical or of equivalent strength.

d) Any components, such as mudguards and bonnet, which may provide support for the ROPS, shall be identical or judged to give at least the same support.

e) The position and critical dimensions of the seat in the ROPS and the roll-over protective structure's relative position shall be such that the clearance zone would have remained within the protection of the deflected structure throughout all the tests.

In such cases, the test report shall contain a reference to the original test report.

13 Labelling

If a label is required, it shall be durable and permanently attached to the main structure such that it can be easily read. It shall be protected from damage and shall contain at least the following information:

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

b) ROPS identification number (design or serial number);

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

d) reference to this International Standard.

14 Test report

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

Annex A
(normative)

Requirements for providing resistance to brittle fracture of ROPS at reduced operating temperature

The following requirements and procedure are intended to provide strength and resistance to brittle fracture at a reduced temperature. The following minimum material requirements shall be met in judging the roll-over protective structure's suitability at a reduced operating temperature in those countries requiring this additional operating protection. Resistance to brittle fracture at reduced temperatures may also be proved by successfully completing the dynamic test procedures specified in this International Standard at a temperature of −18° C or colder. If this method is chosen, the protective structure and all mounting hardware shall be cooled to −18° C or colder prior to beginning the dynamic test.

In certain countries, compliance with the annex is mandatory. See Table A.1.

Table A.1 — Some countries where cold weather embrittlement testing according to this annex is mandatory

Country	Country code
Canada	CA
United States	US

NOTE The requirements and procedure in A.3 and A.4 are given until suitable International Standards are developed.

A.1 Bolts and nuts used to attach the ROPS to the machine frame and to connect structural parts of the ROPS shall be property class 8.8, 9.8 or 10.9 for bolts (see ISO 898-1 [2]) and property class 8, 9 or 10 for nuts (see ISO 898-2 [3]).

A.2 All welding electrodes used in the fabrication of structural members and mounts shall be compatible with the ROPS material as given in A.3.

A.3 Steel materials for structural members of the roll-over protective structure shall be of controlled toughness material exhibiting minimum Charpy V-notch impact energy requirements according to Table A.2. Structural members that can be demonstrated to be in plane stress or are subjected to sufficiently low strain rates such that the possibility of brittle fracture is precluded in the event of a low temperature field upset need not comply with this requirement.

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

A.4 The Charpy V-notch tests shall be made in accordance with the procedure given in ASTM A370 [1)], except that specimen sizes shall be in accordance with the dimensions given in Table A.2.

A.5 One alternative to this procedure is to use killed or semi-killed steel, for which a specification shall be provided.

Table A.2 — Minimum Charpy V-notch energy requirements for ROPS material at specimen temperatures of –20ºC and –30ºC

Specimen size	Absorbed energy	
	–30º C	–20 ºC
mm	J	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 × 3,3	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 ºC is 2,5 times the value specified for –30 ºC. 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.

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

Annex B
(normative)

Test report for roll-over protective structure

B.1 General

Units shown below, according to ISO 1000 [4], shall be stated, followed by national units in parentheses if necessary.

— ROPS manufacturer's name and address:

— Submitted for test by:

— Make of ROPS:

— Model of ROPS:

— Type of ROPS: cab, frame, rear roll bar, cab with integrated frame, etc:

— Date and location of test:

B.2 Specification of test tractor

B.2.1 Identification of tractor to which ROPS is fitted

B.2.1.1 General

— Make of tractor: 2)

— Model (trade name):

— Type: 2-wheel drive or 4-wheel drive; rubber or steel tracks (if applicable); articulated 4-wheel drive or articulated 4-wheel drive with twin (dual) wheels (if applicable).

B.2.1.2 Numbers

— 1st serial no. or prototype:

— Serial no.:

B.2.1.3 **Other specifications** (if applicable)

— Model denomination(s) for other countries:

— Transmission type of gears × range:

2) Possibly different from tractor manufacturer's name.

— Speed version: 30, 40 or other: km/h

— Manufacturer identification or technical type number:

B.2.2 Tractor mass

Front	kg
Rear	kg
Total	kg

— Reference mass used for calculating impact energies and crushing forces: kg

B.2.3 Wheelbase and moment of inertia

— Wheelbase of test tractor: mm

— Moment of inertia used for calculating impact energy at the rear: $kg \cdot m^2$

B.2.4 Minimum track and tyre sizes

	Minimum track	Tyre sizes
Front	mm	
Rear	mm	

B.2.5 Tractor seat

— Tractor with reversible driver's position (reversible seat and steering wheel): Yes/No

— Make/type/model of seat:

— Make/type/model of optional seat(s) and position(s) of seat index point (SIP):

(Description of seat 1 and SIP position)

(Description of seat 2 and SIP position)

(Description of seat ... and SIP position)

B.3 Specification of ROPS

B.3.1 Photographs from side and rear showing mounting details, including mudguards.