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Tractors for agriculture and forestry — Roll-over protective structures — Static test method and acceptance conditions

Tracteurs agricoles et forestiers — Structures de protection contre le retournement — Méthode d'essai statique et conditions d'acceptation

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Foreword

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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 document 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).

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

This sixth edition cancels and replaces the fifth edition (ISO 5700:2013), which has been technically revised.

The main changes are as follows:

— updated the references to the ISO 630 series;

— replaced the ASTM A370 reference with ISO 148-1;

— tolerances have been incorporated in Clause 5 and subsequent clauses have been renumbered;

— cold weather embrittlement in subclause 10.7 has been updated;

— corrected the key table for Figure 17;

— information on clearance zone measuring rig has been moved to Annex A and subsequent annexes have been relabelled;

— removed the alternative to use killed or semi-killed steel from Annex B;

— removed Annex C Designation of Maintenance Agency.

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.

Introduction

Testing of roll-over protective structures (ROPS) for wheeled or tracked tractors for agriculture and forestry aims at avoiding or limiting risks to the driver resulting from accidental overturning during normal operation (e.g. field work) of the tractor. The strength of the ROPS is tested by applying static 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 observation to be made on the strength of the structure and the attachment brackets to the tractor and also of the tractor parts that can 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. For tractors with a reversible driver's position, a clearance zone is defined to be 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 can be tractor designs – 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 document is not appropriate.

This document specifies technical performance requirements, associated test procedures and performance test report information.

NOTE For narrow tractors, see ISO 12003-1 and ISO 12003-2.

Tractors for agriculture and forestry — Roll-over protective structures — Static test method and acceptance conditions

1 Scope

This document specifies a static test method and the acceptance conditions for roll-over protective structures (cab or frame) of wheeled or tracked tractors for agriculture and forestry as described in ISO 12934:2021, 3.2.1.

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 and a minimum track width of the rear wheels greater than 1 150 mm. It is not applicable to tractors having a mass ratio (maximum permissible mass / reference mass) greater than 1,75.

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

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 898-1, *Mechanical properties of fasteners made of carbon steel and alloy steel — Part 1: Bolts, screws and studs with specified property classes — Coarse thread and fine pitch thread*

ISO 898-2, *Fasteners — Mechanical properties of fasteners made of carbon steel and alloy steel — Part 2: Nuts with specified property classes*

ISO 3776-2, *Tractors and machinery for agriculture — Seat belts — Part 2: Anchorage strength requirements*

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

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

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 (safety cab or frame) protecting drivers of tractors for agricultural and forestry that avoids or limits risk to the driver resulting from accidental overturning during normal operation

Note 1 to entry: The ROPS is characterized by the provision of space for a clearance zone, as defined in 9.1, 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.

3.1.1
folding ROPS
ROPS (3.1) with the capability to be stowed temporarily for special operating conditions

3.1.2
tiltable ROPS
ROPS (3.1) with the capability to be tilted in whole for service

3.2
unballasted tractor mass
mass of the 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 1 to entry: 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 unballasted mass, selected by the manufacturer for calculation of the energy inputs and crushing forces to be used in the tests

Note 1 to entry: The reference mass shall not be less than the unballasted mass and must be sufficient to ensure the mass ratio does not exceed 1,75.

3.4
maximum permissible mass
technically permissible mass
maximum allowable equipment mass and allowable payload specified by the manufacturer

3.5
mass ratio
number calculated by taking the maximum permissible mass divided by reference mass

3.6
horizontal loading test
application of a horizontal load to the rear, front and side of the *roll-over protective structure* (3.1)

3.7
crushing test
application of a vertical load through a beam placed laterally across the uppermost members of the *roll-over protective structure* (3.1)

3.8
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

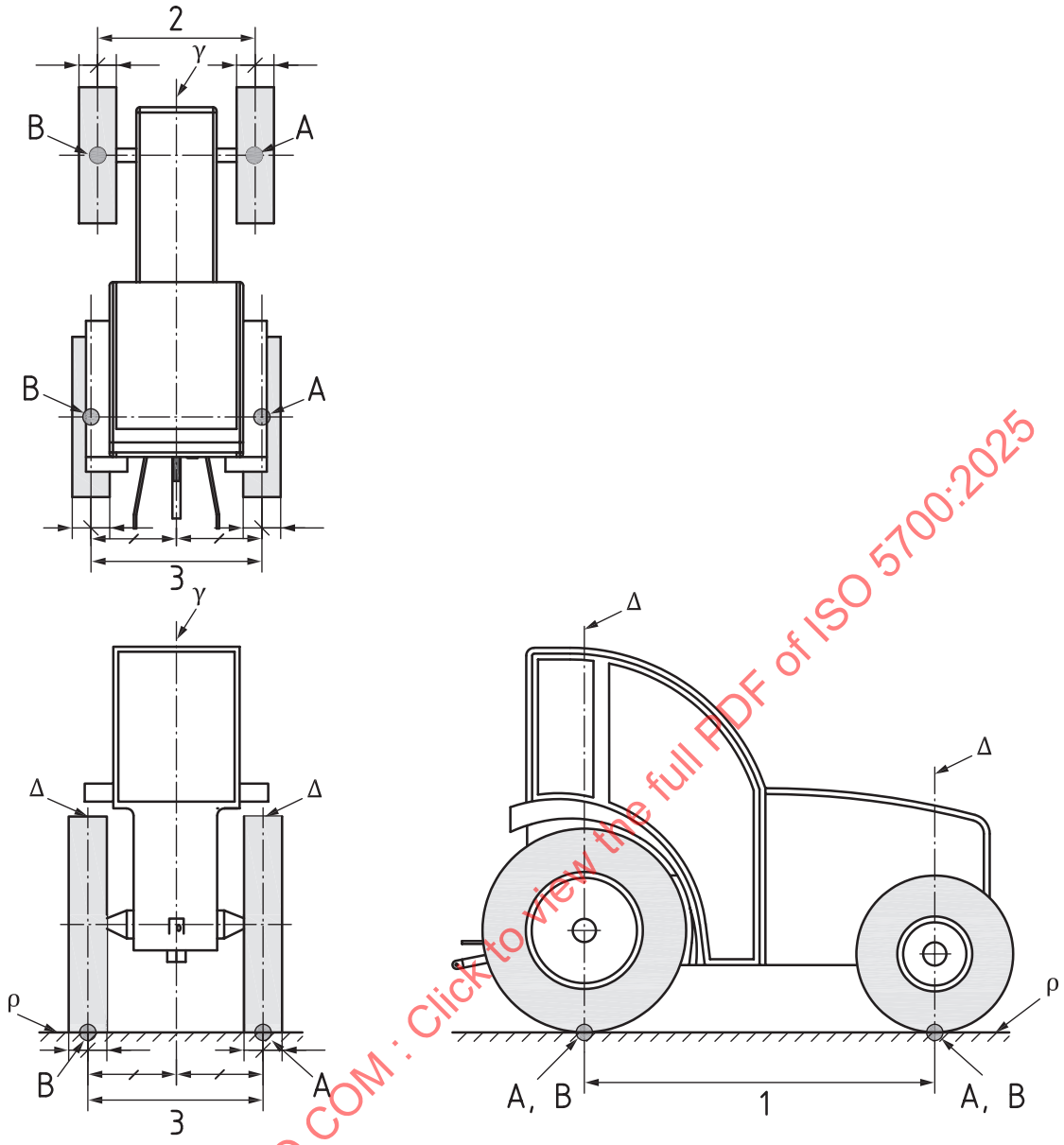
— for each wheel or track of a track-laying tractor, the vertical plane passing through its axis cuts the mid-plane of the wheel or track following a line Δ which meets the supporting surface of the vehicle at one point, and

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

See Figure 1 and Figure 2.

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

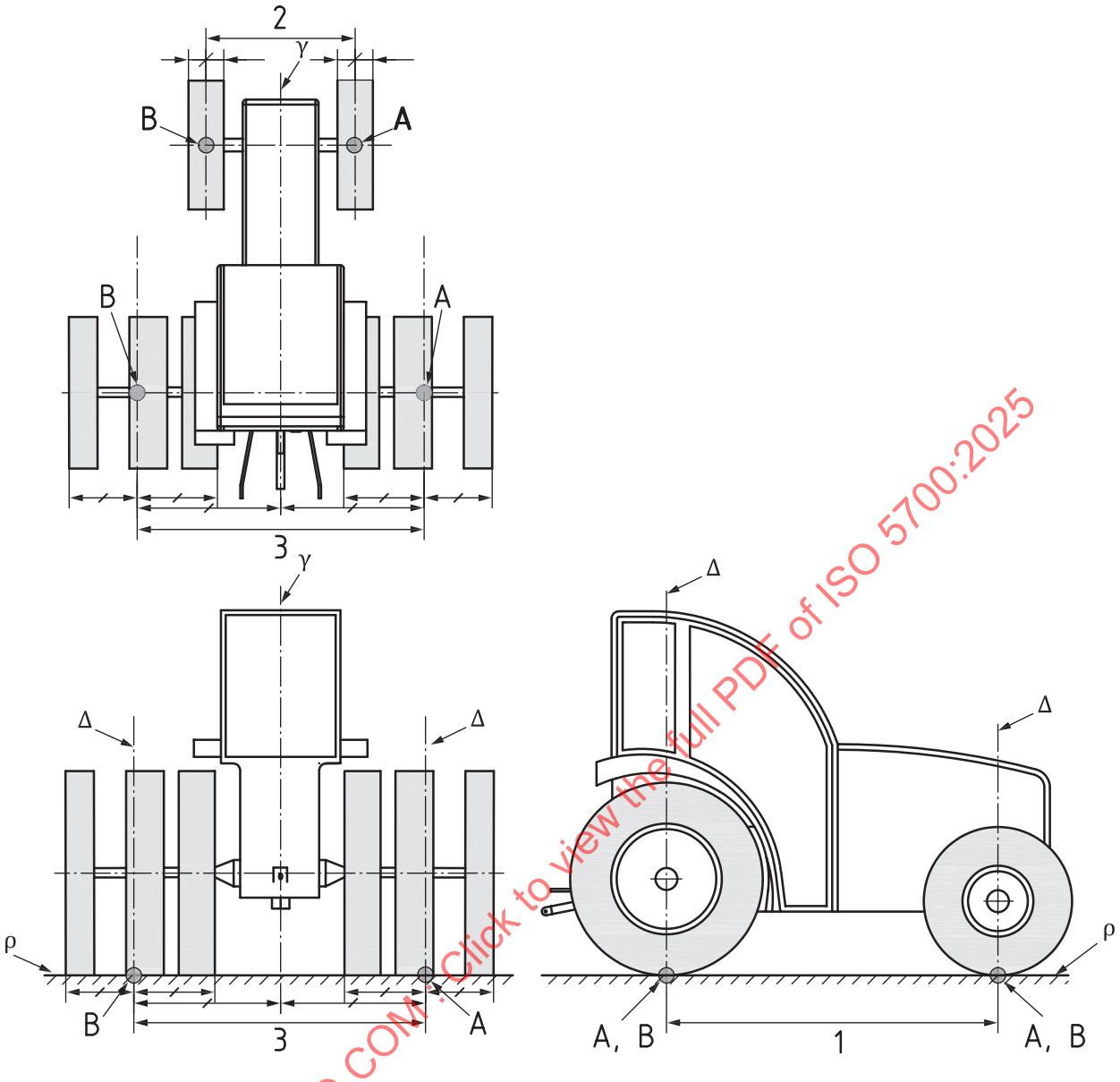
Note 2 to entry: When the longitudinal median plane is different whether the front or rear axle is used, the axle which carries the most static weight may be used to determine longitudinal median plane by convention.



Key

1	wheelbase
2	track width (one axle)
3	track width (the axle which carries the most static weight)
ρ	supporting surface
Δ	line, vertical plane through axle and mid-plane of wheel or track belt
ϒ	longitudinal median plane
A, B	point of intersection of supporting surface, vertical plane through axle and mid-plane of wheel or track belt

Figure 1 — Longitudinal median plane, track width, and wheelbase, single wheel or track



Key

1	wheelbase
2	track width (single wheels on both sides)
3	track width (multi wheels on either or both sides)
ρ	supporting surface
Δ	line, vertical plane through axle and mid-plane of wheel, track belt, or multi wheels
ϒ	longitudinal median plane
A, B	point of intersection of supporting surface, vertical plane through axle and mid-plane of wheel or track belt

Figure 2 — Longitudinal median plane, track width, and wheelbase, multiple wheels

3.9
track width
distance between the mid-planes of the wheels or tracks

Note 1 to entry: If A and B are the two points thus defined for the wheels on the same axle of the tractor, then the track width is the distance between points A and B. The track may be defined for both front and rear wheels.

Note 2 to entry: Where there are multi wheels, the track width is the distance between two planes, each of which is the mid-plane of the multi wheels.

Note 3 to entry: For track-laying tractors, the track width is the distance between the mid-planes of the tracks.

3.10
vertical reference plane
plane established before any application of loading, generally longitudinal to the tractor, passing through the seat index point (SIP) and the steering-wheel centre and which is used for establishing the resultant load point in crush loading tests

Note 1 to entry: When a steering wheel does not exist, a vertical plane passing through the SIP and parallel to the longitudinal median plane of the tractor is used.

3.11
seat reference plane
vertical plane generally longitudinal to the tractor, passing through the seat index point and to the steering wheel centre and which is used for establishing the clearance zone

Note 1 to entry: This plane is established at the beginning of the series of tests and normally coincides with the longitudinal median plane of the tractor. This plane is 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 if the latter is resiliently mounted. When a steering wheel does not exist, a vertical plane passing through the SIP and parallel to the longitudinal median plane of the tractor is used.

3.12
wheelbase
distance between the two lines AB, as defined in 3.8, one for the front wheels and one for the rear wheels

4 Symbols

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

Table 1 — Symbols

Symbol	Description	Unit
α_h	Half of the horizontal seat adjustment	mm
α_v	Half of the vertical seat adjustment	mm
D	Deflection of the ROPS for the calculated basic energy required at the point of, and in line with, the load application	mm
D'	Deflection of the protective structure for the calculated energy required	mm
E_{il1}	Energy input to be absorbed during first longitudinal loading	J
E_{il2}	Energy input to be absorbed during second longitudinal loading	J
E_{is}	Energy input to be absorbed during side loading	J
F	Static load force for the basic energy required	N
F_{max}	Maximum static load force occurring during loading (excluding overload)	N
F'	Force for the calculated energy required	N
F_f	Applied force at front in the crushing test	N
F_r	Applied force at rear in the crushing test	N
m_t	Reference mass	kg
W	Width of the ROPS	mm

5 Apparatus

5.1 Tolerances

Measurements during the tests shall be made to the following tolerances unless specified elsewhere:

a) time ±0,2 s;

b) distance ±0,5 %;

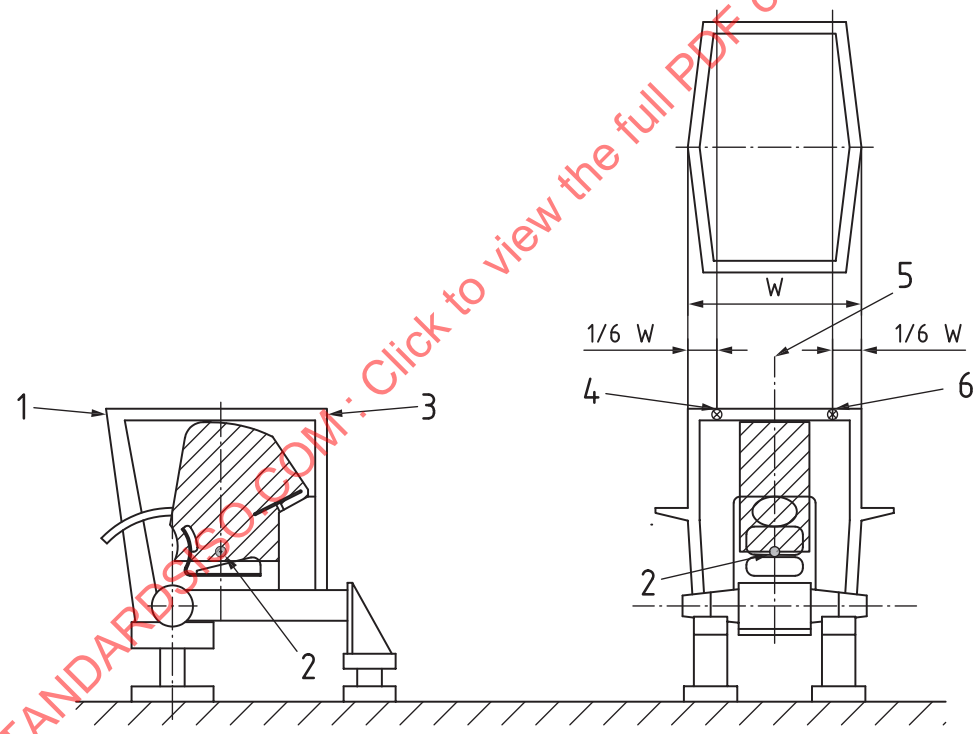
c) force ±1,0 % at maximum force measured;

d) mass ±0,5 %.

5.2 Horizontal loading tests

5.2.1 Material, equipment and attachment means for ensuring that the tractor chassis is firmly fixed to the ground and supported independently of the tyres.

5.2.2 Means of applying a horizontal force to the roll-over protective structure, such as are shown in Figure 3, Figure 4 and Figure 5, conforming with the requirements of 5.2.2.1 to 5.2.2.4.



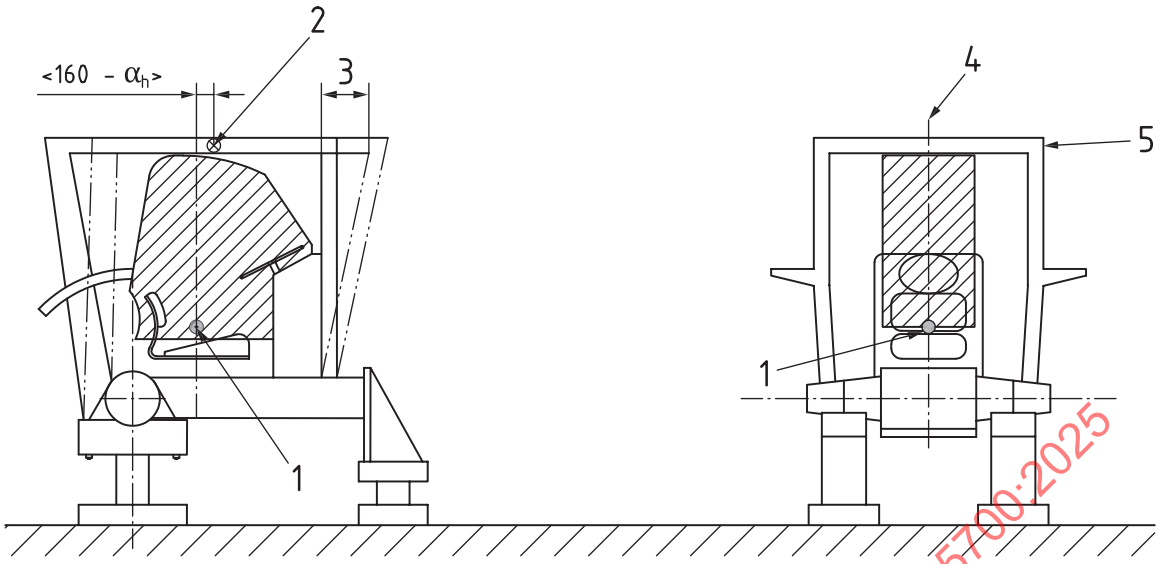
Key

1 rear load
2 seat index point
3 front load
4 second longitudinal load, front or rear
5 seat reference plane, longitudinal median plane
6 longitudinal load, rear or front

NOTE The layout illustrated is typical, but not mandatory.

Figure 3 — Front and rear load application

Dimensions in millimetres



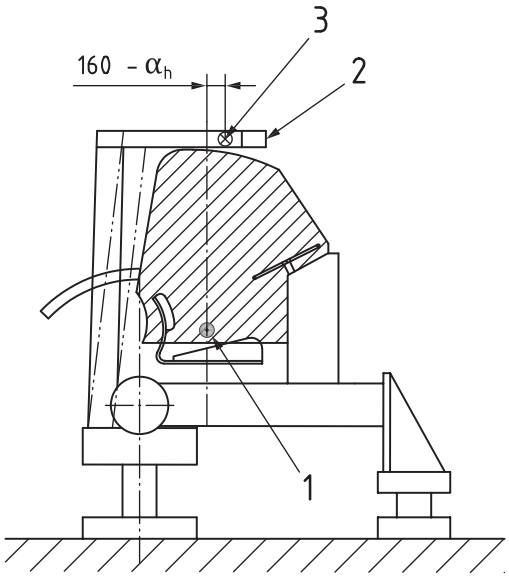
Key

1 seat index point
2 point of side load application (see 7.2.3)
3 deflection due to rear longitudinal loading
4 seat reference plane, longitudinal median plane
5 load

NOTE The layout illustrated is typical, but not mandatory.

Figure 4 — Side load application: Protective cab

Dimensions in millimetres



Key

1 seat index point

2 deflection due to rear longitudinal loading

3 point of side load application (see 7.2.3)

NOTE The layout illustrated is typical, but not mandatory.

Figure 5 — Side load application — Rear roll bar frame

5.2.2.1 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.

5.2.2.2 The edges of the beam in contact with the roll-over protective structure shall be curved with a maximum radius of 50 mm.

5.2.2.3 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.

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

5.2.3 Equipment for measuring 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.

5.2.4 Means of proving that the clearance zone has not been entered during the test. A measuring rig based on the clearance zone as shown in Figure A.1 may be used. The dimensions are given in Table A.1.

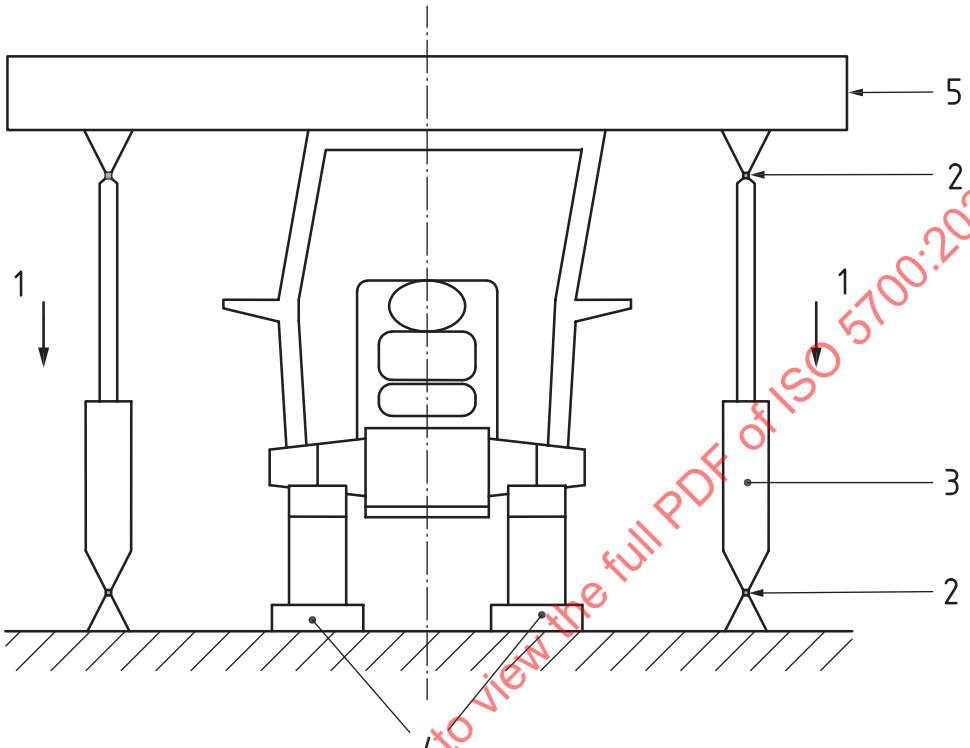
5.3 Crushing tests

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

5.3.2 Means of applying a downward force on the roll-over protective structure, such as are shown in Figure 6 including a stiff beam with a width of 250 mm ± 5 mm.

5.3.3 Means of proving that the clearance zone has not been entered during the test. A measuring rig based on the clearance zone as shown in Figure A.1 may be used.

5.3.4 Equipment for measuring the total vertical force applied.



Key

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

NOTE The layout illustrated is typical, but not mandatory.

Figure 6 — Example of arrangement for crushing test

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, test engineers may verify 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. Alternatively, more than one protective structure may be tested for any one model of tractor.

NOTE See Clause 13 for applicability to other tractor models.

6.3 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 to form 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, should 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 If the ROPS being tested is a folding or tiltable ROPS, the ROPS shall be placed in the position that provides protection to the operator in the event of an overturn prior to testing.

7 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 Sequence of tests

7.1.1 General

The test shall be carried out in accordance with the procedures given in 7.1.2 to 7.1.6 in the sequence as given.

To carry out the longitudinal loading test, it is necessary to first determine the side loading direction 7.1.4 to know where the longitudinal load should be applied.

7.1.2 First longitudinal loading

For a tractor with at least 50 % of its tractor mass on the rear wheels and for track-laying tractors, the longitudinal loading shall be applied from the rear. For other tractors the longitudinal loading shall be applied from the front.

7.1.3 First crushing test

The first crushing test shall be applied at the same end of the ROPS as the longitudinal loading.

7.1.4 Loading from the side

In the case of an offset seat and/or non-symmetrical strength of the ROPS, the side loading shall be on the side most likely to lead to entering of the clearance zone.

7.1.5 Second crushing test

The second crushing test shall be applied at the opposite end of the ROPS to the longitudinal loading. In the case of two-post designs, it may be at the same point as in 7.1.3.

7.1.6 Second longitudinal loading

A second longitudinal loading shall be applied to tractors fitted with a ROPS designed to be folded/tilted when the longitudinal loading in 7.1.2 has not been applied in the direction in which the ROPS is designed to fold/tilt. The second longitudinal loading does not apply to tiltable ROPS where the tilt mechanism is independent from the structural integrity of the ROPS.

7.2 Horizontal loading from rear, front and side

7.2.1 General requirements for horizontal loading tests

7.2.1.1 The loads applied to the ROPS shall be distributed by means of a stiff beam, in accordance with the requirements of 5.2.2, located normal to the direction of load application; the stiff beam may have a means of preventing its being displaced sideways. The rate of load application shall be such that the rate of deflection does not exceed 5 mm/s. Once the initial application has commenced, the load shall not be reduced until the test has been completed; but it is permissible to cease increasing the load if desired, for example, to record measurements.

7.2.1.2 The direction of the applied force shall be within the following limits:

— at start of test (no load), ±2°;

— during test (under load), 10° above and 20° below the horizontal.

7.2.1.3 If no structural cross-member exists at the application point, a substitute test beam which does not add strength to the structure may be used to complete the test procedure.

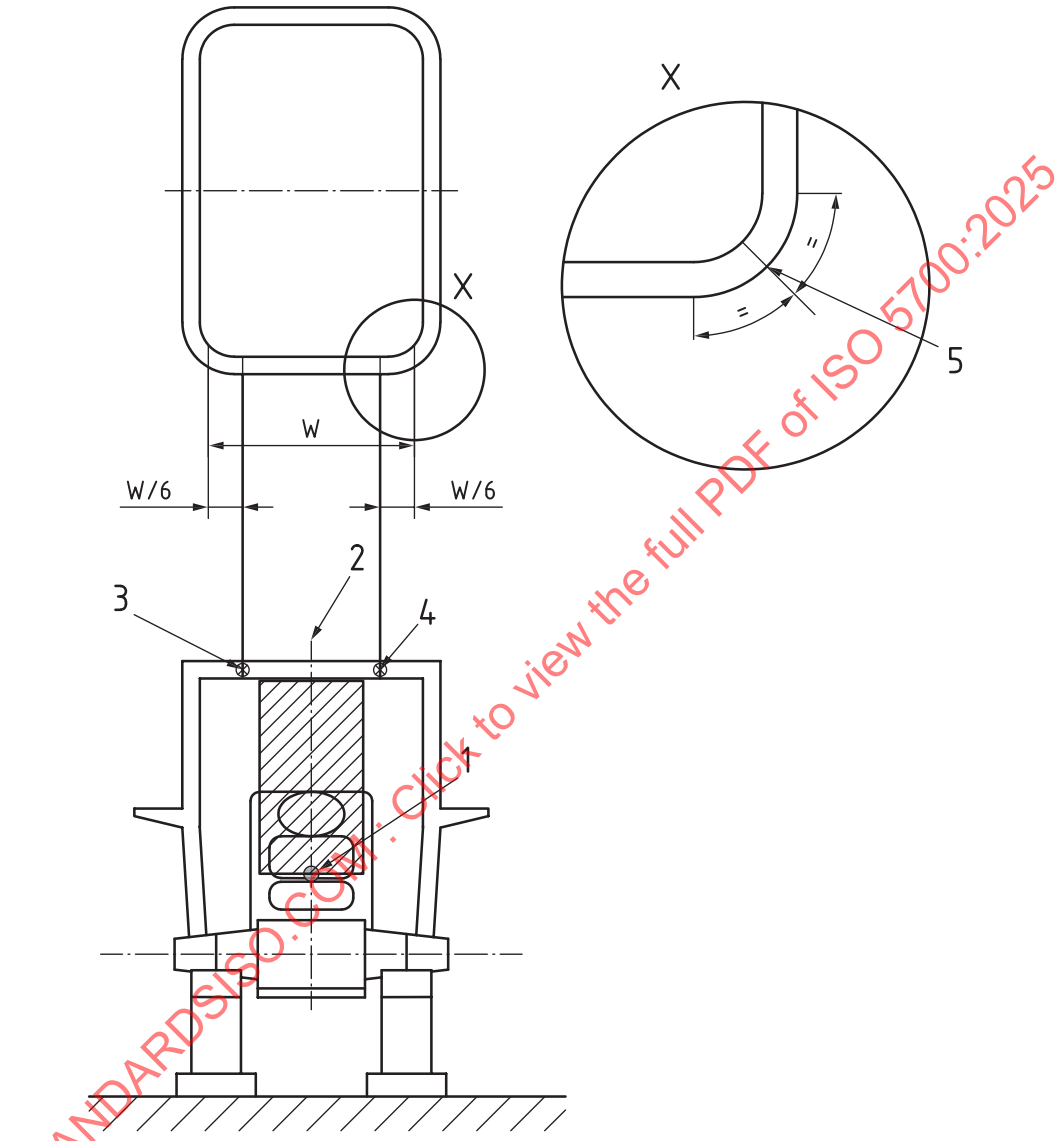
7.2.2 First longitudinal loading

7.2.2.1 The load shall be applied horizontally and parallel to the longitudinal median plane of the tractor from the rear or the front as required by 7.1.2. If from the rear, it shall be applied to the opposite side to that to which the side load is applied. If from the front, it shall be to the same side as the side load.

7.2.2.2 The load shall be applied to the uppermost transverse structural member of the ROPS (i.e. that part which would be likely to strike the ground first in an overturning accident).

7.2.2.3 The load application point shall be at one-sixth of the width of the roll-over protective structure's top, inwards from the outside corner. The width of the ROPS shall be taken as the distance between two lines parallel to the longitudinal median plane of the tractor and touching the outside extremities of the ROPS in the horizontal plane touching the top of the uppermost transverse structural members.

7.2.2.4 In the event that the ROPS is formed of curved members and no appropriate corners exist, the following general procedure shall apply for determining W. The test engineer shall identify the curved member most likely to first strike ground in the event of an asymmetrical rear or front overturn (e.g. an overturn to the front or rear where one side of the ROPS is likely to bear the initial loading). The end points of W shall be the mid-points of the external radii created between other straight or curved members which form the uppermost ROPS structure. In the event that multiple curved members can be selected, the test engineer shall establish ground lines for each possible member to determine which surface is most likely to strike ground first. See Figure 7 and Figure 8 for examples.

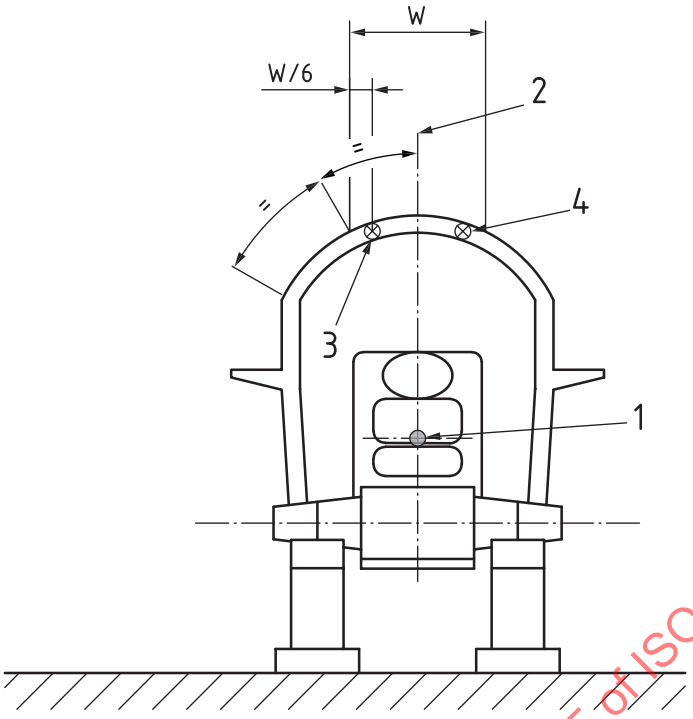


Key

1 seat index point (SIP)
2 seat reference plane, longitudinal median plane
3 point of second longitudinal load application, front or rear
4 point of longitudinal load application, rear or front
5 end point of *W*

NOTE The layout illustrated is typical, but not mandatory.

Figure 7 — Example of *'W'* for ROPS with curved members: 4-post ROPS



Key

1 seat index point (SIP)
2 seat reference plane, longitudinal median plane
3 point of second longitudinal load application, front or rear
4 point of longitudinal load application, rear or front

NOTE The layout illustrated is typical, but not mandatory.

Figure 8 — Example of '*W*' for ROPS with curved members: 2-post ROPS

7.2.2.5 The beam length shall be not less than one-third of the roll-over protective structure's width *W* as described in 7.2.2.4 and not more than 49 mm over this minimum.

7.2.2.6 The test shall be stopped when

a) the strain energy absorbed by the ROPS is greater than or equal to the required input energy, E_{il1}, in joules, where

$$E_{il1} = 1,4 \cdot m_t$$

or

b) the ROPS enters the clearance zone (see Clause 9) or leaves it unprotected.

7.2.3 Loading from side

7.2.3.1 The load shall be applied from the side horizontally normal to the longitudinal median plane. It shall be applied to the roll-over protective structure's upper extremity at a point (160 – α_h) mm (see Figure 4 and Figure 5) forward of the SIP (see Figure 4 and Figure 5, and Clause 8), or, for a tractor with reversible driver's position, midway between the SIPs measured in the two driving directions.

7.2.3.2 If it is certain that any particular part of the cab side will touch the ground first when the tractor overturns sideways, the loading shall be applied at that point, provided that this permits uniform load

distribution as specified in 7.2.1. In the case of a two-post structure, side loading shall be applied at the structural member uppermost on the side, regardless of the SIP.

7.2.3.3 The beam length shall be as long as practicable, subject to a maximum of 700 mm.

7.2.3.4 The test shall be stopped when

a) the strain energy absorbed by the ROPS is greater than or equal to the required input energy, E_{is}, in joules, where

$$E_{is} = 1{,}75 \cdot m_t$$

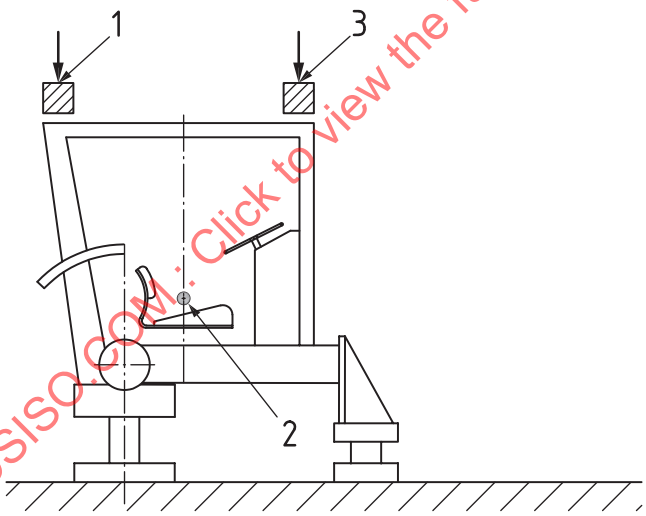
or

b) the ROPS enters the clearance zone (see Clause 9) or leaves it unprotected.

7.3 Crushing tests

7.3.1 Crushing at rear

7.3.1.1 The beam shall be positioned across the rear uppermost structural members (see Figures 9 and 10) and the resultant crushing forces shall be located in the vertical reference plane. The force, F_r, shall be applied, where $F_r = 20\ m_t$, in newtons. This force shall be maintained for at least 5 s after the cessation of any visually detectable movement of the ROPS.

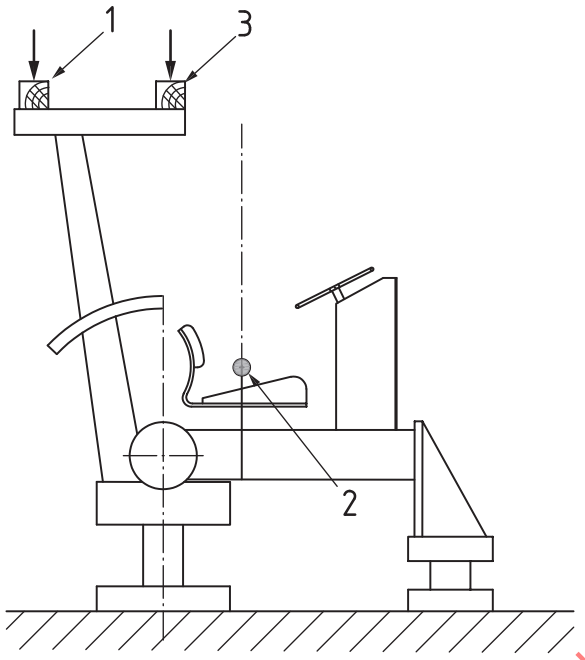


Key

1 position of beam for rear crushing test
2 seat index point
3 position of beam for front crushing test

NOTE The layout illustrated is typical, but not mandatory.

Figure 9 — Position of beam for front and rear crushing tests on 4-post ROPS



Key

1 position of beam for rear crushing test

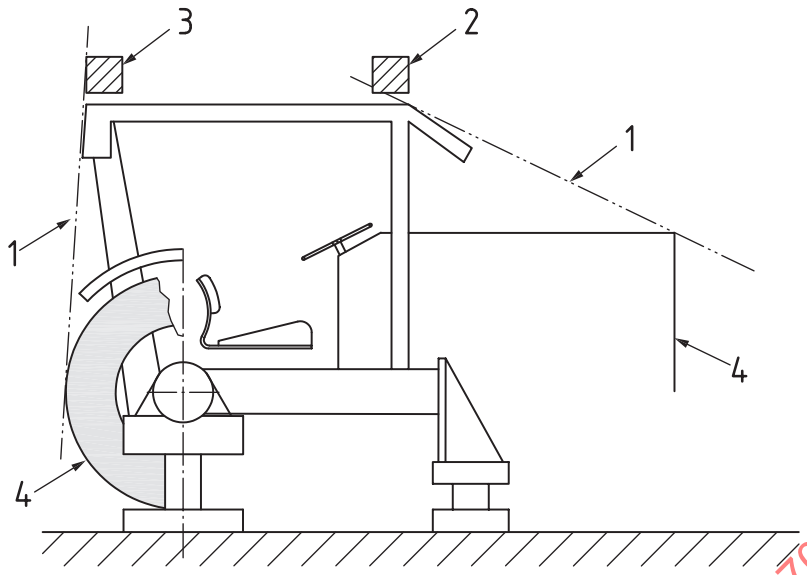
2 seat index point

3 position of beam for front crushing test

NOTE The layout illustrated is typical, but not mandatory.

Figure 10 — Position of beam for front and rear crushing tests on 2-post ROPS

7.3.1.2 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. See Figures 11 and 12. 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.



Key

1 imaginary ground plane

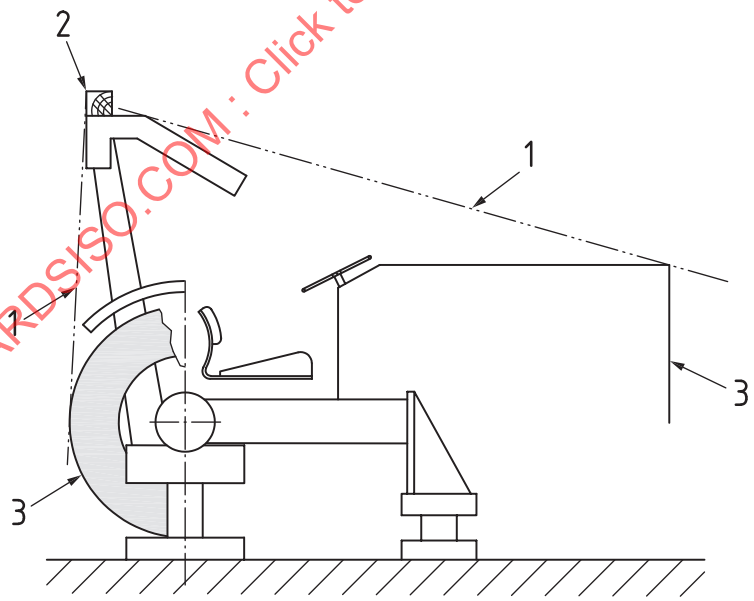
2 second position of the beam for front crushing test where the front part of the roof will not sustain the full crushing force

3 second position of the beam for rear crushing test where the rear part of the roof will not sustain the full crushing force

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

NOTE The layout illustrated is typical, but not mandatory.

Figure 11 — Application of imaginary ground plane for front and rear crushing tests on 4-post ROPS



Key

1 imaginary ground plane

2 second position of the beam for crushing test where the part of the roof will not sustain the full crushing force

3 part of the tractor capable of supporting the mass of the tractor when overturned

NOTE The layout illustrated is typical, but not mandatory.

Figure 12 — Application of imaginary ground plane for front and rear crushing tests on 2-post ROPS

7.3.2 Crushing at front

7.3.2.1 The beam shall be positioned across the front uppermost structural members (see Figures 9 and 10) and the resultant crushing forces shall be located in the vertical reference plane. The force, F_f, shall be applied, where $F_f = 20\ m_t$, in newtons. This force shall be maintained for at least 5 s after the cessation of any visually detectable movement of the ROPS.

7.3.2.2 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. See Figures 11 and 12. 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 rear when completely overturned and the full force applied.

7.4 Second longitudinal loading

7.4.1 The second longitudinal loading shall be applied in the opposite direction to, and at the corner furthest from, the longitudinal loading according to 7.2.2, but otherwise in accordance with 7.2.1.

7.4.2 The test shall be stopped when

a) the strain energy absorbed by the protective structure is greater than or equal to the required input energy, E_{il2}, in joules, where

$$E_{il2} = 0{,}35 \cdot m_t$$

or

b) the ROPS enters the clearance zone (see Clause 9) or leaves it unprotected.

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

8.1 Seat index point

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

8.2 Seat location and adjustment for tests

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

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

8.2.3 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.

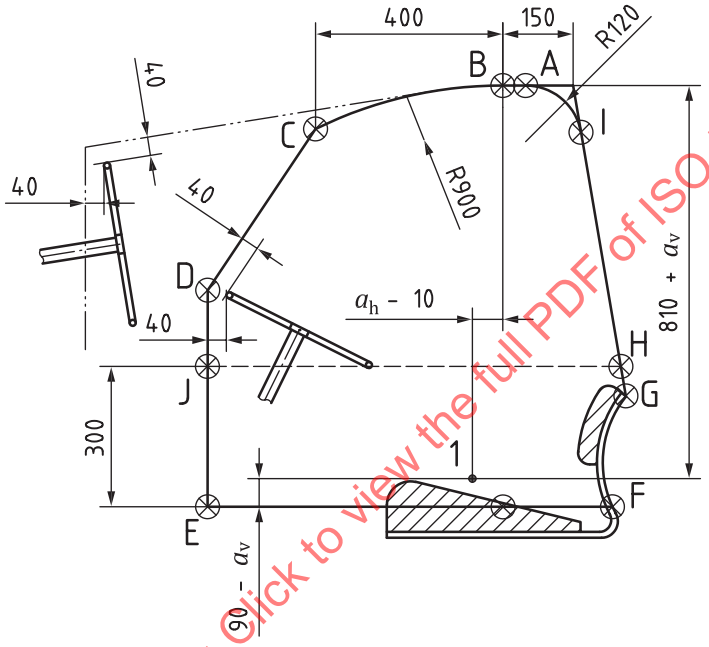
8.2.4 For a suspended seat, the manufacturer's directions for setting the suspension shall be followed if provided. Otherwise, the seat suspension shall be set to the suspension mid-travel point. After the installation of the seat on the tractor, SIP becomes a fixed point with respect to the tractor and does not move with the seat through its horizontal and vertical adjustment range.

9 Clearance zone

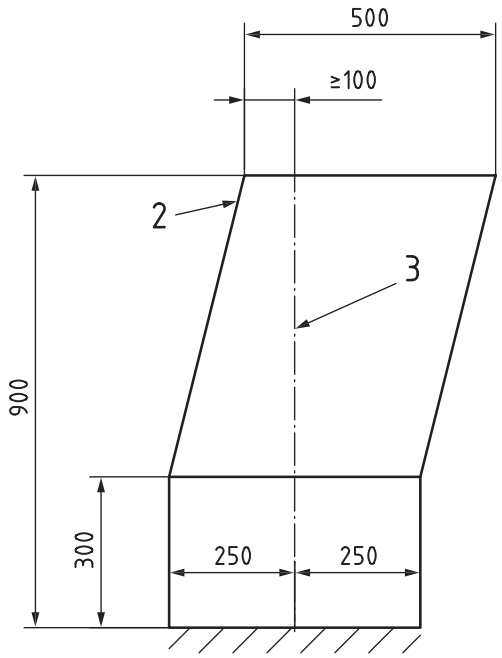
9.1 Determination of the clearance zone

The clearance zone is illustrated in Figure A.1 and Figure 13. The zone is defined in relation to the seat reference plane and the SIP. The seat reference plane is primarily a vertical plane, generally longitudinal to the tractor and passing through the SIP and the centre of the steering wheel. The SIP is determined according to ISO 5353 and is a fixed point with respect to the tractor that does not move as the seat is adjusted away from the mid-position. Normally, the seat reference plane coincides with the longitudinal median plane of the tractor. This seat reference plane shall be assumed to move horizontally with the seat and steering wheel during loading but remain perpendicular to the tractor or the floor of the rollover protective structure if the latter is resiliently mounted. The clearance zone shall be defined on the basis of 9.2 and 9.3.

Dimensions in millimetres



a) — Side view



b) — Front or rear view

Key

1 seat index point
2 force
3 seat reference plane

Figure 13 — Clearance zone

9.2 Determination of the clearance zone for tractors with a non-reversible seat

The clearance zone for tractors with a non-reversible seat is defined and shall be bounded by the planes listed in 9.2.1 to 9.2.10, the tractor being on a horizontal surface, the seat, where adjustable, adjusted and located as specified in 8.2.1 and 8.2.2, and the steering wheel, where adjustable, adjusted to the mid-position or seated driving.

9.2.1 A horizontal plane, $A_1 B_1 B_2 A_2$, $(810 + \alpha_v)$ mm above the seat index point (SIP) with line B_1B_2 located $(\alpha_h - 10)$ mm behind the SIP.

9.2.2 An inclined plane, $G_1 G_2 I_2 I_1$, perpendicular to the seat reference plane, including both a point 150 mm behind line B_1B_2 and the rearmost point of the seat backrest.

9.2.3 A cylindrical surface, $A_1 A_2 I_2 I_1$, perpendicular to the seat reference plane, having a radius of 120 mm, tangential to the planes defined in 9.2.1 and 9.2.2.

9.2.4 A cylindrical surface, $B_1 C_1 C_2 B_2$, perpendicular to the seat reference plane, having a radius of 900 mm extending forward for 400 mm and tangential to the plane defined in 9.2.1 along line B_1B_2.

9.2.5 An inclined plane, $C_1 D_1 D_2 C_2$, perpendicular to the seat reference plane, joining the surface defined in 9.2.4 and passing 40 mm from the forward external edge of the steering wheel, or, in the case of a high steering wheel position, extending forward from line B_1B_2 tangentially to the surface defined in 9.2.4.

9.2.6 A vertical plane, $D_1 E_1 E_2 D_2$, perpendicular to the seat reference plane 40 mm forward of the external edge of the steering wheel.

9.2.7 A horizontal plane, E_1 F_1 F_2 E_2, passing through a point (90 – α_v) mm below the SIP.

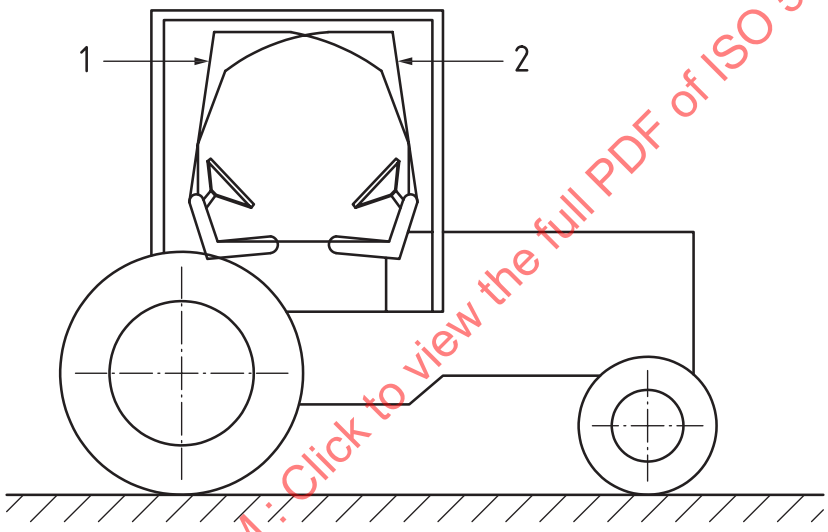
9.2.8 A surface, G_1 F_1 F_2 G_2, if necessary curved from the bottom limit of the plane defined in 9.2.2 to the horizontal plane defined in 9.2.7, perpendicular to the seat reference plane, and in contact with the seat backrest throughout its length.

9.2.9 Vertical planes, J_1 E_1 F_1 G_1 H_1 and J_2 E_2 F_2 G_2 H_2, which extend upwards from plane E_1 F_1 F_2 E_2 for 300 mm, and where the distances E_1 E_0 and E_2 E_0 are 250 mm.

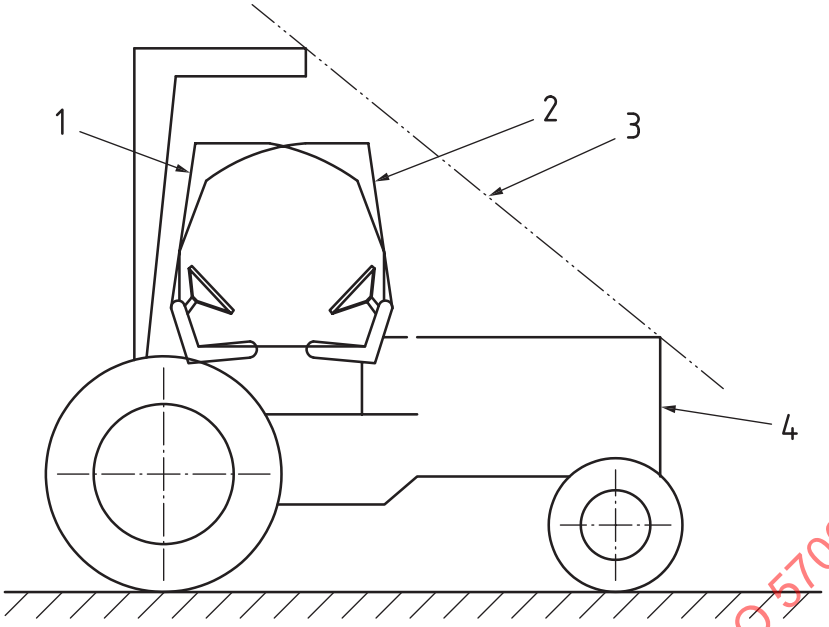
9.2.10 Parallel planes, A_1 B_1 C_1 D_1 J_1 H_1 I_1 and A_2 B_2 C_2 D_2 J_2 H_2 I_2, inclined so that the plane upper edge of the plane on the side on which the force is applied is at least 100 mm from the seat reference plane.

9.3 Determination of the clearance zone for tractors with a reversible driver's position

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. See Figure 14 a) and Figure 14 b).



a) — Protective cab



b) — Rear roll bar frame

Key

1 clearance zone for the forward facing seat position
2 clearance zone for the rearward facing seat position
3 imaginary ground plane
4 part of the tractor capable of supporting the mass of the tractor when overturned

Figure 14 — Clearance zone for tractor with reversible seat and steering wheel

9.4 Optional seats

9.4.1 In the case of tractors that can be fitted with optional seats, the envelope comprising the SIPs 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.

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 not, a new test shall be performed.

10 Acceptance conditions

10.1 General

For the ROPS to be accepted, it shall fulfil the conditions in 10.2 to 10.7 during and after the tests. On articulated tractors, the clearance zone shall remain protected at any angle of articulation of the tractor when overturned.

10.2 Clearance zone

No part shall enter the clearance zone as defined in Clause 9. No part shall strike the seat during the tests. Furthermore, the clearance zone shall not be outside the protection given by the ROPS (see the Note to 3.1). For this purpose, it shall be considered to be outside if any part of it have come into contact with flat ground

if the tractor had overturned in the direction from which the blow was struck. To estimate this, the tyres or tracks and track width setting shall be the smallest standard fitting specified by the manufacturer.

NOTE It is the responsibility of the tractor manufacturer and the test engineer conducting the ROPS test 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.

10.3 Recording permanent deflection

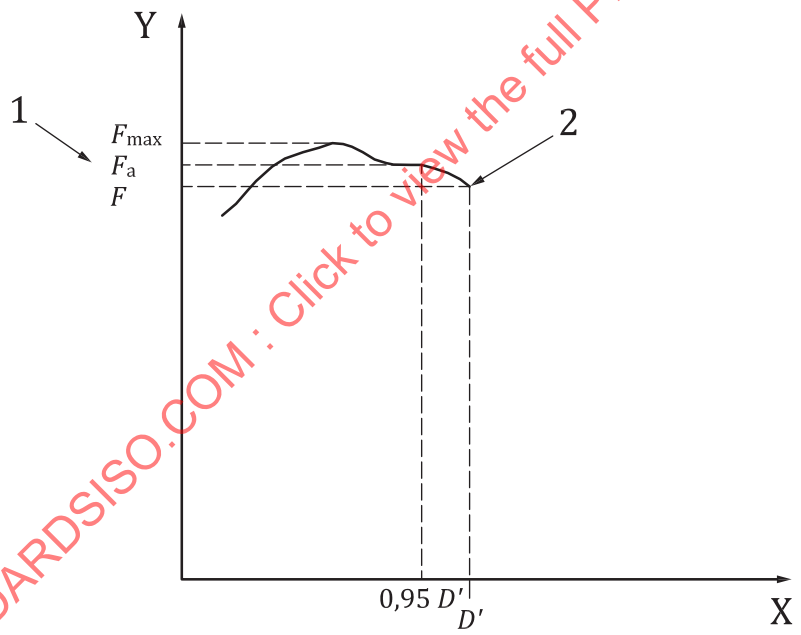
After the final crushing test, the permanent deflection of the protective structure shall be recorded. For this purpose, before the start of the test, the position of the main protective structure members in relation to the SIP shall be recorded. Any displacement of the members resulting from the loading tests and any change of the height of the front and back members of the roof of the protective structure shall be recorded.

10.4 Required force

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

10.5 Overload test

10.5.1 An overload test shall be required if the force drops by more than 3 % over the last 5 % of the deflection attained while absorbing the required energy (see Figure 15 and 16).

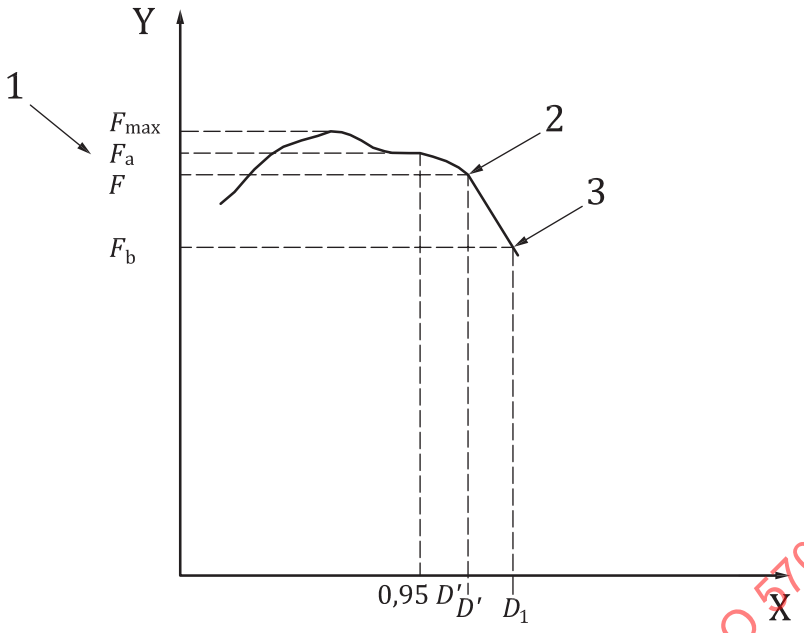


Key

1 locate F_a in relation to $0{,}95D'$

2 overload test not necessary as $F_a \leq 1{,}03\ F$

Figure 15 — Static load force load relative to deflectionn — Overload test not necessary



Key

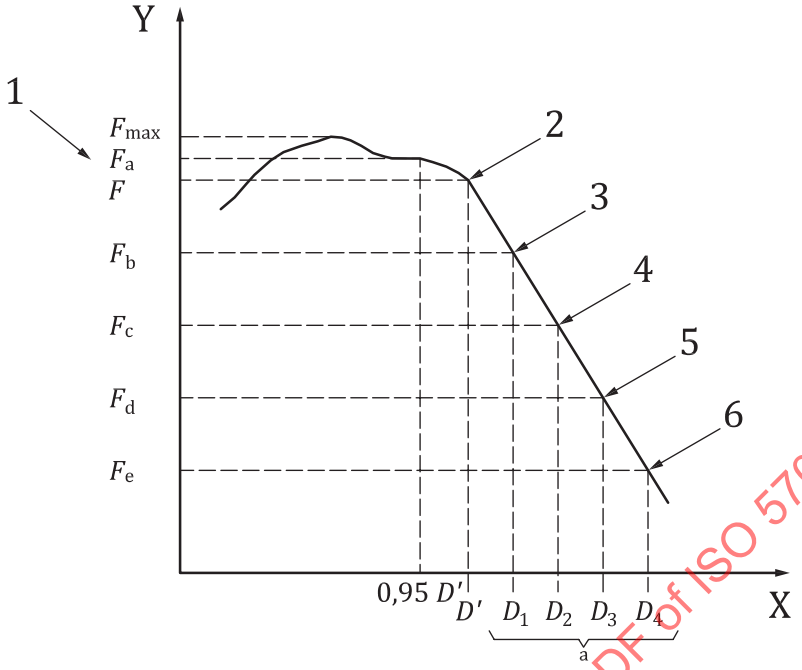
1 locate F_a in relation to 0,95D'

2 overload test necessary as $F_a > 1{,}03\ F$

3 overload test performance satisfactory as $F_b > 0{,}97\ F$ and $F_b > 0{,}8F_{max}$

Figure 16 — Static load force load relative to deflection — Overload test necessary

10.5.2 The 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).



Key

1 locate F_a in relation to 0,95D'

2 overload test necessary as $F_a > 1{,}03\ F$

3 $F_b < 0{,}97\ F$ therefore further overload necessary

4 $F_c < 0{,}97\ F_b$ therefore further overload necessary

5 $F_d < 0{,}97\ F_c$ therefore further overload necessary

6 overload test performance satisfactory, if $F_e > 0{,}8F_{max}$

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

Figure 17 — Static load force load relative to deflection — Continuing overload test

10.5.2.1 The overload test shall be 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 is greater than $0{,}8F_{max}$, and

— after the absorption of 20 % additional energy, the force is greater than $0{,}8F_{max}$.

10.5.2.2 Additional cracks or tears, entry into the clearance zone, or lack of protection of the clearance zone is permitted during this overload test. After removing the load, the structure shall not be in the clearance zone and shall protect the clearance zone.

10.6 Additional conditions

10.6.1 The required force shall be sustained in both crushing tests.

10.6.2 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.

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

10.7 Cold weather embrittlement

10.7.1 When applicable, cold weather embrittlement properties shall be verified in accordance with Annex B. Resistance to cold weather embrittlement at reduced temperatures may also be proved by successfully completing the dynamic ROPS test, based on ISO 3463 or OECD Code 3[5], 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.

10.7.2 Structural members and mounts should be fabricated from material that meets the requirements of Annex B. If they are manufactured from "other material" the use of a reduced temperature dynamic ROPS test, based on ISO 3463 or OECD Code 3[5], is an optional method of approving the ROPS. The test shall be conducted with the structural members material and mounts temperature at −18 °C or colder. The protective structure and all mounting hardware shall be cooled to −18 °C or colder prior to beginning the dynamic test.

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

11 Seatbelt anchorage performance

Optional seatbelt anchorage performance tests, 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.

12 Labelling

If a label is required, it shall be durable and permanently attached to the main structure such that it can be easily read. Tools should not be necessary to see the ROPS label. 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) a reference to this document, i.e. ISO 5700.

13 Applicability to other tractor models and future protective structure modifications

13.1 Applicability 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 13.1.1 to 13.1.5.

13.1.1 The structure shall be identical to the one tested.

13.1.2 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.

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

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

13.1.5 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 Seat Index Point (SIP) of clearance zone as in the original test report.]

13.2 Applicability of the structural test results to modified models of the protective structure

When the provisions of 13.1 are not fulfilled, loading and crushing tests need not be carried out when modifications have no effect 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]. However, 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), the tests need to be carried out.

14 Test report

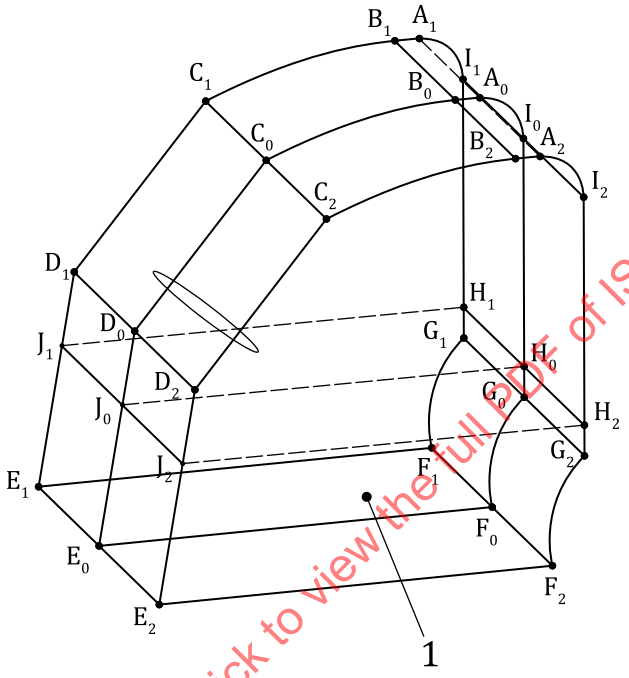
The test report shall contain at least the information according to Annex C.

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

Annex A
(informative)

Clearance zone measuring rig

A measuring rig based on the clearance zone as shown in Figure A.1 may be used. The dimensions are given in Table A.1.



Key

1 seat index point

Figure A.1 — Clearance zone measuring rig

Table A.1 — Dimensions for the Clearance zone measuring rig shown in Figure A.1

Dimensions		Remarks
	mm	
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_1E_2	250	Minimum or equal to the steering-wheel radius plus 40 mm, whichever is greater
J_0E_0	300	
F_0G_0		Depending on the tractor
I_0G_0		
C_0D_0		
E_0F_0		
NOTE For other dimensions, see Figure 13.		

Annex B
(normative)

Optional requirements for providing resistance to brittle fracture of roll-over protective structure at reduced operating temperature

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 roll-over protective structure's suitability at a reduced operating temperature in regions where this additional operating protection is required.

In certain countries, testing for cold weather embrittlement according to this annex is mandatory. See Table B.1.

Table B.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 specified in B.3 and B.4 are provided until suitable International Standards can be developed.

B.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 in accordance with ISO 898-1 for bolts, and property class 8, 9 or 10 in accordance with ISO 898-2 for nuts. In case metric fasteners are not used, property classes shall be equivalent to the metric fastener classes specified.

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

B.3 Steel materials for the tractor structural members that are expected to absorb energy during ROPS testing shall be of controlled toughness material exhibiting minimum Charpy V-notch impact energy requirements according to Table B.2.

NOTE Steel of thickness less than or equal to 2,5 mm having a maximum carbon content of 0,20 % and steel of thickness greater than 2,5 mm but less than or equal to 4,0 mm having a maximum carbon content of 0,20 % and fully-killed with a grain size of 5 or finer according to ISO 643 or equivalent are 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.