Foreword

The formulation of this National Standard was initiated by the Agricultural Machinery Testing and Evaluation Center (AMTEC) with support from the Department of Agriculture (DA).

This standard has been technically prepared in accordance with BPS Directives Part 3:2003 – Rules for the Structure and Drafting of International Standards.

The word "shall" is used to indicate mandatory requirements to conform to the standard.

The word "should" is used to indicate that among several possibilities one is recommended as particularly suitable without mentioning or excluding others.

In the preparation of this standard, the following documents/publications were considered:

American Society of Agricultural Engineers (ASAE) S383.1:1983 – Roll-over Protective Structures (ROPS) for Wheeled Agricultural Tractors.

Guidelines for the Design, Construction, and Installation of Rollover Protective Structures (ROPS) for all Terrain Vehicles. 1998. Occupational Health Safety and Health Service, Department of Labour, Wellington, New Zealand.

International Organization for Standardization (ISO) 3463:1989 Wheeled Tractors for Agriculture – Protective Structures – Dynamic Test Method and Acceptance Conditions.

International Organization for Standardization (ISO) 5700:1989 Wheeled Tractors for Agriculture – Protective Structures – Static Test Method and Acceptance Conditions.

Organisation for Economic Co-operation and Development (OECD) Standard Code for the Official Testing of Protective Structures on Agricultural and Forestry Tractors (Dynamic Test): Code 3. March 2000.

Organisation for Economic Co-operation and Development (OECD) Standard Code for the Official Testing of Protective Structures on Agricultural and Forestry Tractors (Static Test): Code 4. March 2000.

Agricultural Machinery – Roll-Over Protective Structures (ROPS) – Methods of Test

1 Scope

This standard specifies the test procedures for roll-over protective structure (ROPS) attached to a four-wheel tractor with a minimum of 15 kW engine power.

2 References

The following normative documents contain provisions, which through reference in this text, constitute provisions of this National Standard:

ISO 2408:1985, Steel Wire Ropes for General Purposes – Characteristics

ISO 3776: 1989, Tractors for Agriculture – Seat Belt Anchorages

ISO 4253:1993, Agricultural Tractors – Operators Seating Accommodation – Dimensions

ISO 5353:1995, Earth-moving Machinery, and Tractors and Machinery for Agriculture and Forestry – Seat Index Point

PAES 103:2000, Agricultural Machinery – Method of Sampling

PAES 118:2001, Agricultural Machinery – Four-Wheel Tractor – Specifications

PAES 311:2001, Engineering Materials – Bolts and Nuts for Agricultural Machines – Specifications and Applications

PAES 139:2004, Agricultural Machinery – Roll-Over Protective Structures (ROPS) – Specifications

3 Definitions

For the purpose of this standard, the following definitions shall apply:

3.1
crushing test
application of a vertical load through a beam placed laterally across the uppermost members of the protective structure

3.2
horizontal loading test
application of a horizontal load to the rear, front and side of the protective structure

NOTE As loading continues, the cab/frame deformation may cause the direction of loading to change. This is permissible.

3.3
impact test
application of a dynamic load produced by a block acting as a pendulum

3.4
roll-over protective structure (ROPS)
cab or frame installed on agricultural tractors to protect or minimize injury of the operator from accidental overturning during operation

3.5
seat index point (SIP)
point on the central vertical plane of the seat

NOTE For more detailed specification of the SIP refer to PAES 139.

3.6
tractor mass
mass of the unladen tractor in working order with tanks and radiator full, protective structure with cladding, and any track equipment or additional front-wheel drive components required for normal use

NOTE The operator, optional ballast weights, additional wheel equipment, special equipment and loads are not included.

4 General Conditions for Test and Inspection

4.1 ROPS on Test

The ROPS submitted for test shall be sampled in accordance with PAES 103.

4.2 Role of the Manufacturer/Dealer

The manufacturer/dealer shall submit to the official testing agency the specifications and other relevant information on the ROPS. An official representative shall be appointed to make all decisions on matters of preparation of the ROPS for testing and to witness the tests. The manufacturer/dealer shall abide by the terms and conditions set forth by the official testing agency.

5 Preparation of Tractor and Protective Structure

5.1 General

5.1.1 The protective structure shall conform to manufacturer's specifications and installation procedure in accordance with the tractor model chassis.

5.1.2 All detachable windows, panels and removable non-structural fittings that do not contribute to the strength of the protective structure shall be removed.

5.1.3 The list of apparatus and equipment to be used in testing is given in Annex A.

5.2 Seat Index Point

The seat index point (SIP) shall be determined, in accordance with ISO 5353. For a suspended seat, the seat shall be set to the suspension travel mid-point, unless this is contradictory to clearly stated instructions by the seat manufacturer. Where special instructions for the seat setting exist, these shall be observed.

5.3 Test

5.3.1 The bedplate shall be adjusted such that the wheel tread and wheelbase are equal to that of the reference tractor.

5.3.2 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 protective structure and in line with the travel arc of the block center of gravity.

The lashing attachment points shall be approximately 2 m behind the rear axle and 1.5 m in front of the front axle.

5.3.3 Front and Rear Impact Tests

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

5.3.4 Side Impact Test

A wooden beam shall be placed as a prop against the axle and secured to the floor so that it is held tight against the axle during the impact. The beam length shall be chosen so that when in position against the axle it is at an angle of $30 \pm 3^{\circ}$ to the horizontal.

5.3.5 Crushing Test

When in position for the crushing test, the bedplate shall be supported under the axles.

6 Test Procedure

6.1 Sequence of Tests

6.1.1 For two-post ROPS, the following sequence shall be used:

a. Impact from the rear

b. Impact from either side

c. Crushing at the top

6.1.2 For four-post ROPS, the following sequence shall be used:

a. Impact from the rear

b. Impact from the front

c. Impact from either side

d. Crushing at the front

e. Crushing at the rear

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

6.1.4 The energy input to be absorbed by the protective structure during the test shall be reported; it is calculated, in joules, by the formula :

$$E = 19.6\,H$$

where:

E is the energy input to be absorbed during test, J

H is the lift height of the pendulum block center of gravity, mm

6.2 Impact from Rear and Front

6.2.1 Positioning of Test Rig Bedplate

For the impact tests to the rear and front, the bedplate 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 protective structure. If the angle of the 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 protective structure member are parallel at the impact point and maximum deflection, the supporting chains being at 20° to the vertical when the block strikes the protective structure.

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

6.2.2 Impact from Rear (see Figure 1)

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 is made and at two-thirds of the distance from the bedplate median plane to the vertical plane touching the outside extremity of the protective structure top. However, if a curve in the back of the protective structure starts at less than two-thirds of the distance from the center, 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 bedplate median plane.

The height of the pendulum block lift shall be calculated based on the following formula.

$$H = 2.165 \times 10^{-8}\, m_t\, L^2$$

where:

H is the lift height of the pendulum block center of gravity, mm
m_t is the tractor mass, kg
L is the reference wheelbase, which shall not be less than the maximum wheelbase, mm

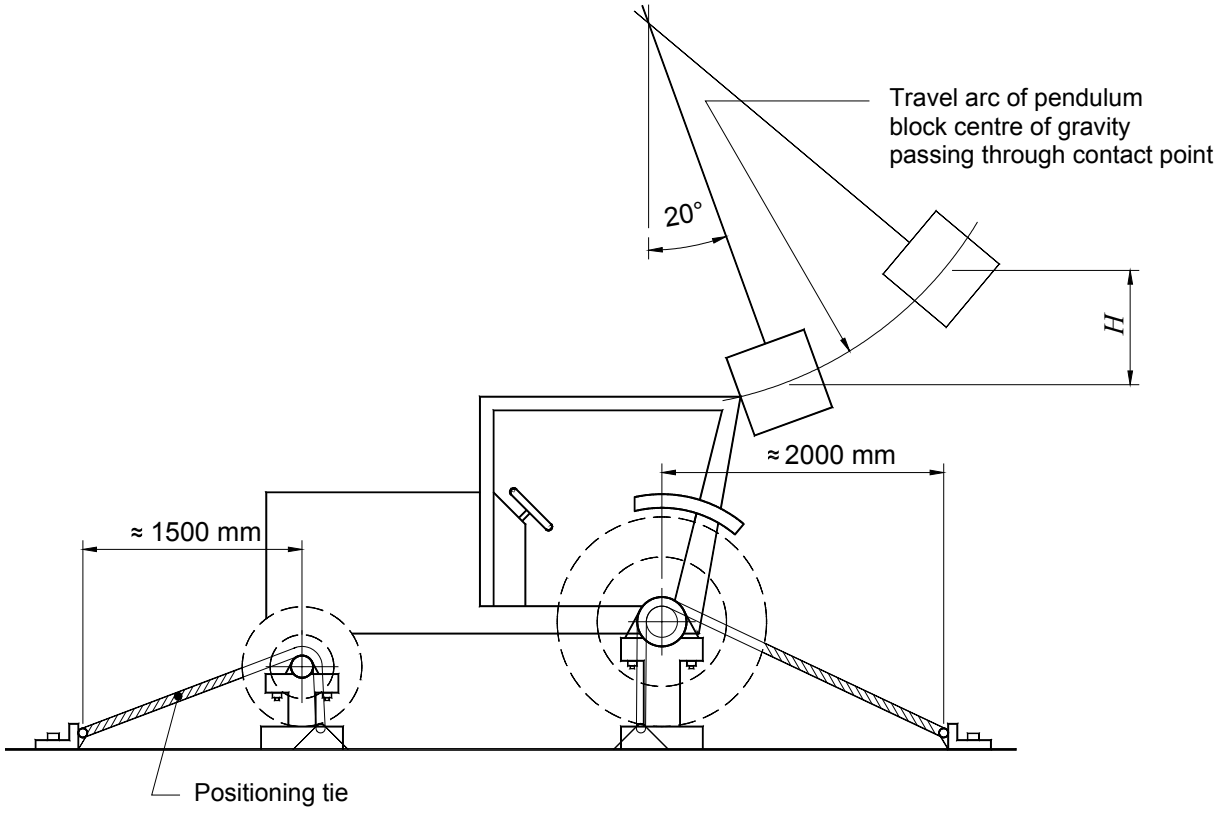

Figure 1 – Impact from Rear

6.2.3 Impact from Front (see Figure 2)

The general requirements for this test are similar to those for the impact from the rear. The blow shall be struck as close to the protective structure top corner as is practicable on the same side as that on which the side impact is made (i.e. 80 mm maximum from a vertical plane parallel to the bedplate longitudinal median plane touching the outside extremity of the protective structure top). However, if a curve in the front of the 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 bedplate.

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

- $H = 25 + 0.07\ m_t$, *where* m_t = 800 kg to 2 000 kg
- $H = 125 + 0.02\ m_t$, where m_t = 2 000 kg to 6 000 kg

where:

H is the lift height of the pendulum block center of gravity, mm
m_t is the tractor mass, kg

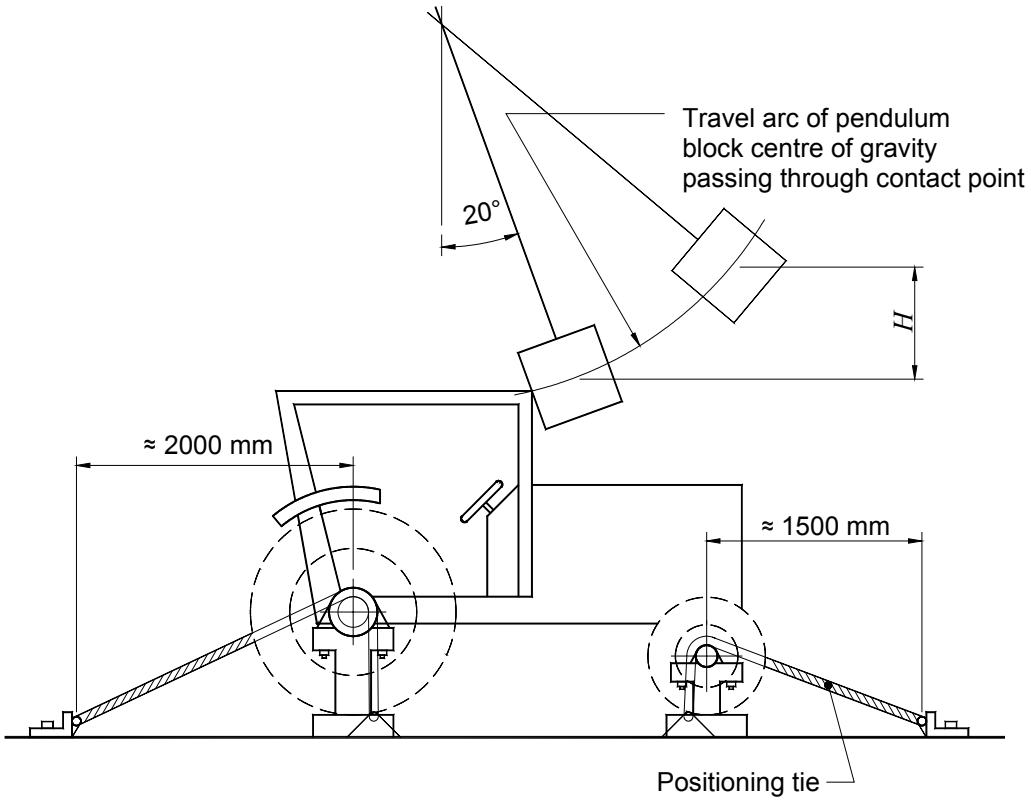

Figure 2 – Impact from Front

6.3 Impact from either Side

6.3.1 Positioning of Test Rig Bedplate

For the side impact test the impact direction shall be horizontal. The bedplate shall be positioned so that the supporting chains and the pendulum block striking face are vertical when striking the protective structure. If the protective structure member angle at the contact Point is not vertical, the pendulum block striking face and the protective 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.

6.3.2 Impact from Side (see Figure 3)

The impact shall be struck against the highest side member and in the vertical plane perpendicular to the longitudinal median plane and 60 mm forward of the seat index point. The lift height of the pendulum block shall be calculated from the following formula:

- $H = 25 + 0.2\ m_t$, where m_t = 800 kg to 2,000 kg
- $H = 125 + 0.15\ m_t$, where m_t = 2,000 kg to 6,000 kg

where:

H is the lift height of the pendulum block center of gravity, mm
m_t is the tractor mass, kg

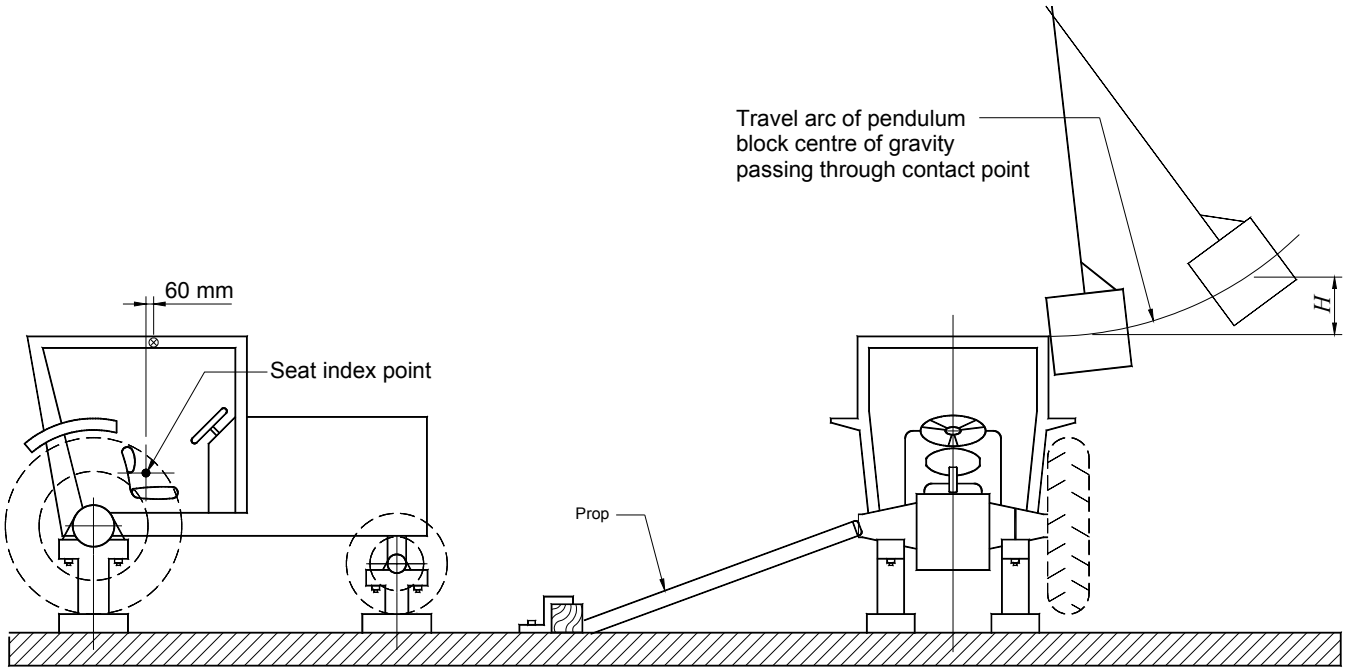

Figure 3 – Impact from Side

6.4 Crushing Test at Rear/Front

The beam shall be positioned across the rear/front uppermost structural members and the resultant crushing forces shall be located in the vertical reference plane. The static load force F shall be applied, equal to $F = 20\ m_t$, in Newtons. This force shall be maintained for at least five seconds after the cessation of any visually detectable movement of the protective structure.

Where the rear/front part of the protective structure 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 protective structure upper part with that part of the bedplate rear/front capable of supporting the vehicle mass when overturned. The force shall then be removed and the bedplate or loading force repositioned so that the beam is over that part of the protective structure which would then support the tractor front/rear when completely overturned and the full force applied. (see Figures 4 and 5)

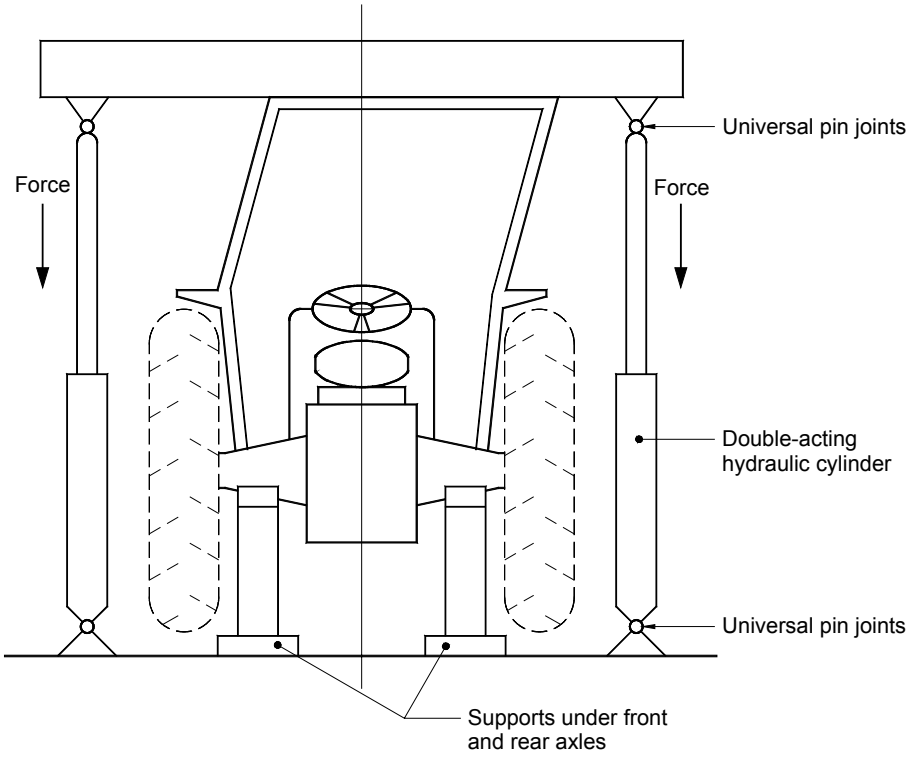

Figure 4 – Example of Arrangement for Crushing Test

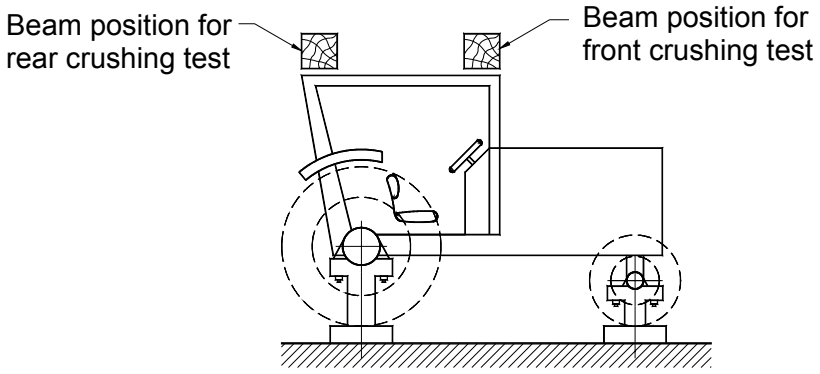

Figure 5 – Beam Position Crushing Test

7 Tolerances

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

a) dimensions of the protective structure and clearance zone : ± 3 mm;

b) deflection : ± 3 mm;

c) lift height of pendulum block set for impact tests: ± 6 mm;

d) measured tractor mass : ± 20 kg;

e) force applied in horizontal and crushing tests: ± 2%;

f) pendulum block mass (chain mass excluded) : ± 20 kg;

g) angle of pendulum block supporting chains at impact point : ± 2˚;

h) deviation from the direction of the applied force:

- at start of test (under zero load) : ± 2˚;
- during test (under load) : + 10˚ above and – 20˚ below the horizontal;

8 Extension to other Tractor Models

In the case of a protective structure which has fulfilled the conditions required for acceptance and which is designed to be used on other tractor models, the tests need not be carried out on each tractor model, provided that the protective structure and tractor comply with the conditions as specified in 8.1 to 8.4. In such cases, the test report shall contain a reference to the previous test report.

8.1 The mass of the other tractor models shall not exceed by more than 5 % that of the reference tractor.

8.2 The attachment method and the tractor component to which the attachment is made shall be identical or of equivalent strength.

8.3 Any component such as fender and hood, which may provide support for the protective structure, shall be identical or judged to give at least the same support.

8.4 The position and critical dimensions of the seat in the protective structure and the relative position of the tractor protective structure shall be such that the clearance zone would have remained within the protection of the deflected structure throughout all the tests.

9 Test Report

The test report shall be in accordance with Annexes B and C.

Annex A

Apparatus and Equipment for Testing

A1 General

A1.1 Material, equipment and attachment shall be used to ensure that the bedplate is firmly fixed to the ground.

A1.2 A measuring rig shall be used to prove that the clearance zone has not been entered during the test.

A2 Impact Test

A2.1 A square pendulum block (i.e. concrete with steel casing) with a mass of 2,000 kg shall be used to strike a blow against the protective structure. The pendulum block 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 A1.

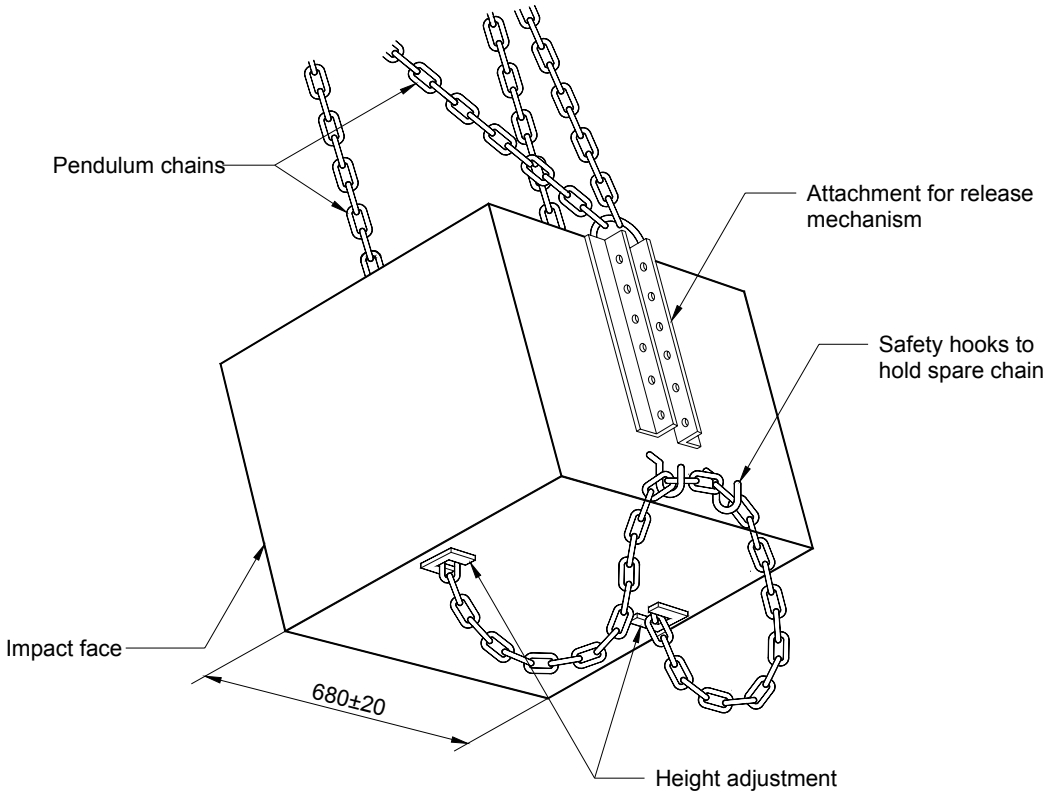

Figure A1 – Pendulum Block

A2.2 The bedplate 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 1.8 m to either side. The wire rope shall be round, stranded with fiber core, construction 6 x 19 according to ISO 2408, and using wire of tensile strength 1,770 N/mm^2**.** The nominal diameter shall be specified in Table A1.

Table A1 – Nominal Diameter of Lashing Ropes

Tractor Mass, m_t ton	Rope Diameter mm
< 5	13
> 5	16

A2.3 A wooden prop shall be used to restrain the opposite axle when striking from the side. Its length shall be 20 to 25 times its thickness and its width 2 to 3 times its thickness.

A2.4 Device to measure elastic deflection shall be used in a horizontal plane that coincides with the upper limiting surface of the clearance zone as shown in Figure A2.

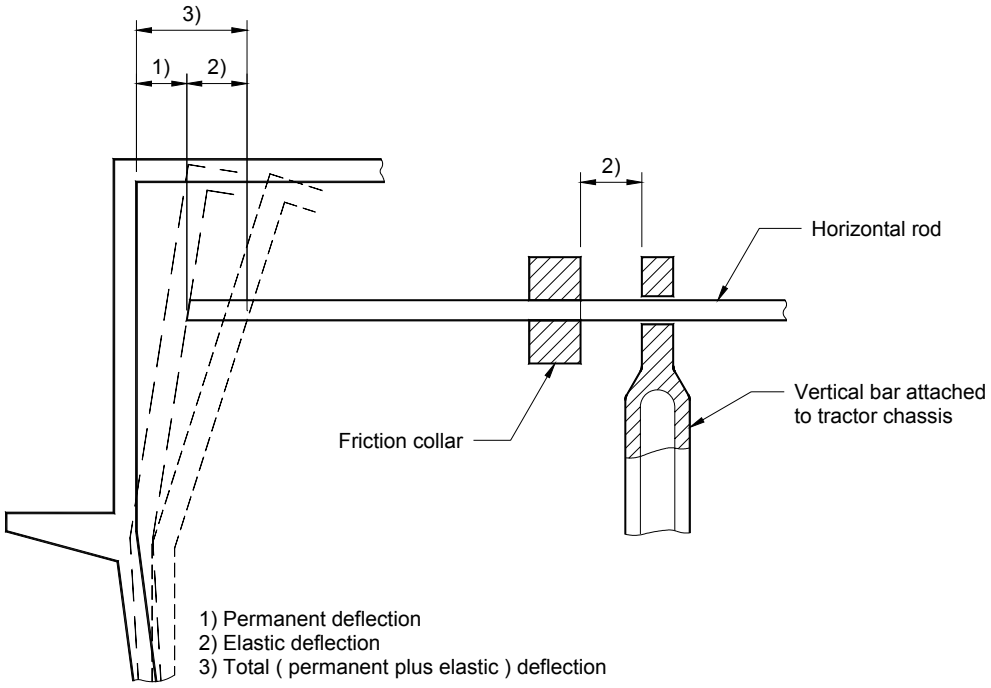

Figure A2 – Example of Device to Measure Elastic Deflection

A3 Crushing Test

A3.1 Means to apply downward force on the protective structure including a stiff beam with a width of 250 mm shall be used.

A3.2 An equipment to measure the total vertical force applied shall be used.

Annex B

Data Sheet for Protective Structure

ITEMS	VALUES
B1 Height of the roof members above the tractor seat index point, mm	
B2 Height of the roof members above the tractor footplate, mm	
B3 Interior width of the protective structure at a point 840 mm above and 215 mm behind the seat index point, mm	
B4 Interior width of the protective structure at the level of the steering-wheel center at a point 215 mm behind the seat index point, mm	
B5 Distance from the steering-wheel center to the right side of the protective structure, mm	
B6 Distance from the steering-wheel center to the left side of the protective structure, mm	
B7 Minimum distance from the steering wheel rim to the protective structure, mm	
B8 Width of the doorways, mm	
B8.1 at the top	
B8.2 at the middle	
B8.3 at the bottom	
B9 Height of the doorways, mm	
B9.1 above the foot platform	
B9.2 above highest mounting step	
B9.3 above lowest mounting step	
B10 Overall height of the tractor with the protective structure fitted, mm	
B11 Overall width of the protective structure, mm	
B12 Horizontal distance from the seat index point to the rear of the protective structure at a height of 840 mm above the seat index point, less 215 mm	
B13 Number of doorways	
B14 Dimension of emergency exit	
B15 Types of glass	
B16 Make and model of seat	

Annex C

Test Report for Protective Structure

Name of Applicant : _____

Address : _____

Telephone No. : _____

Name of Distributor : _____

Address : _____

Name of Manufacturer : _____

Factory Address : _____

GENERAL INFORMATION

1. Protective Structure

Name: _____ Type :_____

2. Tractor on which test was based:

Make: _____Model : _____

3. Date of Test: _____

Items to be measured and inspected

ITEMS	VALUES
C1 Impact test Impact tests were made to the rear and to the front and to the side. The reference wheelbase about the rear axle used for calculating impact energies were:	
C1.1 Impact energies, kJ Rear Front Side	
C2 Crushing test	
C2.1 Crushing force, kN	
The acceptance conditions for these tests concerning freedom from fractures or cracks, maximum elastic deflection and protection of the clearance zone were satisfactorily fulfilled.	
C3 Deflections of protective structure extremities, measured after the series of tests (stating the height on the protective structure at which these measurements were made, for example above the SIP)	

ITEMS	VALUES
C3.1 Rear, mm Permanent deflection Elastic deflection Total deflection	
C3.2 Front, mm (for four-post ROPS) Permanent deflection Elastic deflection Total deflection	
C3.3 Side, mm Permanent deflection Elastic deflection Total deflection	
C3.4 Top, mm Rear: Permanent deflection Elastic deflection Total deflection Front: Permanent deflection Elastic deflection Total deflection	
C4 Specification of reference tractor	
C4.1 Tractor mass, kg	
C4.2 Wheelbase, mm	
C4.3 Tire sizes (front and rear), mm	
C5 Protective structure specification	
C5.1 Photographs, overall view and close-ups showing mounting details	
C5.2 General arrangement drawing	
C6 Details of materials used in the construction of the protective structure	
C6.1 Main frame and cladding	
C6.1.1 Material	
C6.1.2 Dimensions, mm	
C6.2 Mountings	
C6.2.1 Material	
C6.2.2 Dimensions, mm	
C6.3 Assembly and mounting bolts	
C6.3.1 Grade	
C6.3.2 Dimensions, mm	
C6.4 Other items	
C6.4.1 Material	
C6.4.2 Dimensions, mm	