

Australian Standard[®]

**Tractors—Roll-over protective
structures—Criteria and tests**

**Part 3: Mid-mounted for
narrow-track tractors**

This Australian Standard was prepared by Committee ME/65, Agricultural Tractors and Machinery. It was approved on behalf of the Council of Standards Australia on 21 September 1995 and published on 5 January 1996.

The following interests are represented on Committee ME/65:

Department of Primary Industries, Qld
Health and Safety Organisation, Vic.
National Farmers Federation
N.S.W. Agriculture
Safety Institute of Australia
Tractor and Machinery Association of Australia
University of Melbourne
WorkCover Authority of New South Wales

Review of Australian Standards. To keep abreast of progress in industry, Australian Standards are subject to periodic review and are kept up to date by the issue of amendments or new editions as necessary. It is important therefore that Standards users ensure that they are in possession of the latest edition, and any amendments thereto.

Full details of all Australian Standards and related publications will be found in the Standards Australia Catalogue of Publications; this information is supplemented each month by the magazine 'The Australian Standard', which subscribing members receive, and which gives details of new publications, new editions and amendments, and of withdrawn Standards.

Suggestions for improvements to Australian Standards, addressed to the head office of Standards Australia, are welcomed. Notification of any inaccuracy or ambiguity found in an Australian Standard should be made without delay in order that the matter may be investigated and appropriate action taken.

This Standard was issued in draft form for comment as DR 95041.

Australian Standard[®]

**Tractors—Roll-over protective
structures—Criteria and tests**

**Part 3: Mid-mounted for
narrow-track tractors**

PUBLISHED BY STANDARDS AUSTRALIA
(STANDARDS ASSOCIATION OF AUSTRALIA)
1 THE CRESCENT, HOMEBUSH, NSW 2140

ISBN 0 7327 0182 9



Documents
Document Sharing Hub

PREFACE

This Standard was prepared by the Standards Australia Committee ME/65 on Agricultural Tractors and Machinery. It lays down the performance requirements under specified test methods for mid-mounted roll-over protective structures (ROPS) for narrow-track, wheeled tractors intended to protect drivers in the event of a tractor overturning.

The Standard is based upon the Council of the European Communities Directive 87/402/EEC on roll-over protection structures mounted in front of the driver's seat on narrow-track, wheeled agricultural and forestry tractors.

The term 'normative' has been used in this Standard to define the application of the appendix to which it applies. A 'normative' appendix is an integral part of a Standard.

© Copyright — STANDARDS AUSTRALIA

Users of Standards are reminded that copyright subsists in all Standards Australia publications and software. Except where the Copyright Act allows and except where provided for below no publications or software produced by Standards Australia may be reproduced, stored in a retrieval system in any form or transmitted by any means without prior permission in writing from Standards Australia. Permission may be conditional on an appropriate royalty payment. Requests for permission and information on commercial software royalties should be directed to the head office of Standards Australia.

Standards Australia will permit up to 10 percent of the technical content pages of a Standard to be copied for use exclusively in-house by purchasers of the Standard without payment of a royalty or advice to Standards Australia.

Standards Australia will also permit the inclusion of its copyright material in computer software programs for no royalty payment provided such programs are used exclusively in-house by the creators of the programs.

Care should be taken to ensure that material used is from the current edition of the Standard and that it is updated whenever the Standard is amended or revised. The number and date of the Standard should therefore be clearly identified.

The use of material in print form or in computer software programs to be used commercially, with or without payment, or in commercial contracts is subject to the payment of a royalty. This policy may be varied by Standards Australia at any time.

CONTENTS

	<i>Page</i>
SECTION 1 SCOPE AND GENERAL	
1.1 SCOPE	4
1.2 OBJECTIVE	4
1.3 APPLICATION	4
1.4 REFERENCED DOCUMENTS	4
1.5 DEFINITIONS	5
1.6 EQUIVALENCE	5
1.7 ALTERNATIVE TO PHYSICAL TESTING	5
1.8 GENERAL REQUIREMENTS	5
1.9 STABILITY TESTING	8
1.10 MARKING	9
1.11 ALTERNATIVE MARKING	9
SECTION 2 DYNAMIC TESTING	
2.1 SCOPE OF SECTION	16
2.2 CONDITIONS FOR ACCEPTANCE	16
2.3 SELECTION AND PREPARATION FOR TEST OF ROPS AND TRACTOR	16
2.4 APPARATUS AND EQUIPMENT	16
2.5 TESTS FOR ESTABLISHING STRENGTH OF CAB OR FRAME AND ATTACHMENT TO TRACTOR	17
2.6 REPORT AND SPECIFICATION	21
SECTION 3 STATIC TESTING	
3.1 SCOPE OF SECTION	27
3.2 CONDITIONS FOR ACCEPTANCE	27
3.3 SELECTION AND PREPARATION OF ROPS AND TRACTOR	28
3.4 APPARATUS AND EQUIPMENT	28
3.5 TESTS FOR ESTABLISHING STRENGTH OF CAB OR FRAME AND ATTACHMENT TO TRACTOR	34
3.6 REPORT AND SPECIFICATION	36
APPENDICES	
A TYPICAL DATA SHEET FOR A PROTECTIVE STRUCTURE	37
B TYPICAL TEST REPORT FOR A PROTECTIVE STRUCTURE (DYNAMIC TESTING)	39
C TEST REPORT FOR A PROTECTIVE STRUCTURE (STATIC TESTING) ..	41

STANDARDS AUSTRALIA

Australian Standard

Tractors—Roll-over protective structures—Criteria and tests

Part 3: Mid-mounted for narrow-track tractors

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE This Standard specifies procedures for the evaluation of mid-mounted roll-over protective structures (ROPS) for the protection of drivers of narrow-track tractors. It also sets out test procedures and minimum performance criteria for those structures.

It applies to driver-controlled tractors—

- (a) having a ground clearance not greater than 600 mm measured beneath the lowest points of the front or rear axles, allowing for the differential; and
- (b) having fixed or adjustable minimum track widths of—
 - (i) less than 1150 mm for the axle fitted with the widest tyres; and the remaining axle adjustable so that the outer edges of the tyres do not protrude beyond the outer edge of the widest tyres; or
 - (ii) less than 1150 mm for axles where wheels and tyres are all the same size.

This Standard applies to driver-controlled tractors and is not intended to apply to earth-moving machinery as defined in AS 2294. It describes two different methods of testing a ROPS: a dynamic test, which may be applied to tractors having a mass of not less than 800 kg and not greater than 3000 kg; and a static test, which may be applied to tractors having a mass of not less than 560 kg and not greater than 3000 kg.

NOTE: A ROPS is a structure whose primary purpose is to reduce the possibility of an operator from being crushed or otherwise injured in the event of a tractor rolling over. Wearing a seat belt in conjunction with using a ROPS, may provide additional protection in the event of a tractor turning over. Seat belts should comply with AS/NZS 2596 or SAE J386.

1.2 OBJECTIVE The objective of this Standard is to enable designers and manufacturers of mid-mounted ROPS to verify the design and performance of such equipment and to thus minimize the risks to the health and safety of drivers of tractors involved in a roll-over accident.

1.3 APPLICATION This Standard is intended for designers, manufacturers and testers of mid-mounted ROPS who are concerned with the design of ROPS used on narrow-track, wheeled tractors.

1.4 REFERENCED DOCUMENTS The documents below are referred to in this Standard:

AS

2294 Earth-moving machinery—Protective structures

3569 Steel wire ropes

AS/NZS

2596 Seat belts for use in motor vehicles

EEC

87/402 Council directive of 25 June 1987 on roll-over protection structures mounted in front of the driver's seat on narrow-track wheeled agricultural and forestry tractors

ASAE

S 313.2 Cone penetration index

SAE

J 386 Operator restraint systems for off-road work machines

1.5 DEFINITIONS For the purpose of this Standard, the definitions below apply.

1.5.1 Competent person—a person who has, through a combination of training, education and experience, acquired knowledge and skills enabling that person to perform correctly a specified task.

1.5.2 Tractor—a powered vehicle, primarily to haul and provide power for agricultural or horticultural machinery or implements by way of a power-take off or other mechanical means, but excluding earthmoving machinery and passenger vehicles.

1.6 EQUIVALENCE A roll-over protective structure complying with 87/402 EEC shall be deemed to comply with this Standard.

1.7 ALTERNATIVE TO PHYSICAL TESTING Computer-simulated methods for theoretical analysis may be used as an alternative to dynamic or static testing given in Section 2 and Section 3, respectively. Where a theoretical analysis is used, the analysis shall be proven by physical testing of materially and dimensionally similar frames. The design must afford at least equivalent protection for a driver of a tractor in a roll-over incident as would a ROPS design which has undergone dynamic or static testing.

The theoretical analysis shall consider the method and location of means for mounting the ROPS to the tractor, so as to minimize the risk of failure at the mounting point, e.g. the axle of the tractor.

1.8 GENERAL REQUIREMENTS

NOTE: Tests made using special rigs are intended to simulate such loads as are imposed on the cab or frame when the tractor overturns rearwards or sideways. These tests, described in Clauses 2.5 and 3.5, enable observations to be made on the strength of the cab or frame and the attaching brackets to the tractor. The tests are made with the tractor stationary.

1.8.1 ROPS previously tested on different tractor models For a cab or frame which has fulfilled the conditions required for acceptance as a protective cab or frame designed to be used on other models of tractors, the tests as specified in Clauses 2.5 and 3.5 need not be carried out on each model of tractor provided that the cab or frame and tractor comply with the following:

- (a) The combined effect of basic tractor mass as defined in Clause 1.8.3 and the wheelbase is such that the energy, height of lift and crushing loads, as calculated in Clauses 2.5 and 3.5, do not exceed by more than 5 percent the values calculated for the original test.
- (b) The method of attachment and the tractor's components to which the attachment is made are, to all intents and purposes, identical.
- (c) Any components, such as mudguards and bonnet cowls, which may provide support for the cab or frame are, to all intents and purposes, identical.
- (d) The positions and initial dimensions of the seat in the protective frame or cab and the position of the protective frame or cab relative to the tractor shall be such that the clearance zone would have remained within the protection of the deflected structure throughout all tests.
- (e) The test report or approval document contains a reference to the previous tests.

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

- (a) Linear dimensions measured during a test (except Item (b) below), cab or frame and tractor dimensions, zone of clearance and tyre deflections when lashed for impact tests: ± 3 mm.
- (b) Height of pendulum weight set for impact tests: ± 6 mm.
- (c) Basic tractor mass: ± 20 kg.
- (d) Force applied in horizontal and crushing tests: $\pm 2\%$.
- (e) Deviation from the direction of the applied force during static tests, as follows:
 - (i) At start of test (under zero load): $\pm 2^\circ$.
 - (ii) During test (under load): $+10^\circ$ above and -20° below the horizontal.

NOTE: The test rig should be designed to keep these deviations to the minimum as far as possible.

- (f) Angle of mass supporting chains at the point of impact: $\pm 2^\circ$.

1.8.3 Tractor mass

1.8.3.1 Basic tractor mass The basic tractor mass (M) shall be the mass in kilograms of the tractor with full fuel tanks, coolant and lubricating oil topped up and complete with cab or frame fitted with cladding but without driver. Not included are optional front or rear weights, tyre ballast, mounted implements, mounted equipment or any specialized components. For a tandem tractor, the mass of the standard version of that part to which the cab or frame is fitted shall be used.

1.8.3.2 Reference tractor mass The reference tractor mass (m_r), is a mass, not less than the basic tractor mass as defined in Clause 1.8.3.1 above selected by the manufacturer for calculation of the energy inputs to be used in the tests.

1.8.4 Seat location and seat reference point The seat shall be set at the midpoint of any vertical adjustment range where this is independent of adjustment of its horizontal position. For definition of the zone of clearance in Clause 1.8.5, it shall be at the rearmost point of any horizontal adjustment range.

The reference point shall be obtained using the apparatus illustrated in Figures 1.1 and 1.2 to simulate loading by a human occupant. The apparatus shall consist of a seat pan and backrest boards. The lower backrest board shall be jointed in the region of the ischium humps (A) and loin (B), the joint (B) being adjustable in height.

NOTE: The reference point is defined as the point in the centre longitudinal plane of the seat where the tangential plane of the lower backrest and the horizontal plane intersect. This horizontal plane cuts the lower surface of the seat pan board 150 mm in front of the abovementioned tangent.

The apparatus shall be positioned on the seat. It shall then be loaded with a 55 kg weight at a point 50 mm in front of joint (A), and the two parts of the backrest board shall be lightly pressed tangentially against the backrest. If it is not possible to determine a definite tangent to the lower area of the backrest, the lower part of the backrest board shall be lightly pressed against the backrest vertically.

Where no definite tangent to the upper area is possible, the joint (B) is fixed at a height of 230 mm above the lower surface of the seat pan board, the backrest board being perpendicular to the seat pan board. Then the two parts of the backrest board are lightly pressed against the backrest tangentially.

Where the seat position is adjustable, it must be adjusted to its rear uppermost position. If the inclination of the backrest and seat pan is adjustable, these must be adjusted so that the reference point is in its rear uppermost position. Where the seat is equipped with suspension, the latter must be blocked at mid-travel, unless this is contrary to the instructions clearly laid down by the seat manufacturer. If such instructions exist, they must be complied with.

1.8.5 Zone of clearance The zone of clearance is illustrated in Figure 1.3 and is defined in relation to a vertical reference plane generally longitudinal to the tractor and passing through a seat reference point (described in Clause 1.8.4) and the centre of the steering wheel. The reference plane shall be assumed to move horizontally with the seat and steering wheel during impacts but to remain perpendicular to the tractor or cab floor or frame if the cab or frame is resiliently mounted.

NOTE: Where the steering wheel is adjustable, its position should be that for normal seated driving.

The boundaries of the zone shall be taken as follows:

- (a) Two vertical planes are 250 mm on either side of the reference plane. The vertical planes extend 300 mm upwards from the horizontal plane passing through the seat reference point and longitudinally at least 550 mm in front of the vertical plane, perpendicular to the reference plane passing 350 mm in front of the seat reference point.
- (b) Two vertical planes are 200 mm on either side of the reference plane. These vertical planes extend 300 mm upwards from the horizontal plane passing through the seat reference point and longitudinally from the surface defined in Item (k), to the vertical plane perpendicular to the reference plane passing 350 mm in front of the seat reference point.
- (c) An oblique plane is perpendicular to the reference plane, parallel with and 400 mm above the reference line, extending backwards to the point where it intersects the vertical plane which is perpendicular to the reference plane and passes through the seat reference point.
- (d) An oblique plane, perpendicular to the reference plane and resting on the top of the seat backrest, meets the previous plane at its rearmost edge.
- (e) A vertical plane is perpendicular to the reference plane, passing at least 40 mm forward of the steering wheel and at least 900 mm forward of the seat reference point.
- (f) A curvilinear surface with its axis perpendicular to the reference plane, having a radius of 150 mm and meeting the planes (defined in Items (c) and (e) above) at a tangent.
- (g) Two parallel oblique planes passing through the upper edges of the planes (defined in Item (a) above) with the oblique plane on the side where the impact is applied no closer than 100 mm to the reference plane above the zone of clearance.
- (h) A horizontal plane passing through the seat reference point.
- (i) Two portions of the vertical plane perpendicular to the reference plane passing 350 mm forward of the seat reference point, both these part planes joining, respectively, the rearmost limits of the planes (defined in Item (a) above) to the foremost limits of the planes (defined in Item (b) above).
- (j) Two portions of the horizontal plane, passing 300 mm above the seat reference point, both of which planes join, respectively, the uppermost limits of the vertical planes (defined in Item (b) above) to the lowermost limits of the oblique planes (defined in Item (g) above).
- (k) A curvilinear surface whose generating line is perpendicular to the reference plane and rests on the back of the seat backrest.

1.8.6 Repairs to ROPS Repairs to minor damage to a ROPS may be performed by a competent person familiar with ROPS manufacture.

Where repairs are made, the repairer shall affix a label in accordance with Clause 1.10.

The label shall contain at least the following information:

- (a) Name and address of the repairing company.
- (b) A statement that repairs have been carried out to the ROPS.

1.9 STABILITY TESTING

1.9.1 General This Clause sets out the stability and resistance to continuous rolling tests for narrow-track tractors, which shall be satisfactorily completed prior to carrying out any dynamic or static testing described in Sections 2 and 3.

Attention is drawn to the inherent hazards associated with tilting a tractor to a point approaching unstable equilibrium and with performing the overturning test. Care is necessary to ensure that no person can gain access to a position in which the person is exposed to any danger arising from these tests.

1.9.2 Lateral stability test The tractor is positioned on a horizontal plane so that the front axle pivot point or, in the case of an articulated tractor the horizontal pivot point between the two axles, can move freely.

Using any appropriate means, such as a jack or hoist and while continuously measuring the angle of inclination, tilt the part of the tractor which is rigidly connected to the axle that bears more than 50% of the tractor's weight. This angle shall be not less than 38° at the moment when the tractor is resting in a state of unstable equilibrium on the wheels touching the ground.

1.9.3 Non-continuous rolling test

1.9.3.1 Purpose The purpose of this test is to determine whether a structure fitted to the tractor for the purpose of protecting the driver can satisfactorily prevent a continuous roll-over of the tractor in the event of its overturning on a lateral slope having a gradient of 1:1.5.

Evidence of non-continuous rolling can be provided in accordance with either of the methods described in Clauses 1.9.3.2 and 1.9.3.3.

1.9.3.2 Demonstration of non-continuous rolling behaviour by means of the overturning test The overturning test shall be carried out on a test slope not less than 4 m long (see Figure 1.4). The surface of the test slope shall be covered with an 180 mm thick layer of a material having a cone penetration index of A (235 ±20) or B (335 ±20) when measured in accordance with ASAE S 313.2.

The tractor is placed at the start of the test slope so that the wheels on the downhill side rest on the slope and the median plane of the tractor is parallel with the contour lines. The tractor is then tilted laterally with zero forward speed until it rolls over down the test slope.

After striking the test slope on its side, the tractor may lift itself from the surface by pivoting about the upper corner of the ROPS. The tractor shall fall back to rest upon the side which struck first.

1.9.3.3 Demonstration of non-continuous rolling behaviour by calculation Prior to verifying non-continuous rolling behaviour by calculation, the following characteristic tractor data shall be ascertained (see Figure 1.5):

H_1 = height of centre of gravity, in metres

L_3 = horizontal distance between the centre of gravity and the rear axle, in metres

L_2 = horizontal distance between the centre of gravity and the front axles, in metres

D_3 = height of rear tyres, in metres

- D_2 = height of front tyres, in metres
 H_6 = overall height (point of impact height), in metres
 L_6 = horizontal distance between the centre of gravity and the leading point of intersection of the protective structure, in metres. (Where the leading point of intersection of the protective structure lies in front of the plane of the centre of gravity, this is to be assigned a negative value.)
 B_6 = width of protective structure, in metres
 H_7 = height of engine bonnet, in metres
 B_7 = width of engine bonnet, in metres
 L_7 = horizontal distance between the centre of gravity and the front corner of the bonnet, in metres
 H_0 = height of the front axle pivot point, in metres
 S = rear track width, in metres
 B_0 = rear tyre width, in metres
 D_0 = front axle swing angle (from initial point to end of travel), in radians
 M = tractor mass, in kilograms
 Q = moment of inertia about the longitudinal axis through the centre of gravity, in kilogram $\times$ metres squared

The sum of the track width S and tyre width B_0 must be greater than the width of the protective structure B_6 .

For the purpose of calculation, the following simplified assumptions can be made:

- (a) The stationary tractor overturns on a slope with a 1 in 1.5 gradient, with a balanced front axle as soon as the centre of gravity is vertically above the axis of rotation.
- (b) The axis of rotation is parallel to the longitudinal axis of the tractor and passes through the centre of the contact surfaces of the downhill front and rear wheel.
- (c) The tractor does not slide downhill.
- (d) The impact on the slope is partly elastic, with a coefficient of elasticity of $U = 0.2$.
- (e) The depth of penetration into the surface of the slope and the deformation of the protective structure, together amount to $T = 0.2$ m.
- (f) No other components of the tractor penetrate the surface of the slope.

1.10 MARKING A ROPS which has proved to fulfil the performance requirements of this Standard shall be identified by a durable label permanently attached to the main structure and protected from damage so that it might be expected to last for the life of the structure in such a way and in such a position that it can be easily read.

The label shall contain at least the following information:

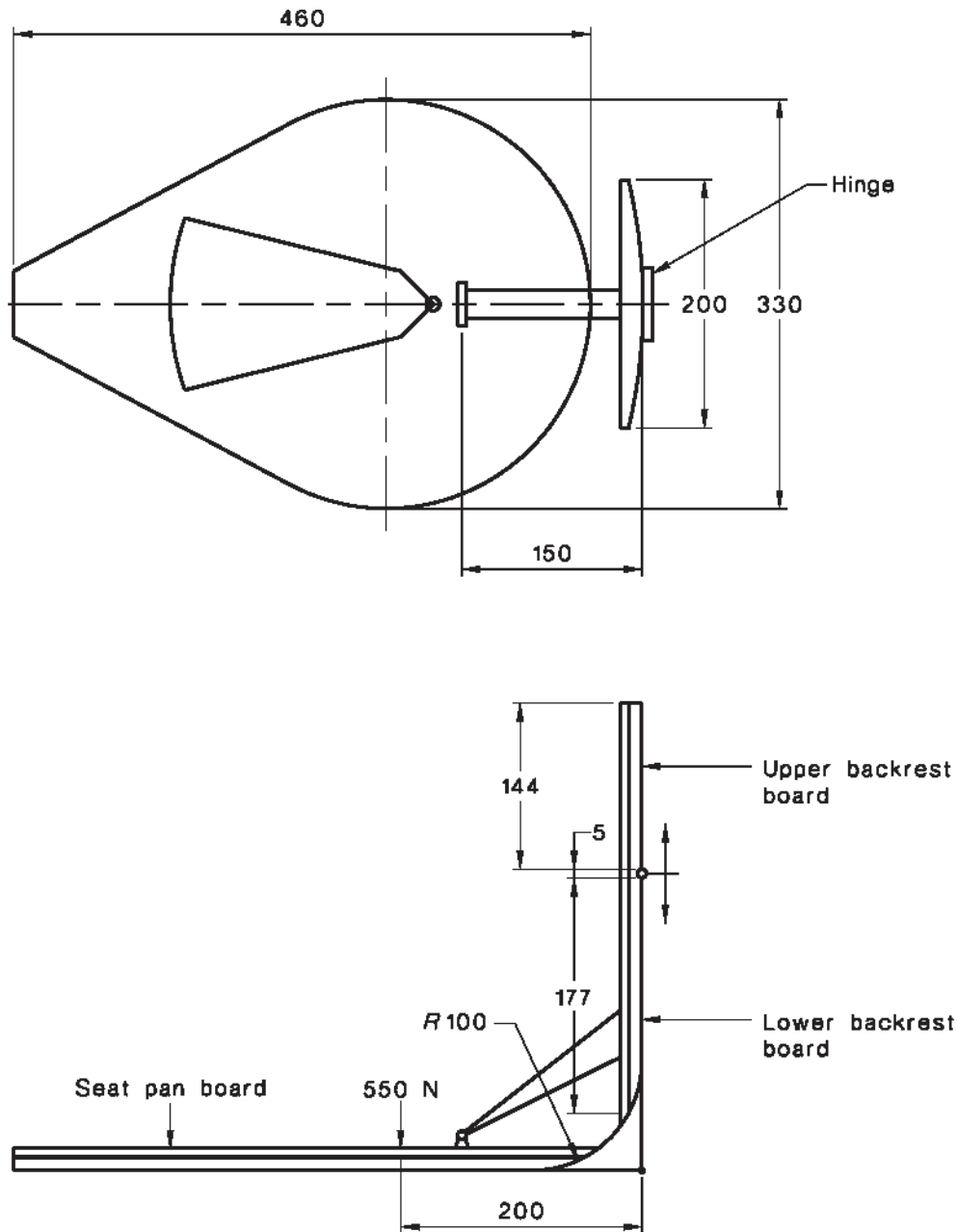
- (a) Name and address of the manufacturer or fabricator of the protective structure.
- (b) Protective structure identification number.
- (c) Tractor make, model(s) or series number(s) and mass which the structure is designed to fit.
- (d) A statement and warning generally as follows:

Tested in accordance with AS 1636.3

WARNING: ADDITIONS, ALTERATIONS, CRACKING, DAMAGE OR CORROSION TO THIS STRUCTURE MAY ADVERSELY AFFECT ITS PERFORMANCE.

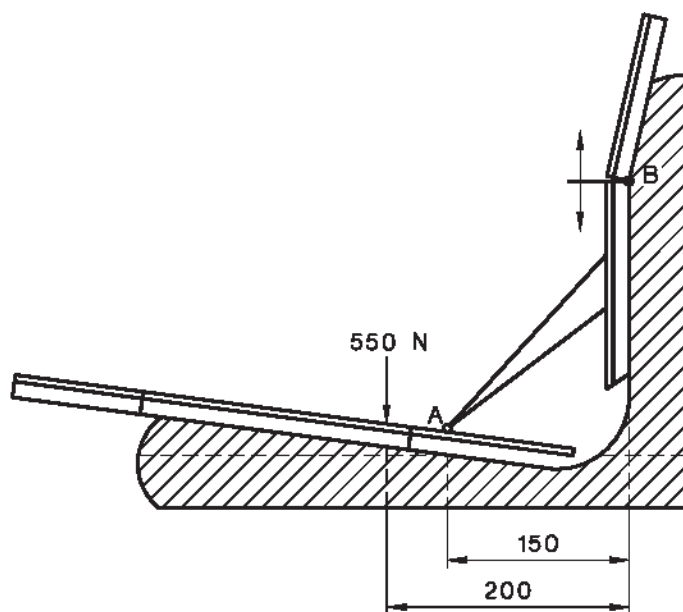
1.11 ALTERNATIVE MARKING Where a ROPS has been proven to meet the requirements of the alternative Standard herein given and notwithstanding the marking requirements of that alternative Standard, the ROPS shall be identified with a label bearing the following information:

- (a) A statement that the ROPS is deemed to comply with AS 1636.3 (this Standard).
- (b) A warning that additions, alterations, damage, cracking or corrosion may adversely affect the performance of the ROPS.



DIMENSIONS IN MILLIMETRES

FIGURE 1.1 APPARATUS FOR DETERMINATION OF SEAT REFERENCE POINT



DIMENSIONS IN MILLIMETRES

FIGURE 1.2 METHOD OF DETERMINING SEAT REFERENCE POINT