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Roll-Over Protective Structures (ROPS) for Wheeled Agricultural Tractors

RATIONALE

This document has been determined to contain stable technology which is not dynamic in nature.

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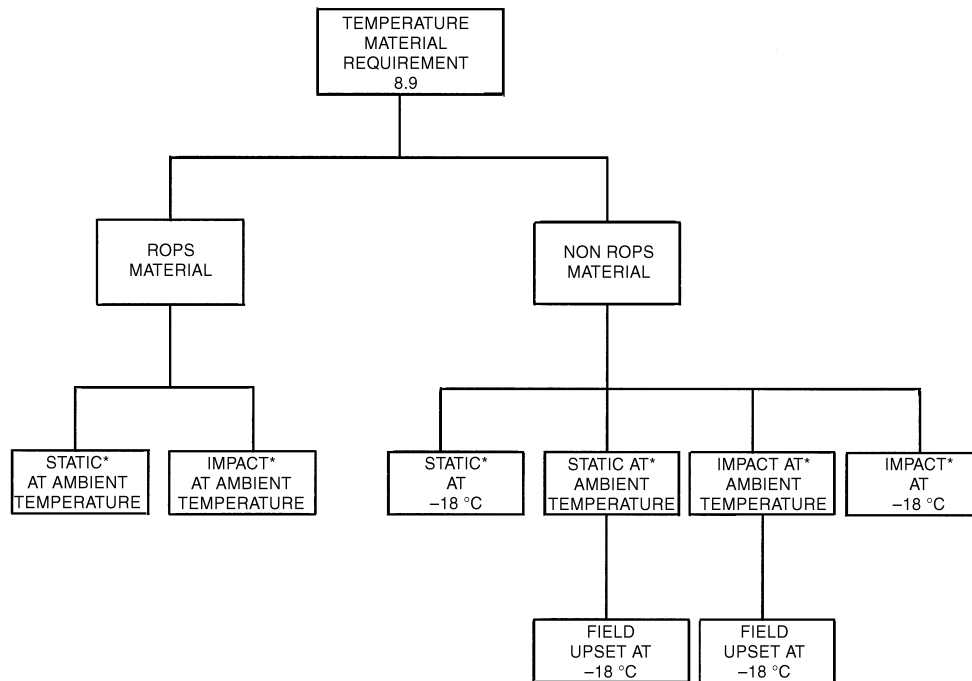
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Foreword—There was one editorial change to this document. SAE J117 was cancelled. This has been removed.

1. Scope

- 1.1** Any ROPS meeting the performance requirement of ISO 5700 (Static ROPS Test Standard) or ISO 3463 (Dynamic ROPS Test Standard) meets the performance requirements of this SAE Standard if the ROPS temperature/material and seat belt requirements of this document are also met.
- 1.2** Fulfillment of the intended purpose requires testing as follows:
 - 1.2.1** A temperature-material requirement (6.9). This can be satisfied by using the appropriate materials or by performing any of the structural performance tests (Sections 7, 8, or 9) at -18°C .
 - 1.2.2** A laboratory test, under repeatable and controlled loading, to permit analysis of the ROPS for compliance with the performance requirements of this document. Either the static test sequence (Section 7) or the impact test sequence (Section 8) shall be conducted. See Figure 1.
 - 1.2.3** A seat belt anchorage test (Section 10).
- 1.3** The test procedures and performance requirements outlined in this document are based on currently available engineering data.
- 1.4 Purpose**—The purpose of this document is to establish the test and performance requirements of a roll-over protective structure (ROPS), designed for wheeled agricultural tractors to minimize the frequency and severity of operator injury resulting from accidental tractor upset.



*See 5.2 for limitation.

FIGURE 1—TEMPERATURE MATERIAL REQUIREMENT

2. References

2.1 Applicable Publications—The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J114—Seat Belt Hardware Webbing Abrasion Performance Requirements
SAE J140—Seat Belt Hardware Test Procedure
SAE J141—Seat Belt Hardware Performance Requirements
SAE J339—Seat Belt Hardware Webbing Abrasion Test Procedure
SAE J800—Motor Vehicle Seat Belt Assembly Installation
SAE J1150—Terminology for Agricultural Equipment
SAE J1194—Rollover Protective Structures (ROPS) for Wheeled Agricultural Tractors

2.1.2 ASAE PUBLICATIONS—Available from the American Society of Agricultural Engineers, 2950 Niles Road, St. Joseph, MI 49085-9659.

ASAE S313—Soil Cone Penetrometer
ASAE S383—Roll-Over Protective Structures (ROPS) for Wheeled Agricultural Tractors

2.1.3 ASTM PUBLICATION—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM A 370—Standard Methods and Definitions for Mechanical Testing of Steel Products

2.1.4 ISO PUBLICATIONS—Available from ANSI, 25 West 43rd Street, New York, NY 10036-8002.

ISO 612—Road vehicles—Dimensions of motor vehicles and towed vehicles—Terms and definitions

ISO 3462—Tractors and machinery for agriculture and forestry—Seat reference point—Method of determination

ISO 3463—Dynamic ROPS test standard

ISO 5700—Static ROPS test standard

2.2 Related Publications—The following publications are provided for information purposes only and are not a required part of this document.

2.2.1 SAE PUBLICATIONS—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J429—Mechanical and Material Requirements for Externally Threaded Fasteners

SAE J674—Safety Glazing Materials—Motor Vehicles and Motor Vehicle Equipment

SAE J995—Mechanical and Material Requirements for Steel Nuts

3. Definitions

3.1 Agricultural Tractor—A traction machine designed and advertised primarily to supply power to agricultural implements and farmstead equipment. An agricultural tractor propels itself and provides a force in the direction of travel to enable attached soil engaging and other agricultural implements to perform their intended function per SAE J1150.

3.2 Rollover Protective Structure (ROPS)—A cab or frame for the protection of operators of agricultural tractors to minimize the possibility of serious operator injury resulting from accidental upset. The ROPS is characterized by providing space for the clearance zone inside the envelope of the structure or within a space bounded by a series of straight lines from the outer edge of the structure to any part of the tractor that might come in contact with flat ground and is capable of supporting the tractor in that position if the tractor overturns. The mounting structure and fasteners forming the mounting connection with the tractor are part of the ROPS.

3.3 Tractor Mass—The mass of the unladen tractor in operating order with tanks and radiators full, protective structure with cladding and any wheel equipment or additional front wheel drive components required to support the tractor static weight. The operator, optional hitch equipment, optional ballast weights, additional wheel equipment, and other special equipment are not included.

3.4 Reference Mass—A mass, not less than the tractor mass, selected for calculation of the force and energy inputs to be used during tests.

3.5 Seat Reference Point (SRP)—The seat reference point shall be determined in accordance with ISO 3462 with the seat adjusted to its rearmost and uppermost position. For a suspended seat, the seat shall be set to the midpoint of the suspension travel, unless this is contradictory to clearly stated instructions by the manufacturer of the seat. Where special instructions for the seat setting exist, these shall be observed.

3.6 Static Test Horizontal Loading—The application of a horizontal static load to the rear, front, or side of the ROPS.

3.7 Impact Test—The application of a dynamic load to the rear, front, or side of the ROPS produced by a mass acting as a pendulum.

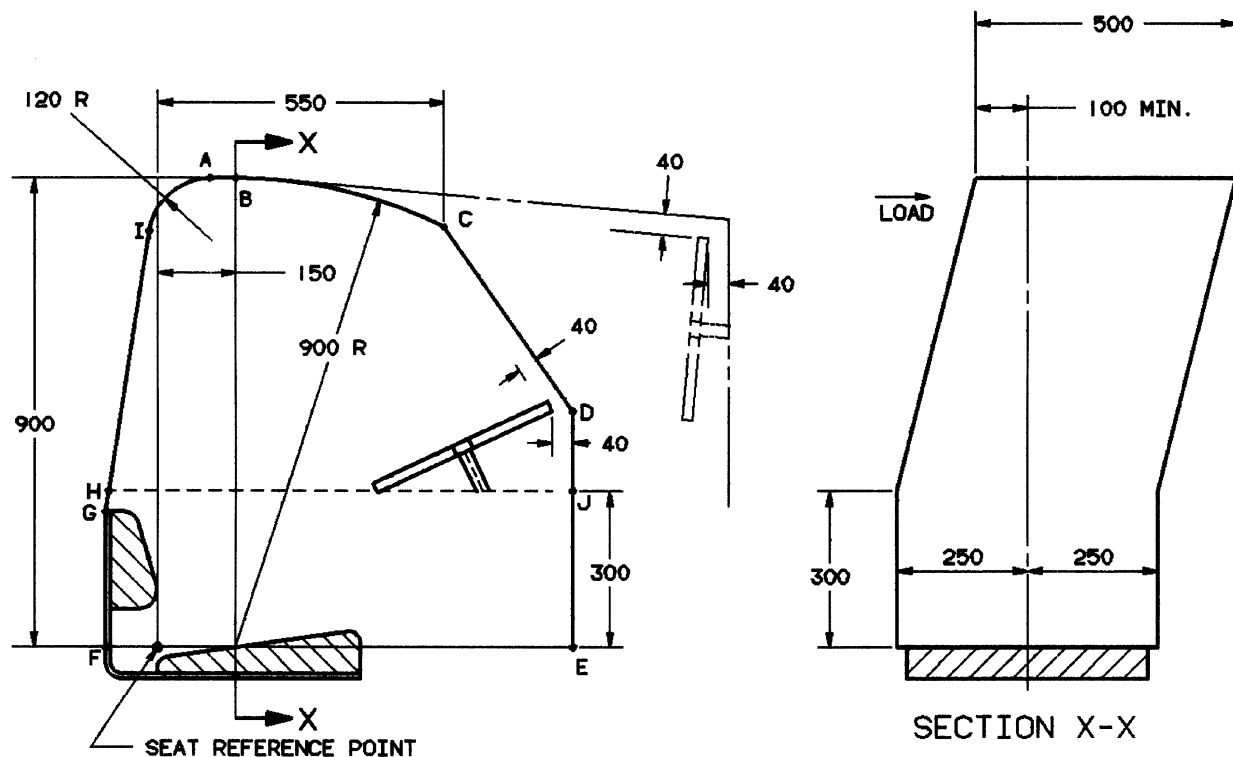
3.8 Crushing Test—The application of a vertical static load through a beam placed laterally across the uppermost members of the ROPS. The resultant of the initial crushing load shall be in the vertical direction and shall be in a vertical reference plane passing through the SRP and parallel to the longitudinal axis of the tractor.

3.9 Vertical Reference Plane—A vertical plane, generally longitudinal to the tractor and passing through the SRP and the center of the steering wheel.

NOTE—Normally the vertical reference plane coincides with the longitudinal median plane of the tractor.

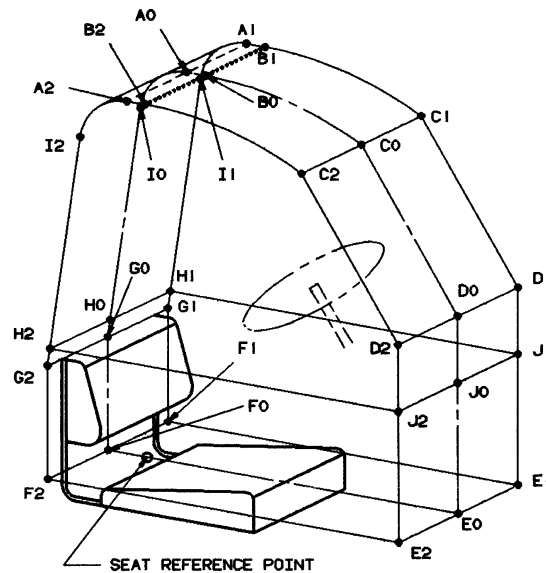
3.10 ROPS Material—Any material that meets the requirements set forth in 6.9.1.

3.11 Clearance Zone—The clearance zone is illustrated in Figures 2A and 2B. Referring to the figures, the zone is defined in relation to the vertical reference plane. This reference plane shall be assumed to move horizontally with the seat and steering wheel during loading and to remain perpendicular to the tractor or the floor of the protective structure. The clearance zone is defined when the tractor is standing on its wheels on a horizontal surface and, where applicable, the steering wheel is adjusted to the midposition for seated driving.



DIMENSIONS ARE MILLIMETERS.

FIGURE 2A—CLEARANCE ZONE FROM THE SIDE



DIMENSIONS	mm	REMARKS
A1A0 B1B0	100	Minimum
A1A2 B1B2 C1C2	500	
D1D2 E1E2	500	{ Minimum or equal to the diameter of the steering wheel plus 80mm, whichever is the greater.
F1F2 G1G2 H1H2 I1I2 J1J2	500	
E1E0 E2E0	250	{ Minimum or equal to the radius of the steering wheel plus 40mm, whichever is the greater.
J0E0 F0G0 I0G0 C0D0 E0F0	300 - - - -	Depending on the tractor.

FIGURE 2B—CLEARANCE ZONE DEFINITION

NOTE—Referring to Figure 2B:

- A horizontal plane ($A_1B_1B_2A_2$) 900 mm above the seat reference point.
- An inclined plane ($G_1G_2I_2I_1$) perpendicular to the reference plane and including the rearmost point of the seat backrest and the extension of which passes through a point 900 mm directly above the seat reference point
- A cylindrical surface ($A_1A_2I_2I_1$) perpendicular to the reference plane, with a radius of 120 mm tangential to the planes defined in (a) and (b)
- A cylindrical surface ($B_1C_1C_2B_2$) perpendicular to the reference plane, having a radius of 900 mm extending forward for 400 mm from and tangential to the plane defined in (a) at a point 150 mm forward of the seat reference point
- An inclined plane ($C_1D_1D_2C_2$) perpendicular to the reference plane, joining the surface defined in (d) at its forward edge and passing 40 mm from the rim of the steering wheel

- f. A vertical plane ($D_1E_1E_2D_2$) perpendicular to the reference plane 40 mm forward of the rim of the steering wheel
- g. A horizontal plane ($E_1F_1F_2E_2$) through the seat reference point
- h. A surface ($G_1F_1F_2G_2$), curved if necessary, from the bottom limit of the plane defined in (b) to the horizontal plane defined in (g) following the general direction of, and in contact with, the rear surface of the seat backrest
- i. Vertical planes ($J_1E_1F_1G_1H_1$ and $J_2E_2F_2G_2H_2$) not less than 250 mm on either side of the reference plane;
The distance E_1E_2 shall be equal to the diameter of the steering wheel plus 40 mm on each side of the rim of the wheel or 500 mm, whichever is greater
- j. Parallel planes ($A_1B_1C_1D_1J_1H_1I_1$ and $A_2B_2C_2D_2J_2H_2I_2$) inclined so that the upper edge of the plane on the side on which the load is applied is at least 100 mm from the reference plane

3.12 Longitudinal Median Plane—See ISO 612.

3.13 Gross Machine Mass—Tractor mass as described in 3.3 with the addition of an operator, wheel equipment, ballast weights, hitch equipment, and special equipment required for operation.

4. Symbols

- m = Tractor mass, as defined in 3.3, in kilograms
- m_t = Reference mass, as defined in 3.4, in kilograms
- D = Deflection of the ROPS at the point of and in line with the load application, in millimeters
- $D_{\max}$ = Total deflection of the ROPS during static test corresponding to E_i , in millimeters
- D' = Deflection of the ROPS for the calculated energy required, in millimeters
- F = Static load force, in newtons
- $F_{\max}$ = Maximum static load force occurring during loading, with the exception of the overload, in newtons
- F' = Force for the calculated energy required, in newtons
- E_{is} = Energy input to be absorbed during side loading, in joules
- $F-D$ = Force-deflection curve
- $E_{il,1}$ = Energy input to be absorbed during longitudinal loading, in joules
- $E_{il,2}$ = Energy input to be absorbed during a second longitudinal loading, in joules
- F_r = Applied force at rear in the crushing test, in newtons
- F_f = Applied force at front in the crushing test, in newtons
- E_i = Energy absorbed by the ROPS area under $F-D$ curve at the point where $D = D_{\max}$, in joules
- E'_i = Total energy absorbed by the ROPS structure after static overload test, in joules
- H = Height of pendulum at start of impact test, in millimeters
- L = Reference wheelbase, which shall be not less than the maximum wheelbase, in millimeters
- I = Reference moment of inertia about the rear axle, excluding the rear wheels which shall be not less than the maximum moment of inertia in kilogram meters squared

5. Applications

5.1 This document applies to wheeled agricultural tractors as defined in 3.1. It does not preclude the use of extendable or foldable ROPS as long as these ROPS meet the performance requirements of the document. Tractors used in construction and self-propelled implements are excluded.

5.2 Test procedures in this document are limited by tractor mass (see 3.3) as follows:

5.2.1 STATIC TEST (SECTION 7)—800 kg min.

5.2.2 IMPACT TEST (SECTION 8)—800 to 6000 kg.

5.2.3 FIELD UPSET TEST (SECTION 9)—No limitation.

- 5.3** The minimum tread of the rear wheels should generally be greater than 1150 mm. This Standard Code may not apply to some designs of tractors, for example, lawn mowing tractors, narrow vineyard tractors, low profile tractors used in buildings with limited overhead clearance or orchards, and stilt tractors (high clearance). For specialized applications, SAE J1194 (ASAE S383) may be used.

6. General Requirements

- 6.1** The ROPS shall be to production specifications. Where a number of tractor models form a family and use the same ROPS, testing may be performed based on the largest tractor mass within the family. New ROPS and mounting connections shall be used for conducting the test sequence described in Figure 4.
- 6.2** A tread setting for the wheels, if present, shall be chosen such that no interference exists with the ROPS during the tests.
- 6.3** Moveable ROPS sections, such as windows, or removable sections, such as doors, which may add to structural strength, shall be removed or placed in configurations that contribute least to strength during a test. All normally moveable glazing shall be removed before tests; however, glazing material that is permanently affixed or is designed as a structural component need not be removed.
- 6.4** If an overhead weather shield or overhead falling object protective cover is available as an optional attachment to the ROPS, it may be in place during tests, provided it does not contribute to the strength of the ROPS.
- 6.5** In case of an offset seat and/or nonsymmetrical strength of the ROPS structure, the side loading shall be on the side more likely to lead to infringement of the clearance zone.
- 6.6** Repairs or adjustments to the ROPS shall not be made during the test sequence.

6.7 Accuracy of Measurement

- a. Dimensions: ± 3 mm
 - b. Deflections: ± 3 mm
 - c. Tractor Mass: ± 20 kg
 - d. Loads and Forces: $\pm 2\%$
 - e. Direction of Loading:
 1. At start of test: ± 2 degrees, all loading.
 2. During test: 10 degrees above to 20 degrees below horizontal, for horizontal loads
 - f. Pendulum lift height: ± 6 mm
 - g. Mass of pendulum: ± 20 kg
 - h. Pendulum suspension angle: ± 2 degrees
 - i. Moment of inertia: $\pm 5\%$
- 6.8** If any fixturing used to restrain the tractor breaks or shifts during any test, the test shall be repeated.

6.9 Material Requirements

- 6.9.1** The temperature material requirements will be met:
- a. If the ROPS passes any of the structural performance tests (Sections 7, 8, or 9) at a metal temperature of -18 °C or below, or
 - b. If the structural members are from material which exhibits Charpy V-notch impact strengths at -30 °C shown in Table 1.