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Document Name: SAE J320: Minimum Performance Criteria for Roll-Over Protective Structures for Rubber-Tired Self-Propelled Scrapers

CFR Section(s): 29 CFR 1926.1001(h)

Standards Body: Society for Automotive Engineering

APPROVED

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MINIMUM PERFORMANCE CRITERIA FOR ROLL-OVER PROTECTIVE STRUCTURES FOR PRIME MOVERS—SAE J320b

SAE Recommended Practice

Report of Construction and Industrial Machinery Technical Committee approved November 1967 and last revised January 1972. Editorial change September 1972.

1. Objective—This SAE Recommended Practice is intended to establish a consistent, repeatable means of evaluating force-deflection characteristics of roll-over protective structures under static loading and to prescribe minimum performance requirements for these structures under such loading. Roll-over protective structures (ROPS) are structures whose primary purpose is to reduce the possibility of an operator being crushed should his vehicle roll over.

2. Scope—These criteria apply to pneumatic-tired prime movers such as those used to pull scrapers, water wagons, bottom dump wagons, side dump wagons, rear dump wagons, and towed fifth wheel attachments. (See SAE J869, J728, and J734 for description and nomenclature.)

Because this recommended practice presents both procedure and criteria that are intended for consideration as worldwide standards for ROPS, the following points are explicitly stated to aid in understanding its underlying principles, intention, and application.

2.1 This evaluation procedure will not necessarily duplicate structural deformations due to a given actual roll.

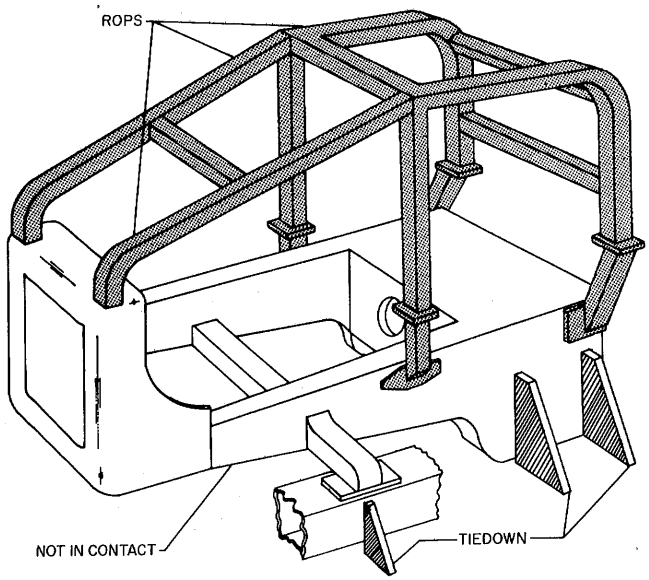


FIG. 1—TYPICAL BUT NOT MANDATORY TEST CONFIGURATION

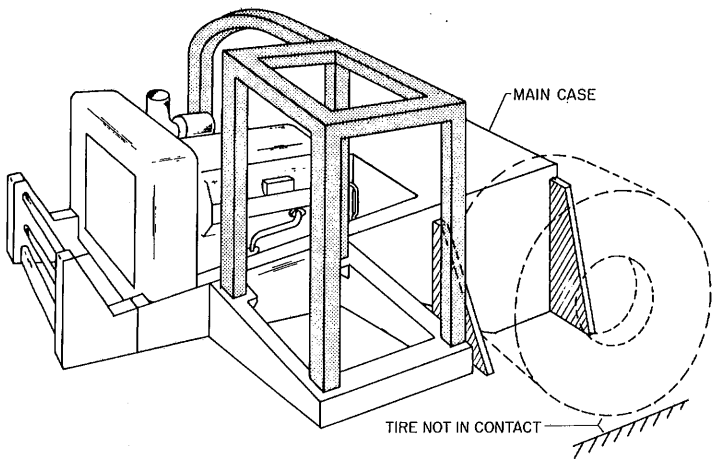


FIG. 2—TYPICAL BUT NOT MANDATORY TEST CONFIGURATION

2.2 This evaluation procedure is generally destructive of the ROPS-vehicle assembly, as permanent deformation is apt to be induced in either or both.

2.3 Although ROPS meeting these criteria may not give crush protection under all conceivable circumstances in which a vehicle could overturn, it is expected that crush protection will be assured under at least the following condition: an initial forward velocity of 0-10 mph (0-16 km/h) on a hard clay surface of 30 deg maximum slope, 360 deg of roll about the vehicle's longitudinal axis without losing contact with the slope.

2.4 The side load force requirement and limitation on deflection (critical zone) are intended to assure that the ROPS will penetrate unfrozen soil, thereby giving a braking action to a roll.

2.5 The side load energy requirement and limitation on deflection (critical zone) are intended to assure that the ROPS will deflect when it impacts a surface that will not significantly deform (frozen ground, concrete, rock), while retaining significant capability of withstanding subsequent impacts.

2.6 The vertical loading requirement is intended to assure that a deformed ROPS will be able to support the vehicle in an upside-down attitude.

2.7 The temperature-material requirement is intended to assure the ROPS will have meaningful resistance to brittle fracture. The material requirement is the conventional Charpy V notch evaluation; it is primarily a quality control check and the indicated temperatures do not directly relate to operating conditions.

2.8 The side load force-energy-deflection limitation criterion should not be taken to mean that either minimum side force or minimum energy are to be met just at the critical zone deflection limitation or that they shall be met simultaneously.

2.9 Because, in an actual roll, loading will be dynamic (possibly impact), the use of conventional "safety factors" based on static force loading should be used with caution. The "safety factor" of a ROPS is related more to energy absorption capability and details of weldment design and welding procedure than it is to static force resistance.

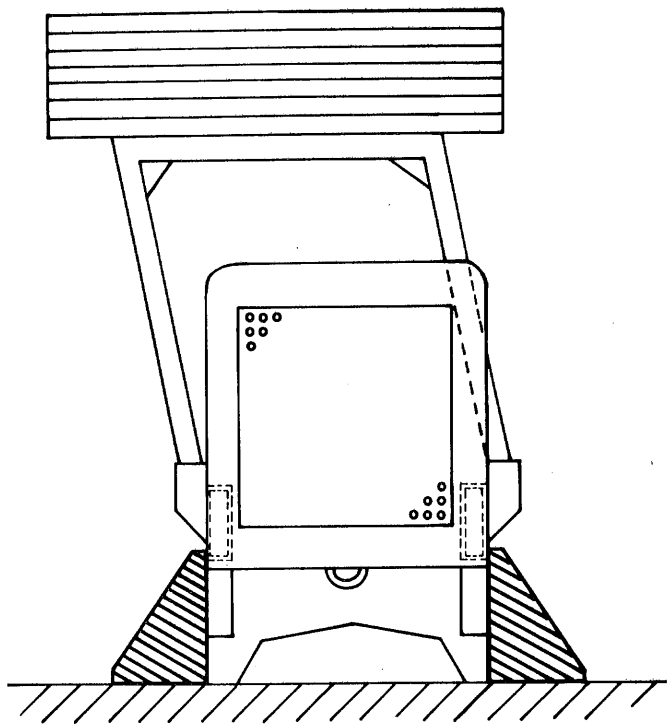


FIG. 3—TYPICAL BUT NOT MANDATORY TEST CONFIGURATION

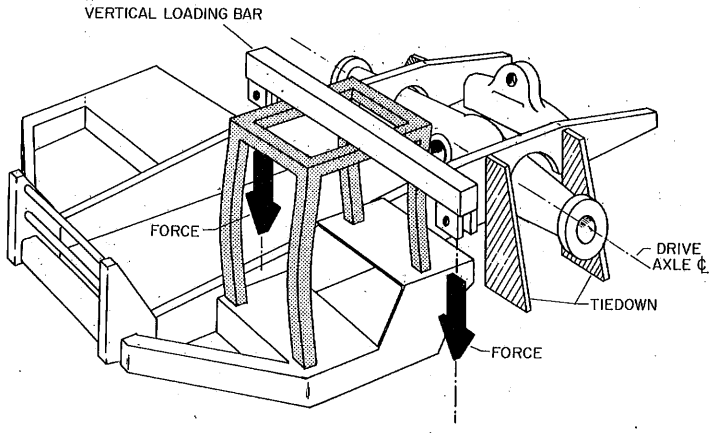


FIG. 4—TYPICAL BUT NOT MANDATORY TEST CONFIGURATION

3. Facilities and Instruments—Facilities to secure the ROPS-vehicle frame assembly to the bedplate, as described below, and to apply the side and vertical loads are required. Typical, but not mandatory, loading arrangements are shown in Figs. 1-4.

Instrument systems used to measure weight, force, and deflection shall be as follows:

Means to Measure	Accuracy
Deflection of ROPS	±5% of max deflection measured
Vehicle weight	±5% of max weight measured
Force applied to ROPS	±5% of max force measured

The above percentages are nominal ratings of the accuracy of the instrumentation and should not be taken to indicate that compensating overtest is required.

4. ROPS-Vehicle Assembly and Attachment to Bedplate—The ROPS shall be attached to the vehicle frame as it would be on an operating vehicle. A complete vehicle is not required for the evaluation; however, the vehicle frame and ROPS mounting must represent an operating installation. All normally detachable windows, panels, doors, and other nonstructural elements shall be removed so they do not contribute to or detract from the structural evaluation.

For side loading, the ROPS-vehicle frame assembly shall be secured to the bedplate so that the members connecting the assembly and bedplate experience minimal deflection when the ROPS is side loaded. See Figs. 1 and 2. Connection to the bedplate shall be directly from the vehicle frame (or case) at or near the drive tire or axle location. (For prime movers that are adaptations of another basic vehicle, for example, trucks, wheel tractors, etc., the tie-down shall be as specified under the ROPS criteria for the basic vehicle.) During side loading, the ROPS-vehicle frame assembly shall not receive any support from the bedplate, other than that due to the initial attachment. (See SAE J728 and J869 for nomenclature.)

The assembly shall be secured and/or modified so that any vehicle element that might be considered a suspension (rubber, gas, gas-oil, or mechanical spring) shall be effectively eliminated as an energy absorber.

For the vertical loading, there is no limitation on securing or supporting the ROPS-vehicle frame assembly other than that no repair or straightening of the assembly is permissible.

5. Procedure

5.1 **Side Loading**—The force-deflection characteristics shall be determined by side loading the top of the ROPS. The side loading may be applied through a load distribution device which shall not be longer than 80% of the horizontal distance from the front to the rear of ROPS at the top (Fig. 5), except when a simple, two-post frame with cantilevered FOPS-weather shield is evaluated. For the latter structures, the initial line of action is dictated by the total longitudinal distance between major, upper ROPS members; and it shall be applied at one-third of this distance from the frame (Fig. 6). This side force on the two-post frame may be applied through a load distribution plate; however, the use of the plate must not impede any torsional rotation of the ROPS during loading.

The initial direction of loading shall be horizontal and perpendicular

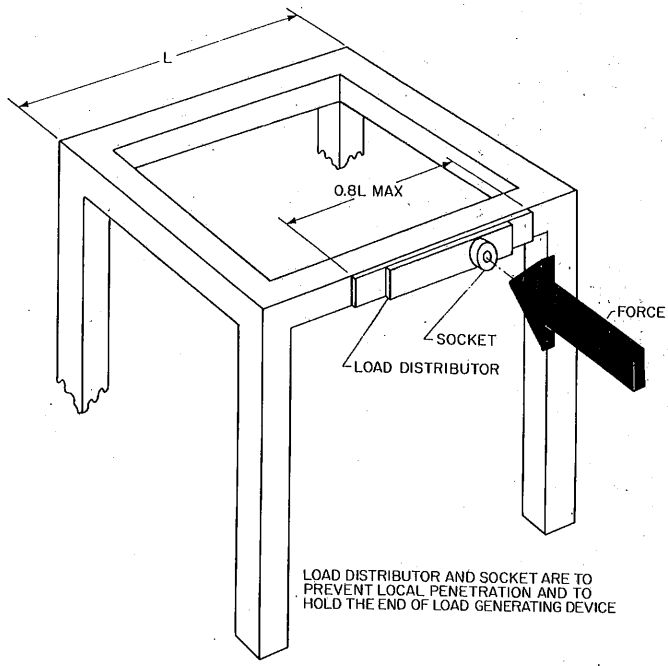


FIG. 5—TYPICAL BUT NOT MANDATORY TEST CONFIGURATION

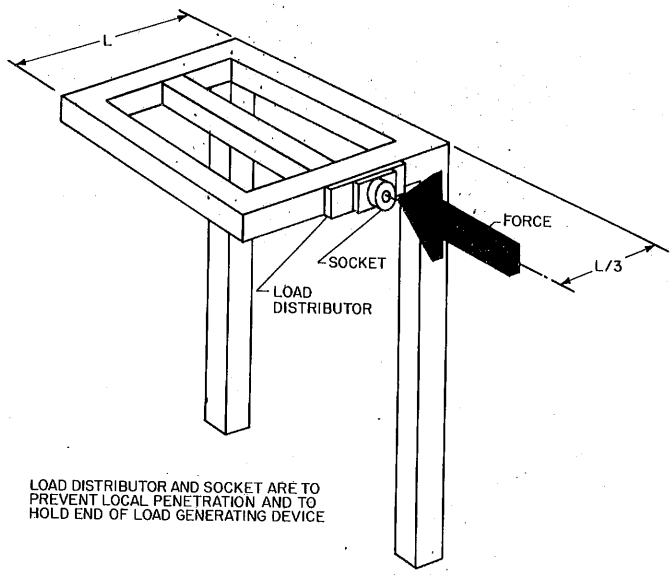


FIG. 6—TYPICAL BUT NOT MANDATORY TEST CONFIGURATION

to a vertical plane through the vehicle's longitudinal centerline. As loading continues, the ROPS-vehicle frame deformations may cause the direction of loading to change; this is permissible.

Should the operator's seat be off of the vehicle's longitudinal centerline, the loading shall be against the outermost side nearest the seat. For on-centerline seats, if mounting of the ROPS is such that different force-deflection relations are obtained from loading from left or right sides, the side loaded shall be that which will place the most severe requirements on the ROPS-vehicle assembly.

The rate of application of deflection (load) shall be such that it can be considered static. At deflection increments no greater than 0.5 in (13 mm) at the point of application of the resultant load, force and deflection are to be recorded. This loading is to continue until the ROPS has achieved both the force and energy requirements. (See Fig. 7 for method of calculating energy.) The deflection(s) used in calculating energy is (are) to be that of the ROPS along the line(s) of action of the force(s). Any deflection of members used to support load application

devices shall be deducted from total deflection.

5.2 Vertical Loading—After removal of the side load, a vertical load shall be applied to the top of the ROPS. There are no limitations on the manner of distributing this load on the ROPS. See Figs. 3 and 4 for a typical vertical loading arrangement.

5.3 General—No repair or straightening of any ROPS-vehicle member shall be carried out during or between the side and vertical loading.

6. Force-Energy and Vertical Load Requirements—These requirements shall be met within the deflection(s) permitted by the critical zone (SAE J397) interpretation. The requirements are related to W, the vehicle manufacturer's "maximum recommended weight" in pounds (newtons) of the prime mover.

6.1 The side load force attained shall be as required by the following equation:

$$F = 8500\left[\frac{W}{10{,}000}\right]^{1.22} \text{lb} \quad \left(F = 6121\left[\frac{W}{10{,}000}\right]^{1.22} \text{N}\right)$$

If the force is attained before the energy, the force level may decrease but must again attain the required level when the energy is achieved or exceeded.

6.2 The energy absorbed during side loading shall be as required by the following equation:

$$U = 70{,}000\left[\frac{W}{10{,}000}\right]^{1.25} \text{in-lb} \quad \left(U = 1224\left[\frac{W}{10{,}000}\right]^{1.25} \text{J}\right)$$

6.3 After removal of the side load, the ROPS-vehicle assembly shall support a vertical load of the maximum recommended weight.

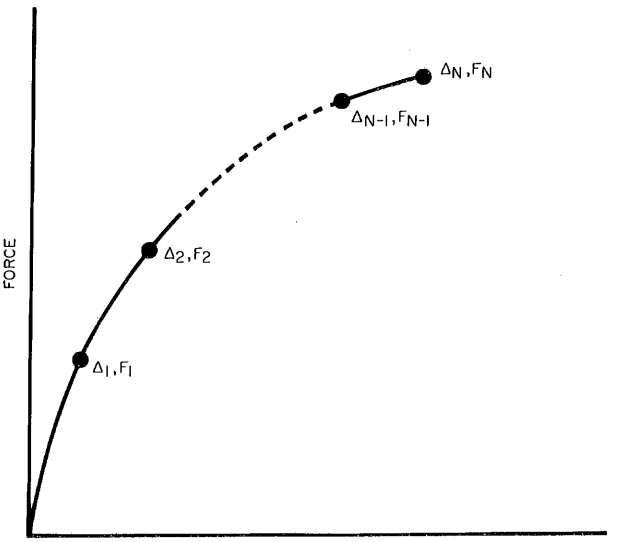
7. Temperature-Material Requirements—The laboratory evaluations shall be performed with all ROPS and vehicle frame members soaked to 0 F (−17.8 C) or below. In lieu of performing the evaluations at this temperature, the following minimum material requirements shall be met.

7.1 Bolts and nuts used to attach the ROPS to the vehicle frame and to connect structural parts of the ROPS shall be SAE Grade 5 or 8 (see SAE J429 and J995).

7.2 Structural members of the ROPS and the mounts which attach it to the vehicle frame shall be made of steels that have one of the following Charpy V notch impact strengths:

10 mm x 10 mm specimen: 8 ft-lb at −20 F (10.8 J at −30 C)

10 mm x 8 mm specimen: 6.4 ft-lb at −20 F (8.6 J at −30 C)



$$\text{AREA} = \frac{\Delta_1 F_1}{2} + (\Delta_2 - \Delta_1)\left[\frac{F_1 + F_2}{2}\right] + \cdots$$
$$+ (\Delta_N - \Delta_{N-1})\left[\frac{F_{N-1} + F_N}{2}\right]$$

FIG. 7

10 mm x 5 mm specimen: 5 ft-lb at −50 F (6.8 J at −45 C)

10 mm x 2.5 mm specimen: 2 ft-lb at −70 F (2.7 J at −57 C)

(See ASTM A 370-68, Standard Methods and Definitions for Mechanical Testing of Steel Products.)

Specimens are to be "longitudinal" and taken from flat stock, tubular, or structural sections before forming or welding for use in the ROPS. Specimens from tubular or structural sections are to be taken from the middle of the side of greatest dimension—not to include welds.