SOCIETY OF AUTOMOTIVE ENGINEERS, INC. • TWO PENNSYLVANIA PLAZA • NEW YORK, NEW YORK 10001

LAND SEA AIR SPACE

TECHNICAL REPORT J394a

MINIMUM PERFORMANCE CRITERIA FOR ROLL-OVER PROTECTIVE STRUCTURES FOR WHEELED FRONT-END LOADERS AND WHEELED DOZERS—SAE J394a

SAE Recommended Practice

Report of Construction and Industrial Machinery Technical Committee approved July 1969 and last revised March 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 wheeled front-end loaders and wheeled dozers.

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.

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 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.

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.

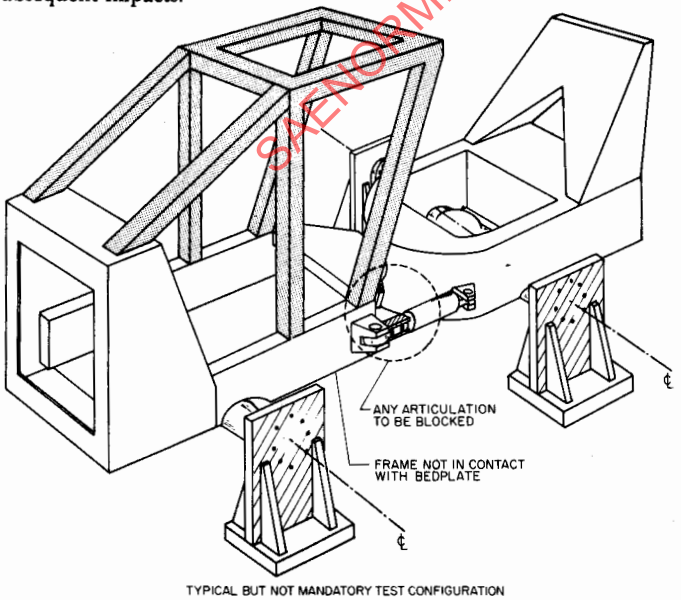


FIG. 1—TYPICAL BUT NOT MANDATORY TEST CONFIGURATION

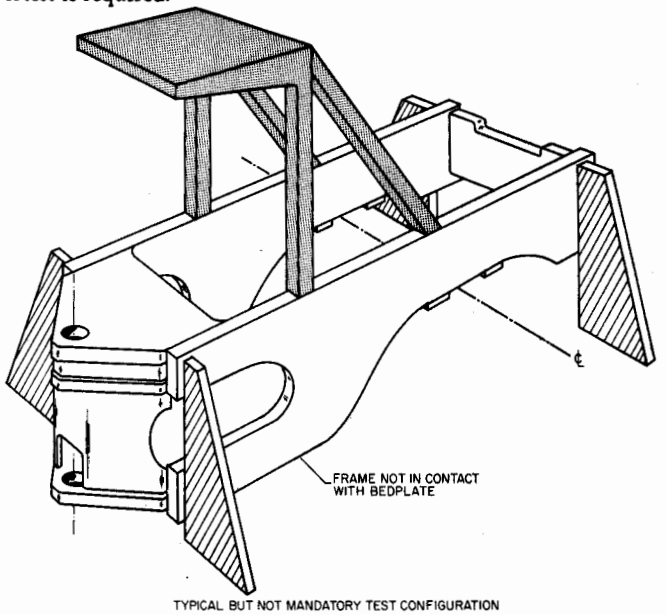


FIG. 2—TYPICAL BUT NOT MANDATORY TEST CONFIGURATION

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.

Connections shall be directly from the vehicle frame at or near the front axle support and the rear drive support. For articulated vehicles, the hinge shall be locked if both frames are used in the evaluation; if only that frame to which the ROPS is mounted is used, the connections shall be at or near the extreme ends of the frame. During side loading, the ROPS-vehicle frame assembly shall not receive any support from the bedplate, other than that due to the initial attachment.

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 nor straightening of the assembly is permissible.

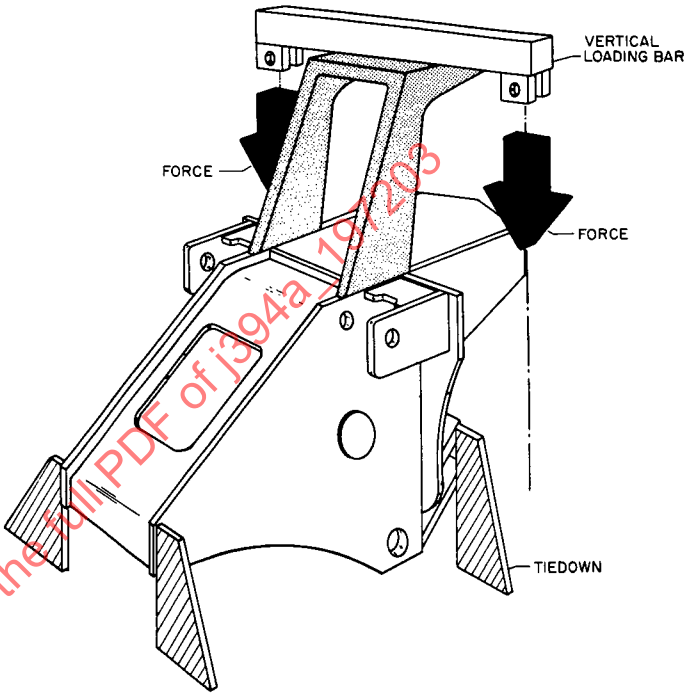
5. Procedure

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). The side force on the two-post frame may be applied through a load distribution plate; however, the use of this plate must not impede any torsional rotation of the ROPS during loading.

The initial direction of loading shall be horizontal and perpendicular 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 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 requirement on the ROPS-vehicle frame assembly.

The rate of application of deflection (load) shall be such that it can be considered static. At deflection increments at the point of application of the resultant load, no greater than 0.5 in (13 mm) 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



TYPICAL BUT NOT MANDATORY TEST CONFIGURATION

FIG. 4—TYPICAL BUT NOT MANDATORY TEST CONFIGURATION

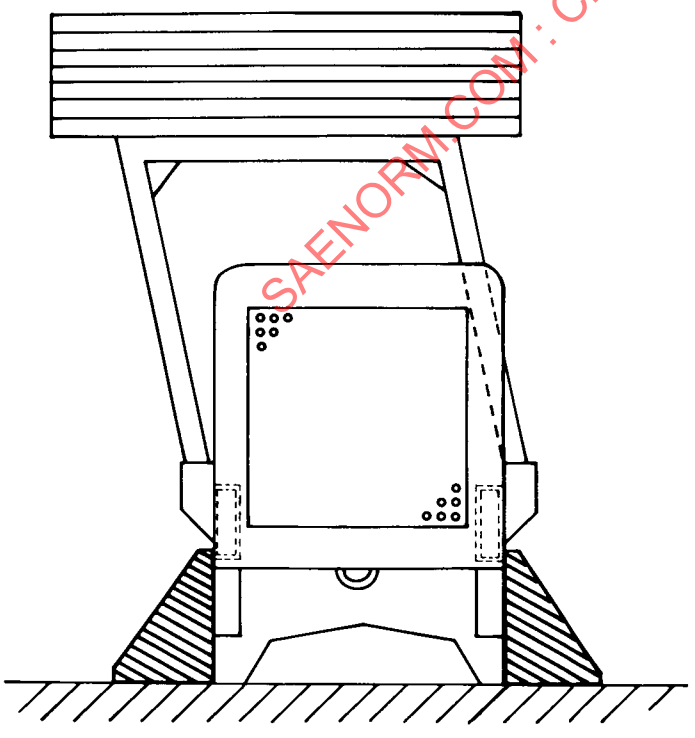


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FIG. 3—TYPICAL BUT NOT MANDATORY TEST CONFIGURATION

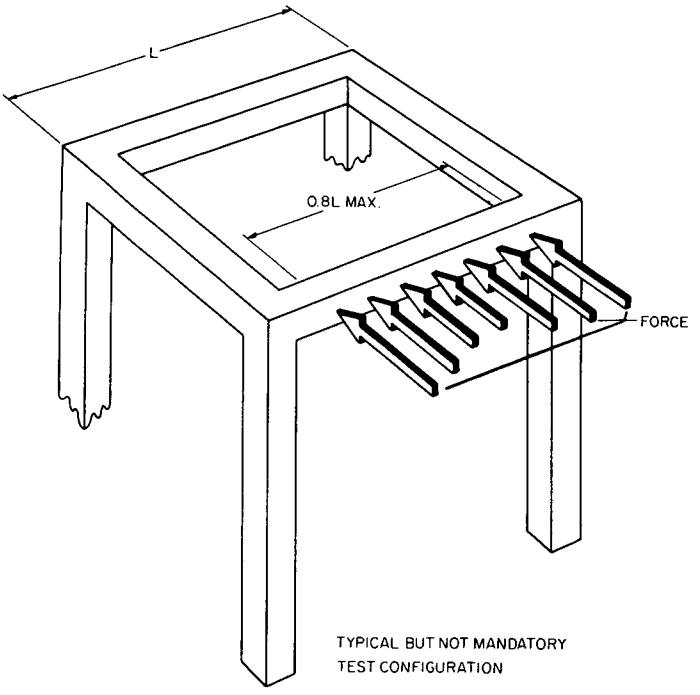

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FIG. 5—TYPICAL BUT NOT MANDATORY TEST CONFIGURATION