Protective Enclosures for Agricultural Tractors - Test Procedures and Performance Requirements - SAE J168a

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

SAE STANDARD
APPROVED FEBRUARY 1974

PROTECTIVE ENCLOSURES FOR AGRICULTURAL TRACTORS—TEST PROCEDURES AND PERFORMANCE REQUIREMENTS—SAE J168a SAE Standard

Report of Tractor Technical Committee approved July 1970 and last revised February 1974.

1. Purpose—The purpose of this standard is to establish the test and performance requirements of a protective enclosure designed for wheel-type agricultural tractors to minimize the frequency and severity of operator injury resulting from accidental upset during normal operations. General requirements for the protection of operators are specified in SAE J333.

2. Scope

2.1 Fulfillment of the intended purpose requires testing as follows:

2.1.1 A laboratory test, either static or dynamic, under repeatable and controlled loading, to permit analysis of the protective enclosure for compliance with the performance requirements of this standard.

2.1.2 A field upset test under reasonably controlled conditions, both to the side and rear, to verify effectiveness of the protective system under actual dynamic conditions. If the protective enclosure laboratory energy absorption test (static or dynamic) results indicate compliance of 115% or more, the field upset test (paragraph 5.4) may be omitted. Compliance of at least 115% input energy level is to be determined on the basis of paragraph 5.2.2 or 5.3.2.

2.2 The test procedures and performance requirements outlined in this standard are based on currently available engineering data.

3. Definitions

3.1 An agricultural tractor is defined in paragraph 2.1 of SAE J333.

3.2 The weight of the tractor includes the protective enclosure, all fuels, and other components required for normal use of the tractor. Ballast shall be added as necessary to achieve a minimum total weight of 110 lb (50.0 kg) per maximum power takeoff horsepower (watts) at rated engine speed or the maximum gross vehicle weight specified by the manufacturer, whichever is the greatest. Front end weight shall be at least 25% of the tractor test weight. (In case power takeoff horsepower is not available, use 95% of net engine flywheel horsepower.)

4. Description—The protective enclosure to which this standard applies is a structure generally comprising a frame and/or enclosure mounted to the tractor and conforming generally to Fig. 1 and paragraph 6.1.6 exit requirements.

5. Test Procedures

5.1 General

5.1.1 The tractor weight used shall be that of the tractor model with the maximum weight on which the protective enclosure is to be used (paragraph 3.2).

5.1.2 A new protective enclosure (structural members of cab) and mounting connections of the same design shall be used for conducting each test as described in paragraphs 5.2, 5.3, and 5.4.

5.1.3 Instantaneous deflection shall be measured and recorded for each segment of test. Minimum dimensions during test are specified for each test. The instantaneous deflection shall not violate the minimum dimensions specified in paragraph 6.1.1.

5.1.4 Seat reference point (SRP in Figs. 2 and 3) is that point where the vertical line tangent to the most forward point at the longitudinal seat centerline of the seat back, and the horizontal line tangent to the highest point of the seat cushion intersect in the longitudinal seat section. The SRP is to be determined with the seat unloaded and adjusted to the highest and most rearward position provided for seated operation of the tractor.

5.1.5 In case of an offset seat, the protective enclosure loading shall be on the side with least space between the centerline of the seat and the protective structure.

5.1.6 Low temperature characteristics of the protective enclosure or its material shall be demonstrated as specified in paragraph 6.1.2.

5.1.7 Rear input energy tests (static, dynamic, or field upset) need not be performed on enclosures applied to tractors having four driven wheels and more than one-half their unballasted weight on the front wheels, since this type of vehicle is not prone to rearward upset.

5.1.8 Accuracy table:

Means to Measure	Accuracy
Deflection of enclosure, in (mm)	±5% of deflection measured
Vehicle weight, lb (kg)	±5% of weight measured
Force applied to frame, lbf (N)	±5% of force measured
Dimensions of critical zone, in (mm)	± 0.5 in (12.5 mm)

5.1.9 Where movable or normally removable portions of the enclosure add to structural strength, they shall be placed in configurations that contribute least to the structural strength during the test.

5.2 Static Test Procedure (optional to paragraph 5.3)

5.2.1 TEST CONDITIONS

5.2.1.1 The laboratory mounting base shall be the tractor chassis or the equivalent for which the protective enclosure is designed to assure the integrity of the entire system.

5.2.1.2 The protective enclosure shall be instrumented with the neces-

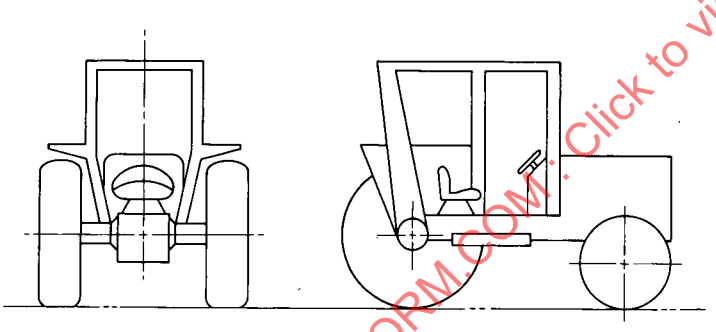

FIG. 1—TRACTOR WITH TYPICAL PROTECTIVE ENCLOSURE

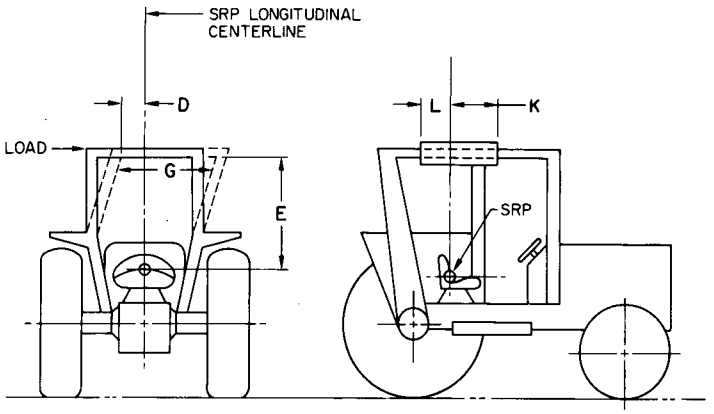

FIG. 2—SIDE LOAD APPLICATION

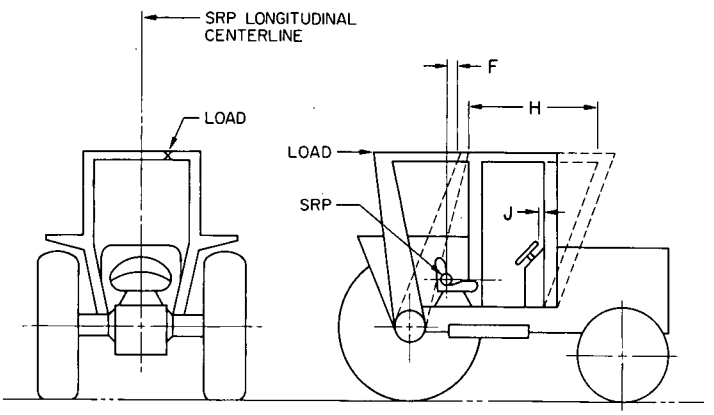

FIG. 3—REAR LOAD APPLICATION

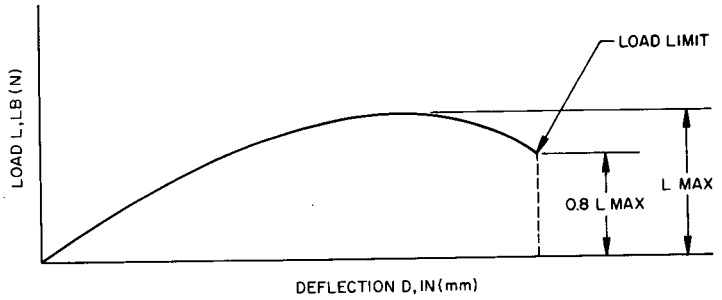

FIG. 4—TYPICAL L-D DIAGRAM

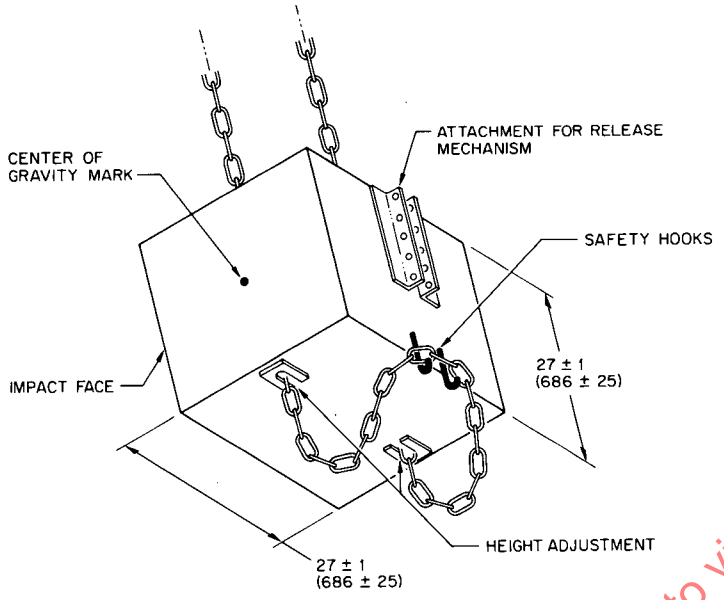

FIG. 5—PENDULUM

sary equipment to obtain the required load deflection data at the location and direction as specified in Figs. 2 and 3.

5.2.2 DEFINITION OF TERMS

W = tractor weight as defined in paragraphs 3.2 and 5.1.1, lb (W′ in kg)

E_{1s} = energy input to be absorbed during side loading, ft-lb (E'_{1s} in J)
= 723 + 0.4 W (E'_{1s} = 100 + 0.12 W′)

E_{1r} = energy input to be absorbed during rear loading, ft-lb (E'_{1r} in J)
= 0.47 W (E'_{1r} = 0.14 W′)

L = static load, lbf (N)

D = deflection under L, in (mm)

L-D = static load-deflection diagram

L_{max} = maximum observed static load

Load limit = point on a continuous L-D curve where observed static load is 0.8 L_{max} on down slope of curve (refer to Fig. 4)

E_u = strain energy absorbed by the protective enclosure, ft-lb (J). Area under L-D curve

FER = factor of energy ratio

$FER_{1s} = E_u/E_{1s}$

$FER_{1r} = E_u/E_{1r}$

5.2.3 TEST PROCEDURE

5.2.3.1 When the protective frame structures are not an integral part of the enclosure, the direction and point of load application for both side and rear shall be the same as specified in paragraphs 5.2 and 5.3 of SAE J334.

5.2.3.2 When the protective frame structures are an integral part of the enclosure, apply the rear load as shown in Fig. 3 and record L and D simultaneously. Static rear load application shall be uniformly distributed along a projected dimension no greater than 27 in (686 mm) and an area no greater than 160 in² (1032 cm²) normal to the direction of load application. The load shall be applied to the upper extremity of the structure at the point which is midway between the centerline of the protective enclosure and the inside of the protective structure. If no structural cross member exists at the rear of the enclosure, a substitute test beam which does not add strength to the structure may be utilized to complete this test procedure. (See paragraph 2.1.2 if field upset is omitted.) Stop test when:

(a) The strain energy absorbed by the structure is equal to or greater than (paragraph 2.1.2) the required input energy E_{1r}, or

(b) Deflection of the structure exceeds the allowable deflection (paragraph 6.1.1), or

(c) The structure load limit occurs before the allowable deflection is reached in rear load.

5.2.3.3 Using data obtained in paragraph 5.2.3.2, construct the L-D diagram for rear loads as shown typically in Fig. 4.

5.2.3.4 Calculate E_{1r}.

5.2.3.5 Calculate FER_{1r}.

5.2.3.6 When the protective frame structures are an integral part of the enclosure, apply the side load as shown in Fig. 2 and record L and D simultaneously. Static side load application shall be uniformly distributed along a projected dimension no greater than 27 in (686 mm) and an area no greater than 160 in² (1032 cm²) normal to the direction of load application. Side load application shall be at a 90 deg angle to the centerline of vehicle. The center of side load application shall be located between a point "k" 24 in (610 mm) forward, and a point "l" 12 in (305 mm) rearward of the seat reference point to best utilize the structural strength. (See Fig. 2.) This side load shall be applied to the longitudinal side farthest from the point of rear load application. (See paragraph 2.1.2 if field upset is omitted.) Stop test when:

(a) The strain energy absorbed by the structure is equal to or greater than (paragraph 2.1.2) the required input energy E_{1s}, or

(b) Deflection of the structure exceeds the allowable deflection (paragraph 6.1.1), or

(c) The structure load limit occurs before the allowable deflection is reached in side load.

5.2.3.7 Using data obtained in paragraph 5.2.3.6, construct the L-D diagram for side load as shown typically in Fig. 4.

5.2.3.8 Calculate E_{1s}.

5.2.3.9 Calculate FER_{1s}.

5.3 Dynamic Test Procedure (option to paragraph 5.2)

5.3.1 TEST CONDITIONS

5.3.1.1 The protective enclosure and tractor shall comply with paragraph 5.4.1.1.

5.3.1.2 The dynamic loading shall be produced by use of a 4410 lb (2000 kg) weight acting as a pendulum. The impact face of the weight shall be 27 ±1 × 27 ±1 in (686 ±25 × 686 ±25 mm) and shall be constructed so that its center of gravity is within 1 in (25.4 mm) of its geometric center. The weight shall be suspended from a pivot point 18-22 ft (5.5-6.7 m) above the point of impact on the enclosure and shall be conveniently and safely adjustable for height. (See Fig. 5.)

5.3.1.3 For each phase of testing, the tractor shall be restrained from moving when the dynamic load is applied. The restraining members shall have strength no less than, and elasticity no greater than that of a 0.50 in (12.7 mm) diameter steel cable. Points of attaching restraining members shall be located an appropriate distance behind

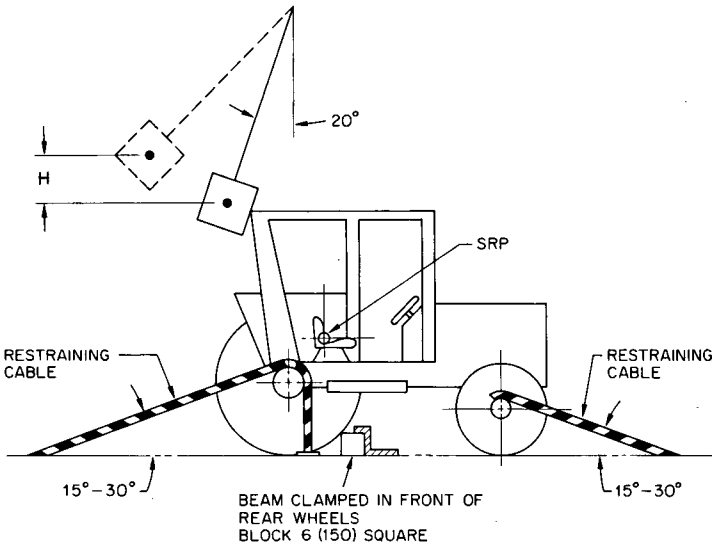

FIG. 6—REAR IMPACT APPLICATION

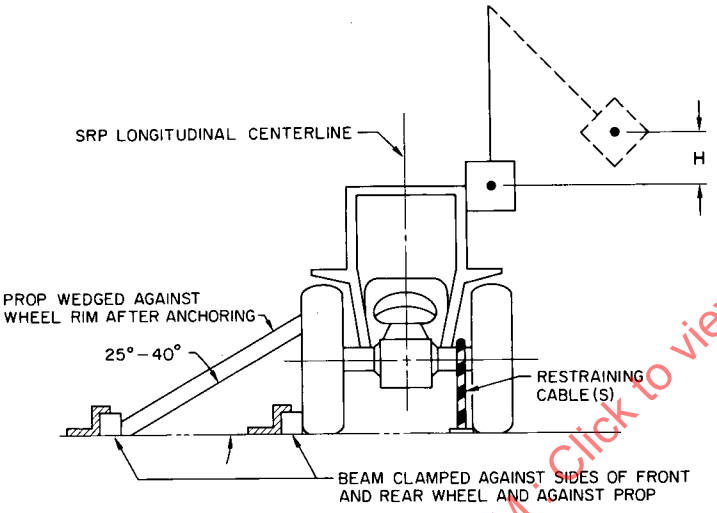

FIG. 7—SIDE IMPACT APPLICATION

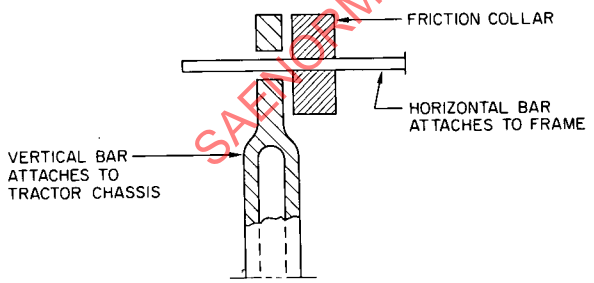

FIG. 8—TYPICAL METHOD OF MEASURING DEFLECTION

the rear axle and in front of the front axle to provide a 15-30 deg angle between a restraining cable and the horizontal. For the impact from the rear, the restraining cables shall be located in the plane in which the center of gravity of the pendulum will swing or, alternatively, two sets of symmetrically located cables may be used at convenient lateral locations on the tractor. For the impact from the side, restraining cables shall be used as shown in Figs. 6 and 7.

5.3.1.4 The wheel tread setting shall comply with paragraph 5.4.1.4. The tires shall have no liquid ballast and shall be inflated to the maximum operating pressure recommended by the manufacturer. With specified tire inflation, the restraining cable shall be tightened to provide tire deflection of 6-8% of nominal tire section width.

After the vehicle is properly restrained, a wooden beam no smaller than 6 × 6 in (150 × 150 mm) cross section shall be driven tightly against the appropriate wheels and clamped. For the test to the side, an additional wooden beam shall be placed as a prop against the wheel nearest the operator's station and shall be secured to the base so it is held tightly against the wheel rim during impact. The length of this beam shall be chosen so that it is at an angle of 25-40 deg to the horizontal when it is positioned against the wheel rim. It shall have a length 20-25 times its depth and a width 2-3 times its depth. (See Figs. 6 and 7.)

5.3.1.5 Means shall be provided for indicating the maximum instantaneous deflection along the line of impact. A simple friction device is illustrated in Fig. 8.

5.3.1.6 No repairs or adjustments shall be made during the test.

5.3.1.7 If any cables, props, or blocking shift or break during the test, the test shall be repeated.

5.3.2 Definition of Terms

W = tractor weight as defined in paragraph 3.2, lb (W′ in kg)

H = vertical height of center of gravity of 4410 lb (2000 kg) weight, in (H′ in mm). The weight shall be pulled back so that the height of its center of gravity above the point of impact is defined as follows:

$$H = 4.92 + 0.00190\,W \text{ or } (H' = 125 \pm 0.107\,W') \text{ (Fig. 9)}$$

(See paragraph 2.1.2 if field upset is omitted.)

5.3.3 Test Procedures

5.3.3.1 The enclosure structure shall be evaluated by imposing