# Protective Frame for Agricultural Tractors - Test Procedures and Performance Requirements - SAE J334b



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SAE STANDARD
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# PROTECTIVE FRAME FOR AGRICULTURAL TRACTORS—TEST PROCEDURES AND PERFORMANCE REQUIREMENTS—SAE J334b

**SAE Standard**

Report of Tractor Technical Committee approved April 1968 and last revised February 1974.

*1. Purpose*—The purpose of this standard is to establish the test and performance requirements of a protective frame designed for wheel-type agricultural tractors to minimize the frequency and severity of operator injury resulting from accidental upsets during normal operation. General systems 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 frame 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 analysis of the protective frame 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 frame, 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*

**4.1 Protective Frame**—The protective frame to which this standard applies is a structure generally comprised of uprights mounted to the tractor, extending above the operator's seat. A typical two-post frame is shown in Fig. 1.

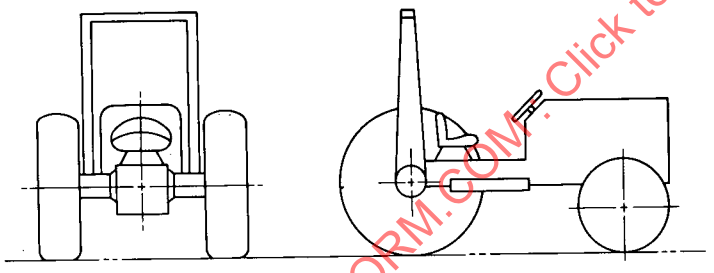

FIG. 1—TRACTOR WITH TYPICAL PROTECTIVE FRAME

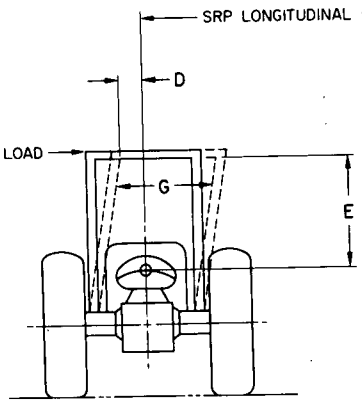


FIG. 2—SIDE LOAD APPLICATION

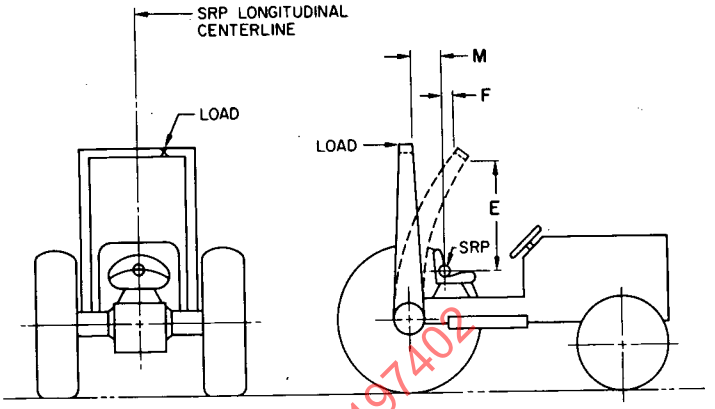


FIG. 3—REAR LOAD APPLICATION

**4.2 Overhead Weather Shield**—If an overhead weather shield is available for attachment to the protective frame, it may be in place during tests, providing it does not contribute to the strength of the protective frame.

**4.3 Overhead Falling Object Protection**—If an overhead falling object protection device is available for attachment to the protective frame, it may be in place during tests provided it does not contribute to the strength of the protective frame. (See SAE J167.)

*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 frame is to be used (paragraph 3.2).

5.1.2 A new protective frame 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 the test. Minimum dimensions during test are specified for each segment of 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 the case of an offset seat, the frame loading shall be on the side with the least space between centerline of seat and protective frame.

5.1.6 Low temperature characteristics of the protective frame 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 frames applied to tractors having four driven wheels and more than one-half the 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 frame, 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) |

**5.2 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

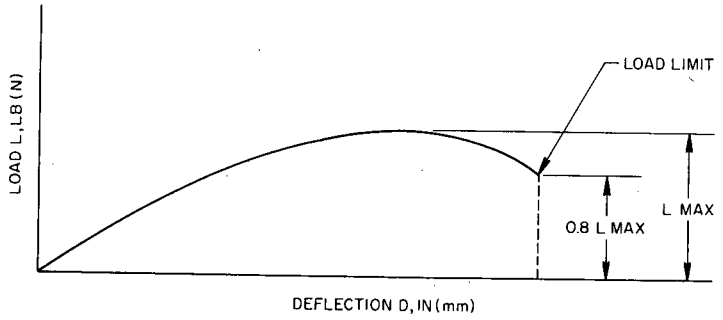


FIG. 4—TYPICAL L-D DIAGRAM

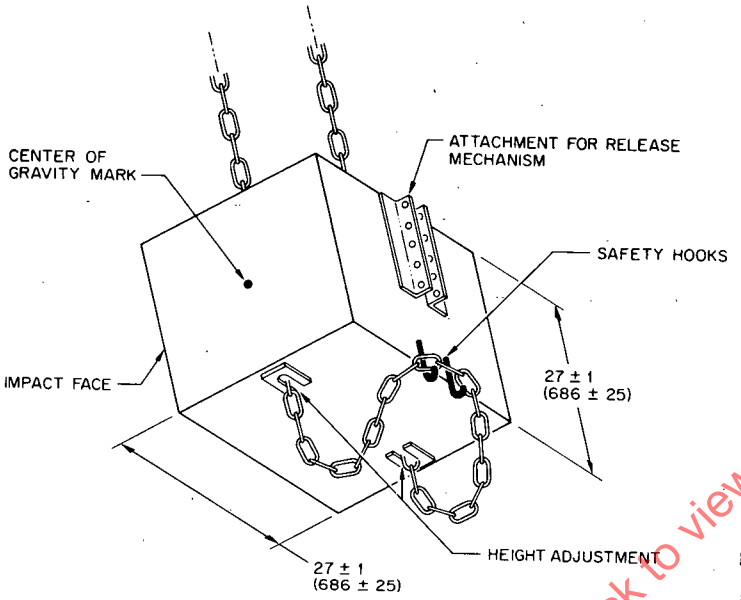


FIG. 5—PENDULUM

or the equivalent for which the protective frame is designed to assure the integrity of the entire system.

5.2.1.2 The protective frame shall be instrumented with the necessary equipment to obtain the required load deflection data at location and direction specified in Figs. 2 and 3.

5.2.1.3 If the protective frame is a one or two upright design, mounting connections shall be instrumented with the necessary equipment to record the required force to be used in paragraph 5.2.3.5. Instrumentation shall be placed on mounting connections before installation load is applied.

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 frame, ft-lb (J). Area under L-D curve

FER = factor of energy ratio
$FER_{1s} = E_u/E_{1s}$
$FER_{1r} = E_u/E_{1r}$

$P_b$ = maximum observed force in mounting connection under static load[1], L, lbf (N)

$P_u$ = ultimate force capacity of mounting connection[1], lb (N)

FSB = design margin for mounting connection[1]
$= P_u/P_b$

5.2.3 TEST PROCEDURES

5.2.3.1 Apply the rear load per Fig. 3 and record L and D simultaneously. 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 frame at the point which is midway between the center of frame and the inside of the frame upright. If no structural cross member exists at the rear of the frame, a substitute test beam which does not add strength to the frame 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 frame is equal to or greater than (paragraph 2.1.2) the required input energy $E_{1r}$, or

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

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

5.2.3.2 Using data obtained in paragraph 5.2.3.1, construct the L-D diagram as shown typically in Fig. 4.

5.2.3.3 Calculate $E_{1r}$.

5.2.3.4 Calculate $FER_{1r}$.

5.2.3.5 Calculate FSB (see paragraph 5.2.1.3).

5.2.3.6 Apply the side load tests on the same frame and record L and D simultaneously. Side load application shall be at the upper extremity of the frame at a 90 deg angle to the centerline of vehicle. The side load shall be applied to the longitudinal side farthest from the point of rear load application. Apply side load L per Fig. 2. (See paragraph 2.1.2 if field upset is omitted.) Stop tests when:

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

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

(c) Frame 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 as shown typically in Fig. 4.

5.2.3.8 Calculate $E_{1s}$.

5.2.3.9 Calculate $FER_{1s}$.

5.2.3.10 Calculate FSB (see paragraph 5.2.1.3).

**5.3 Dynamic Test Procedure** (option to paragraph 5.2)

5.3.1 TEST CONDITIONS

5.3.1.1 The protective frame 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 frame 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 0.50 in (12.7 mm) diameter steel cable. Points of attaching restraining members shall be located an appropriate distance behind 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 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.

[1]See Paragraph 5.2.1.3.

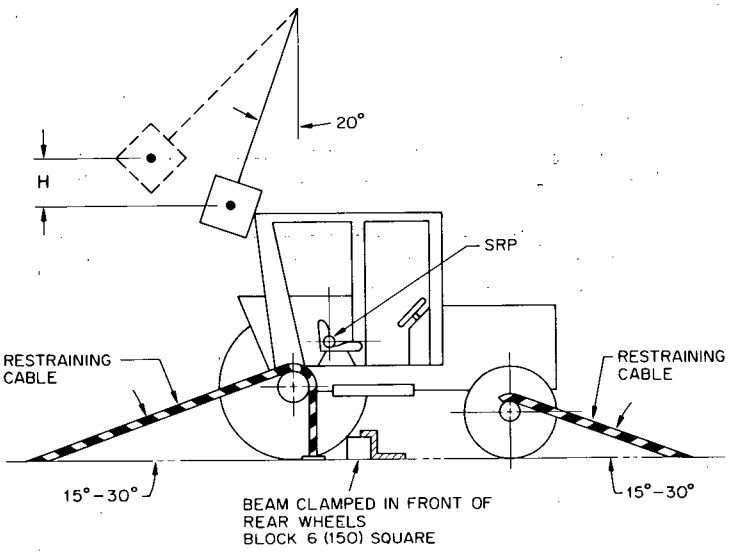


FIG. 6—REAR IMPACT APPLICATION

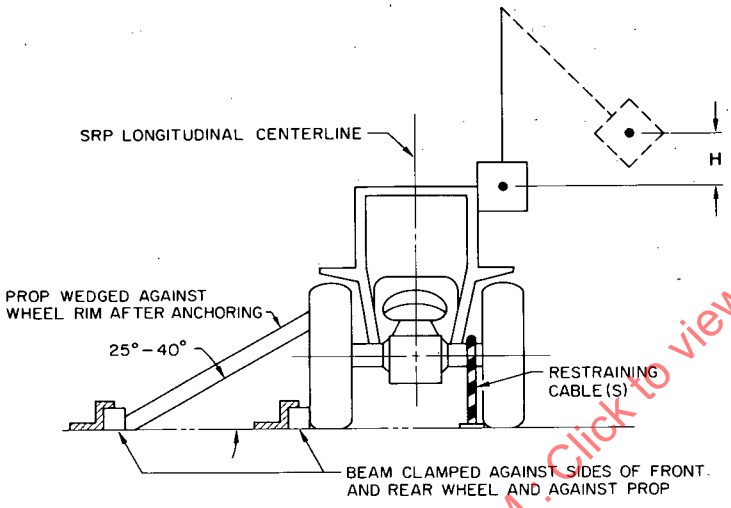


FIG. 7—SIDE IMPACT APPLICATION

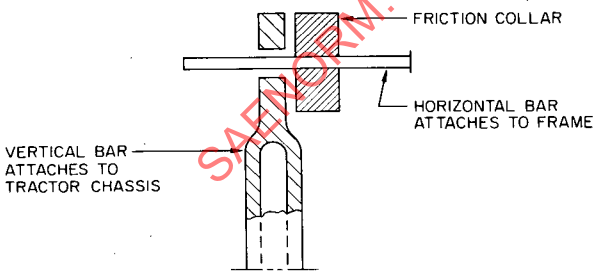


FIG. 8—TYPICAL METHOD OF MEASURING DEFLECTION

After the vehicle is properly restrained, a wooden beam no less 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:

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

(See paragraph 2.1.2 if field upset is omitted.)

5.3.3 Test Procedure

5.3.3.1 The frame shall be evaluated by imposing dynamic loading from the rear followed by a load to the side on the same frame. The pendulum swinging from the height determined by paragraph 5.3.2 imposes the dynamic load. The position of the pendulum shall be so selected that the initial point of impact on the frame shall be in line with the arc of travel of the center of gravity of the pendulum. A quick release mechanism should be used but shall not influence the attitude of the block.

5.3.3.2 *Impact at Rear*—The tractor shall be properly restrained per paragraphs 5.3.1.3 and 5.3.1.4. The tractor shall be positioned with respect to the pivot point of the pendulum so that the pendulum is 20 deg from the vertical prior to impact as shown in Fig. 6. The impact shall be applied to the upper extremity of the frame at the point which is midway between the centerline of the frame and the inside of the frame upright. If no structural cross member exists at the rear of the frame, a substitute test beam which does not add to the strength of