

yards where the vertical clearance requirements would substantially interfere with normal operations, and while their use is incidental to the work performed therein.

(ii) *Low profile tractors* while used inside a farm building or greenhouse in which the vertical clearance is insufficient to allow a ROPS equipped tractor to operate, and while their use is incidental to the work performed therein.

(iii) Tractors while used with mounted equipment which is incompatible with ROPS (e.g. cornpickers, cotton strippers, vegetable pickers and fruit harvesters).

(6) *Remounting*. Where ROPS are removed for any reason, they shall be remounted so as to meet the requirements of this paragraph.

(c) *Labeling*. Each ROPS shall have a label, permanently affixed to the structure, which states:

(1) Manufacturer's or fabricator's name and address;

(2) ROPS model number, if any;

(3) Tractor makes, models, or series numbers that the structure is designed to fit; and

(4) That the ROPS model was tested in accordance with the requirements of this subpart.

(d) *Operating instructions*. Every employee who operates an agricultural tractor shall be informed of the operating practices contained in appendix A of this part and of any other practices dictated by the work environment. Such information shall be provided at the time of initial assignment and at least annually thereafter.

[40 FR 18257, Apr. 25, 1975, as amended at 61 FR 9255, Mar. 7, 1996; 69 FR 18803, Apr. 9, 2004; 70 FR 77003, Dec. 29, 2005]

**§ 1928.52 Protective frames for wheel-type agricultural tractors—test procedures and performance requirements.**

(a) *Purpose*. The purpose of this section is to establish the test and performance requirements for a protective frame designed for wheel-type agricultural tractors to minimize the frequency and severity of operator injury resulting from accidental upsets. General requirements for the protection of operators are specified in 29 CFR 1928.51.

(b) *Types of tests*. All protective frames for wheel-type agricultural tractors shall be of a model that has been tested as follows:

(1) *Laboratory test*. A laboratory energy-absorption 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) *Field-upset test*. A field-upset test under controlled conditions, both to the side and rear, to verify the effectiveness of the protective system under actual dynamic conditions. Such testing may be omitted when:

(i) The analysis of the protective-frame static-energy absorption test results indicates that both  $FER_{is}$  and  $FER_{ir}$  (as defined in paragraph (d)(2)(ii) of this section) exceed 1.15; or

(ii) The analysis of the protective-frame dynamic-energy absorption test results indicates that the frame can withstand an impact of 15 percent greater than the impact it is required to withstand for the tractor weight as shown in Figure C-7.

(c) *Descriptions*. (1) *Protective frame*. A protective frame is a structure comprised of uprights mounted to the tractor, extending above the operator's seat. A typical two-post frame is shown in Figure C-1.

(2) *Overhead weather shield*. When an overhead weather shield 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.

(3) *Overhead falling object protection*. When 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.

(d) *Test procedures*. (1) *General*. (i) The tractor weight used shall be that of the heaviest tractor model on which the protective frame is to be used.

(ii) Each test required under this section shall be performed on a new protective frame. Mounting connections of the same design shall be used during each such test.

(iii) Instantaneous deflection shall be measured and recorded for each segment of the test; see paragraph (e)(1)(i) of this section for permissible deflections.

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

(v) When the centerline of the seat is off the longitudinal center, the frame loading shall be on the side with the least space between the centerline of seat and the protective frame.

(vi) Low-temperature characteristics of the protective frame or its material shall be demonstrated as specified in paragraph (e)(1)(ii) of this section.

(vii) Rear input energy tests (static, dynamic, or field-upset) need not be performed on frames mounted to tractors having four driven wheels and more than one-half their unballasted weight on the front wheels.

(viii) Accuracy table:

| Measurements  | Accuracy                               |
|---|--|
| Deflection of the frame, in. (mm).                  | ±5 percent of the deflection measured. |
| Vertical weight, lb (kg) .....                      | ±5 percent of the weight measured.     |
| Force applied to the frame, pounds force (newtons). | ±5 percent of the force measured.      |
| Dimensions of the critical zone, in. (mm).          | ±0.5 in. (12.5 mm).                    |

(2) *Static test procedure.* (i) The following test conditions shall be met:

(A) The laboratory mounting base shall be the tractor chassis for which the protective frame is designed, or its equivalent;

(B) The protective frame shall be instrumented with the necessary equipment to obtain the required load-deflection data at the locations and directions specified in Figures C-2 and C-3; and

(C) When the protective frame is of 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 (d)(2)(iii)(E) and (J) of this section. Instrumentation shall be placed on mounting connections before installation load is applied.

(ii) The following definitions shall apply:

$W$  = Tractor weight (see 29 CFR 1928.51(a)) in lb ( $W$  in kg);

$E_{is}$  = Energy input to be absorbed during side loading in ft-lb ( $E'_{is}$  in J [joules]);

$E_{is} = 723 + 0.4 W$  ( $E'_{is} = 100 + 0.12 W$ );

$E_{ir}$  = Energy input to be absorbed during rear loading in ft-lb ( $E'_{ir}$  in J);

$E_{ir} = 0.47 W$  ( $E'_{ir} = 0.14 W$ );

$L$  = Static load, lbf [pounds force], (N) [newtons];

$D$  = 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 the observed static load is 0.8  $L_{max}$  on the down slope of the curve (see Figure C-5);

$E_u$  = Strain energy absorbed by the frame in ft-lb (J); area under the  $L-D$  curve;

$FER$  = Factor of energy ratio;

$FER_{is} = E_u E_{is}$ ;

$FER_{ir} = E_u E_{ir}$ ;

$P_b$  = Maximum observed force in mounting connection under a static load,  $L$  lbf (N);

$P_u$  = Ultimate force capacity of a mounting connection, lbf (N);

$FSB$  = Design margin for a mounting connection; and

$FSB = P_u/P_b$

(iii) The test procedures shall be as follows:

(A) Apply the rear load according to Figure C-3, and record  $L$  and  $D$  simultaneously. Rear-load application shall be distributed uniformly on the frame over an area perpendicular to the direction of load application, no greater than 160 sq. in. (1,032 sq. cm) in size, with the largest dimension no greater than 27 in. (686 mm). The load shall be applied to the upper extremity of the frame at the point that is midway between the center of the frame and the inside of the frame upright. When no structural cross member exists at the rear of the frame, a substitute test beam that does not add strength to the frame may be used to complete this

test procedure. The test shall be stopped when:

(1) The strain energy absorbed by the frame is equal to or greater than the required input energy  $E_{ir}$ ; or

(2) Deflection of the frame exceeds the allowable deflection (see paragraph (e)(1)(i) of this section); or

(3) Frame load limit occurs before the allowable deflection is reached in rear load (see Figure C-5).

(B) Using data obtained under paragraph (d)(2)(iii)(A) of this section, construct the *L-D* diagram shown in Figure C-5;

(C) Calculate  $E_{ir}$ ;

(D) Calculate  $FER_{ir}$ ;

(E) Calculate *FSB* as required by paragraph (d)(2)(i)(C) of this section;

(F) 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° angle to the centerline of the vehicle. The side load shall be applied to the longitudinal side farthest from the point of rear-load application. Apply side load *L* as shown in Figure C-2. The test shall be stopped when:

(1) The strain energy absorbed by the frame is equal to or greater than the required input energy  $E_{is}$ ; or

(2) Deflection of the frame exceeds the allowable deflection (see paragraph (e)(1)(i) of this section); or

(3) Frame load limit occurs before the allowable deflection is reached in side load (see Figure C-5).

(G) Using data obtained in paragraph (d)(2)(iii)(F) of this section, construct the *L-D* diagram as shown in Figure C-5;

(H) Calculate  $E_{is}$ ;

(I) Calculate  $FER_{is}$ ; and

(J) Calculate *FSB* as required by paragraph (d)(2)(i)(C) of this section.

(3) *Dynamic test procedure.* (i) The following test conditions shall be met:

(A) The protective frame and tractor shall be tested at the weight defined by 29 CFR 1928.51(a);

(B) The dynamic loading shall be accomplished by using a 4,410-lb (2,000-kg) weight acting as a pendulum. The impact face of the weight shall be  $27 \pm 1$  in. by  $27 \pm 1$  in. ( $686 \pm 25$  mm by  $686 \pm 25$  mm), and shall be constructed so that its center of gravity is within 1.0 in. (25.4 mm) of its geometric center. The

weight shall be suspended from a pivot point 18 to 22 ft (5.5 to 6.7 m) above the point of impact on the frame, and shall be conveniently and safely adjustable for height (see Figure C-6);

(C) 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) steel cable. Points of attachment for the restraining members shall be located an appropriate distance behind the rear axle and in front of the front axle to provide a 15° to 30° angle between a restraining cable and the horizontal. For 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 lateral locations on the tractor. For impact from the side, restraining cables shall be used as shown in Figures C-8 and C-9;

(D) The front and rear wheel-tread settings, when adjustable, shall be at the position nearest to halfway between the minimum and maximum settings obtainable on the vehicle. When only two settings are obtainable, the minimum setting shall be used. The tires shall have no liquid ballast, and shall be inflated to the maximum operating pressure recommended by the manufacturer. With the specified tire inflation, the restraining cable shall be tightened to provide tire deflection of 6 to 8 percent of the nominal tire-section width. After the vehicle is restrained properly, a wooden beam no less than 6-in. × 6-in. (150-mm × 150-mm) in 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 to the operator's station, and shall be secured to the base so that 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° to 40° to the horizontal when it is positioned against the wheel rim. It shall have a length 20 to 25 times its depth, and a width two to three times its depth (see Figures C-8 and C-9);

§ 1928.52

29 CFR Ch. XVII (7-1-06 Edition)

(E) Means shall be provided for indicating the maximum instantaneous deflection along the line of impact. A simple friction device is illustrated in Figure C-4;

(F) No repairs or adjustments shall be made during the test; and

(G) When any cables, props, or blocking shift or break during the test, the test shall be repeated.

(ii)  $H$  = Vertical height of the center of gravity of a 4,410-lb (2,000-kg) weight in 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:  $H = 4.92 + 0.00190 W$  ( $H' = 125 \pm 0.170 W'$ ) (see Figure C-7).

(iii) The test procedures shall be as follows:

(A) 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 (d)(3)(ii) of this section shall be used to impose the dynamic load. The position of the pendulum shall be so selected that the initial point of impact on the frame is in line with the arc of travel of the center of gravity of the pendulum. When a quick-release mechanism is used, it shall not influence the attitude of the block;

(B) *Impact at rear.* The tractor shall be restrained properly according to paragraphs (d)(3)(i)(C) and (d)(3)(i)(D) of this section. The tractor shall be positioned with respect to the pivot point of the pendulum so that the pendulum is 20° from the vertical prior to impact as shown in Figure C-8. The impact shall be applied to the upper extremity of the frame at the point that is midway between the centerline of the frame and the inside of the frame upright. When no structural cross member exists at the rear of the frame, a substitute test beam that does not add to the strength of the frame may be used to complete the test procedure; and

(C) *Impact at side.* The blocking and restraining shall conform to paragraphs (d)(3)(i)(C) and (d)(3)(i)(D) of this section. The center point of impact shall be at the upper extremity of the frame at a point most likely to hit the ground first, and at a 90° to the centerline of the vehicle (see Figure C-

9). The side impact shall be applied to the longitudinal side farthest from the point of rear impact.

(4) *Field-upset test procedure.* (i) The following test conditions shall be met:

(A) The tractor shall be tested at the weight defined in 29 CFR 1928.51(a);

(B) The following provisions address soil bank test conditions.

(1) The test shall be conducted on a dry, firm soil bank. The soil in the impact area shall have an average cone index in the 0-in. to 6-in. (0-mm to 152-mm) layer of not less than 150. Cone index shall be determined according to American Society of Agricultural Engineers (“ASAE”) recommendation ASAE R313.1-1971 (“Soil cone penetrometer”), as reconfirmed in 1975, which is incorporated by reference. The incorporation by reference was approved by the Director of the Federal Register in accordance with 5 U.S.C. 552(a) and 1 CFR part 51. The path of vehicle travel shall be 12° ± 2° to the top edge of the bank.

(2) ASAE recommendation R313.1-1971, as reconfirmed in 1975, appears in the 1977 Agricultural Engineers Yearbook, or it may be examined at: Any OSHA Regional Office; the OSHA Docket Office, U.S. Department of Labor, 200 Constitution Avenue, NW., Room N-2625, Washington, DC 20210 (telephone: (202) 693-2350 (TTY number: (877) 889-5627)); or the National Archives and Records Administration (“NARA”). (For information on the availability of this material at NARA, telephone (202) 741-6030 or access the NARA Web site at [http://www.archives.gov/federal\\_register/code\\_of\\_federal\\_regulations/ibr\\_locations.html](http://www.archives.gov/federal_register/code_of_federal_regulations/ibr_locations.html).) Copies may be purchased from the American Society of Agricultural Engineers, 2950 Niles Road, St. Joseph, MI 49085.

(C) An 18-in. (457-mm) high ramp (see Figure C-10) shall be used to assist in upsetting the vehicle to the side; and

(D) The front and rear wheel-tread settings, when adjustable, shall be at the position nearest to halfway between the minimum and maximum settings obtainable on the vehicle. When only two settings are obtainable, the minimum setting shall be used.

(ii) Field upsets shall be induced to the rear and side as follows:

(A) Rear upset shall be induced by engine power, with the tractor operating in gear to obtain 3 to 5 mph (4.8 to 8.0 kph) at maximum governed engine rpm by driving forward directly up a minimum slope of  $60^\circ \pm 5^\circ$  as shown in Figure C-11, or by an alternative equivalent means. The engine clutch may be used to aid in inducing the upset; and

(B) To induce side upset, the tractor shall be driven under its own power along the specified path of travel at a minimum speed of 10 mph (16 kph), or at maximum vehicle speed when under 10 mph (16 kph), and over the ramp as described in paragraph (d)(4)(i)(C) of this section.

(e) *Performance requirements.* (1) *General requirements.* (i) The frame, overhead weather shield, fenders, or other parts in the operator area may be deformed in these tests, but shall not shatter or leave sharp edges exposed to the operator, or encroach on the dimensions shown in Figures C-2 and C-3, and specified as follows:

$d$  = 2 in. (51 mm) inside of the frame upright to the vertical centerline of the seat;

$e$  = 30 in. (762 mm) at the longitudinal centerline;

$f$  = Not greater than 4 in. (102 mm) to the rear edge of the crossbar, measured forward of the seat-reference point ("SRP");

$g$  = 24 in. (610 mm) minimum; and

$m$  = Not greater than 12 in. (305 mm), measured from the seat-reference point to the forward edge of the crossbar.

(ii) The protective structure and connecting fasteners must pass the static or dynamic tests described in paragraphs (d)(2), (d)(3), or (d)(4) of this section at a metal temperature of  $0^\circ\text{F}$  ( $-18^\circ\text{C}$ ) or below, or exhibit Charpy V-notch impact strengths as follows:

10-mm  $\times$  10-mm (0.394-in.  $\times$  0.394-in.) specimen: 8.0 ft-lb (10.8 J) at  $-20^\circ\text{F}$  ( $-30^\circ\text{C}$ );

10-mm  $\times$  7.5-mm (0.394-in.  $\times$  0.296-in.) specimen: 7.0 ft-lb (9.5 J) at  $-20^\circ\text{F}$  ( $-30^\circ\text{C}$ );

10-mm  $\times$  5-mm (0.394-in.  $\times$  0.197-in.) specimen: 5.5 ft-lb (7.5 J) at  $-20^\circ\text{F}$  ( $-30^\circ\text{C}$ ); or

10-mm  $\times$  2.5-mm (0.394-in.  $\times$  0.098-in.) specimen: 4.0 ft-lb (5.5 J) at  $-20^\circ\text{F}$  ( $-30^\circ\text{C}$ ).

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

(2) *Static test-performance requirements.* In addition to meeting the requirements of paragraph (e)(1) of this section for both side and rear loads,  $FER_{is}$  and  $FER_{ir}$ , shall be greater than 1.0, and when the ROPS contains one or two upright frames only,  $FSB$  shall be greater than 1.3.

(3) *Dynamic test-performance requirements.* The structural requirements shall be met when the dimensions in paragraph (e)(1) of this section are used in both side and rear loads.

(4) *Field-upset test performance requirements.* The requirements of paragraph (e)(1) of this section shall be met for both side and rear upsets.

[70 FR 77004, Dec. 29, 2005]

### § 1928.53 Protective enclosures for wheel-type agricultural tractors—test procedures and performance requirements.

(a) *Purpose.* The purpose of this section is to establish the test and performance requirements for a protective enclosure designed for wheel-type agricultural tractors to minimize the frequency and severity of operator injury resulting from accidental upset. General requirements for the protection of operators are specified in 29 CFR 1928.51.

(b) *Types of tests.* All protective enclosures for wheel-type agricultural tractors shall be of a model that has been tested as follows:

(1) *Laboratory test.* A laboratory energy-absorption 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; and

(2) *Field-upset test.* A field-upset test under controlled conditions, both to the side and rear, to verify the effectiveness of the protective system under actual dynamic conditions. This test may be omitted when: