

JIS

JAPANESE INDUSTRIAL STANDARD

**Earth-moving Machinery
—Roll-over Protective Structures—
Laboratory Tests and
Performance Requirements**

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Earth-moving Machinery — Roll-over
Protective Structures — Laboratory
Tests and Performance Requirements

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1. Scope

This Japanese Industrial Standard specifies the performance requirements for the earth-moving machinery — roll-over protective structures provided for the machinery (hereafter referred to as the "ROPS") and its test method in order to protect the operator from being crashed under the condition that the earth-moving machinery of not more than 15 kW {20 PS} in engine output at a running speed of not more than 16 km/h rolls over 360° with taking the vertical axis of machinery as the center without losing contact with the inclined ground surface on the hard clay ground of not more than 30° in angle of inclination.

- (1) Crawler loader and wheel loader (crawler tractor shovel and wheel tractor shovel)
- (2) Crawler tractor, wheel tractor and back hoe loader
- (3) Grader (motor grader)
- (4) Tractor scraper (motor scraper)
- (5) Articulated dumper (articulated heavy dump truck)

Remark: The units and numerical values given in { } in this Standard are based on the traditional units and are appended for informative reference.

2. Definitions and Symbols

To the principal terms and symbols used in this Standard, the following definitions apply.

- (1) roll-over protective structure (ROPS) The structure fitted to the machine for the purpose of protecting the operator worn with the seat belt from crushing when a machine has rolled over. ROPS includes the subframe, bracket, mounting, socket, pin, suspension or shock absorber etc. to fit this to the machine frame, but the fitting seat of integral structure with the machine frame is not included.
- (2) deflection limiting volume (DLV) The volume related to the operator specified in Annex.

Applicable Standards and Corresponding International Standards: See page 22.

- (3) simulated ground plane (SGP) The simulated ground plane specified in Annex.
- (4) maximum designated mass (M) The maximum mass of the machinery designated by a manufacturer of machinery. For the tractor scraper and the articulated dumper, the maximum mass of only the tractor part specified by the machinery manufacturer. However, it includes attachments required for work, specified amount of fuel, lubricating oil, cooling water, etc., tools, operator and ROPS, but does not include the tractor drawn attachments such as load and roller, compactor, tractor drawn scraper, etc.
- (5) ROPS • frame assembly Assembly combined together with ROPS and machinery frame.

3. Performance

Concerning the roll-over protective structures, the members constituting the protective structure and the simulated ground plane (SGP) shall not enter the deflection limiting volume (DLV) due to deflection of protective structure and frame assembly when side loading test and vertical loading test are carried out according to the method specified in 6.3.

4. Shape

The parts of working range for operator or service personnel of ROPS shall be free from sharp angle, edge part, etc.

5. Materials

Materials to be used for roll-over protective structure shall meet each item of the following:

- (1) Bolts and nuts to be used for fitting the roll-over protective structure with the machinery or for connecting the protective structures shall be bolts of 8.8 or 10.9 in strength division specified in JIS B 1180 and nuts of 8 or 10 in strength division specified in JIS B 1181.
- (2) Materials of stand seats to be fitted with the members of roll-over protective structure and with machinery frame shall meet either one of Charpy absorption energy shown in Table 1.

Furthermore, dimensions of test piece and the test method shall be in accordance with JIS Z 2202 and JIS Z 2242 respectively.

Table 1. Charpy Absorption Energy of Material

Test piece (1)	Charpy absorption energy J {kgf·m}
10 mm x 10 mm	At -30°C 10.8 {1.10}
10 mm x 7.5 mm	At -30°C 9.5 {0.97}
10 mm x 5 mm	At -30°C 7.5 {0.76}
10 mm x 2.5 mm	At -30°C 5.5 {0.56}

Note (1) The test piece shall be taken from the sheet, pipe, steel section and the like before forming or welding so that its long side direction coincides with the rolling direction of roll. The test piece for tube or steel section shall be taken from the middle part of the longest dimension of section and not include the weld:

6. Tests

6.1 Test Facilities

6.1.1 Test Apparatus The test apparatus shall be capable of fixing securely the protective structure and frame assembly to the test apparatus bedplate and of loading side load and vertical load to the ROPS.

6.1.2 Instruments The test facilities shall be provided with instruments capable of measuring the load to be applied to ROPS and the deflection of ROPS at that time.

Further, the instruments shall be capable of measuring the maximum load applied to the ROPS and the maximum deflection of the ROPS at that time with an accuracy of $\pm 5\%$.

6.2 Preparation for Test

6.2.1 General Items The general items shall be as follows:

- (1) Deflection Limiting Volume (DLV) The deflection limiting volume shall be fixed securely to the operating seat of machinery (or a position corresponding to this) and shall not be fallen down during the test.
- (2) Fixing of ROPS and Machinery Frame For the test, the complete machinery may be not necessarily used, but the fixing of ROPS and machinery frame shall be same as that of the complete machinery. All of the attachable and detachable windows, panels, doors and the non-constitutional parts of ROPS shall be removed so that those do not affect the test.

- (3) Attachment of ROPS · Frame Assembly with Test Apparatus Bedplate
The ROPS · frame assembly shall be attached securely to the test apparatus bedplate through fixing members. The fixing members shall not be deformed when ROPS · frame assembly have received the side loading.

Furthermore, at the time of attachment, cares shall be taken so that during ROPS · frame assembly are receiving the side loading, the bottom surface of machinery frame does not contact with the test apparatus bedplate and further does not receive supporting from other than the initial fixing portion.

- (4) Removal of Energy-Absorbing Body Elements of machinery considered to be the energy-absorbing body (rubber tire, spring, shock absorber, etc.) shall be removed (or fixed securely during the test).

6.2.2 Items by Kinds of Machineries at Side Loading The items by kinds of machineries at side loadings shall be as follows:

- (1) Wheel Loader, Wheel Tractor, Back Hoe Loader and Grader The ROPS · frame assembly shall be attached to the test apparatus bedplate by taking front axle and rear axle or the neighborhoods of these axles as fixing points. In the case of articulated machinery, the hinges shall be fixed so that both frames become straight. When testing by only the frame equipped with ROPS, the frame assembly shall be attached to the test apparatus bedplate with taking both ends of frame or the neighbourhoods as fixed points (see Attached Fig. 1 and Attached Fig. 2).
- (2) Tractor Scraper and Dumper of Articulated Type The ROPS · frame assembly shall be attached to the test apparatus bedplate by taking the frame or the case in the neighborhood of axle as the fixed point (see Attached Fig. 3).
- (3) Crawler Tractor and Crawler Loader The ROPS · frame assembly shall be attached to the test apparatus bedplate by taking the main housing and the truck frame or anyone of both as the fixed point (see Attached Fig. 4).

6.2.3 Items for All Classes of Machinery at the Vertical Loading Time
Concerning the vertical load, there is no restriction in fixation or support of the ROPS · frame assembly.

6.3 Test Methods

6.3.1 Procedures The procedures shall be as follows:

- (1) The test shall be carried out in the order of 6.3.2 and 6.3.3.
- (2) During test, the repair or straightening of bend for any member of ROPS · frame assembly shall not be carried out.

6.3.2 Side Loading Test The side loading test shall be as follows:

- (1) Apply side load to the main members of the longitudinal direction (advance direction of machinery) of the upper part of ROPS and find the load-deflection characteristics at that time.
- (2) The side load to ROPS of three or more posts type shall be applied through a load-distribution device having a length not greater than 80 % of the distance of horizontal part of the upper longitudinal main member between the front and rear posts (see Attached Fig. 5).

Furthermore, the force arriving point shall be at 80 mm outside of front and rear faces of DLV and be within the range determined by the vertical projections of two faces parallel to these faces (see Attached Figs. 5 (a) to (c)).

- (3) The ROPS, appended with an upper cover, of two posts type shall be as follows: When taking the distance in the longitudinal direction between the upper main members as L , the arriving point of force of side load shall be separate not smaller than $L/3$ from the strut of ROPS and moreover, between the vertical projected lines of front and rear faces of DLV [see Attached Fig. 5 (d)].

The load distribution device shall not prevent ROPS from the rotation around its vertical shaft during loading and not restrict its movement and further, its length shall be not more than 80 % of L of Appendix Fig. 5.

The side load of ROPS of two posts type shall be applied to the upper main members in the longitudinal direction.

Provided that it is necessary to apply load in the direction of the upper crossing members of ROPS for the ROPS of two posts type without the upper cover of cantilever type.

- (4) The first direction of the side load shall be at right angle with the vertical surface including the center line of the advance direction of a machinery and horizontal ⁽²⁾.

Note ⁽²⁾ There is a case where the direction of load is changed due to deflection of ROPS · frame assembly during the test but this is allowable.

- (5) In the case where the operator's seat deviates from the centre line of advancing direction of the vehicle, the load shall be applied to the outermost side of ROPS of the deviated side.
- (6) In the case where the operator's seat is on the centre line of vehicle advancing direction and further the load-deflection characteristics are different at right and left sides of ROPS · frame assembly, the side load shall be applied to the side where the deflection becomes larger.
- (7) Side loading shall be applied at a speed considerable to be static.

- (8) Deflection at a interval of about 10 mm at the loading position of side loading and the load at that time shall be measured and the results be recorded in Attached Table.
- (9) The test shall be continued until both of the required minimum load and the required minimum energy specified in Table 2 or Table 3 are satisfied ⁽³⁾. The energy (U) shall be calculated according to the following formula in Figure.

Furthermore, the deflection to be used for calculation of energy shall be that of ROPS · frame assembly along the working line of load and that of member supporting the loading device shall not be added.

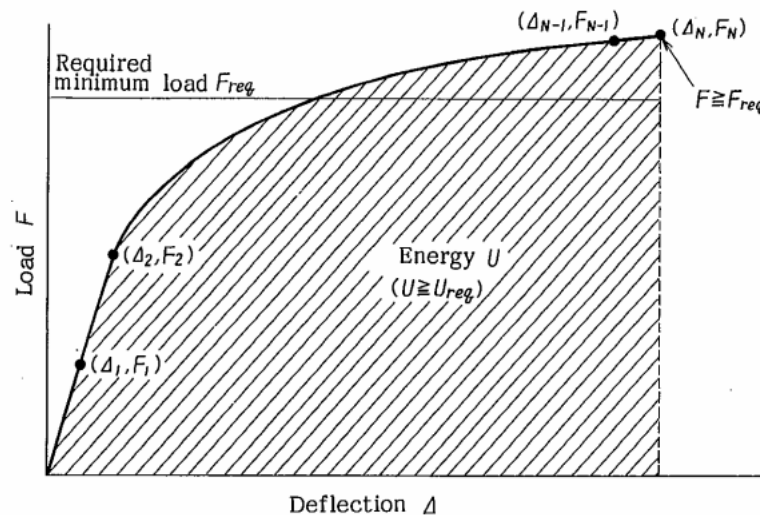
$$U = \frac{\Delta_1 F_1}{2} + (\Delta_2 - \Delta_1) \left(\frac{F_1 + F_2}{2} \right) + \dots + (\Delta_N - \Delta_{N-1}) \left(\frac{F_{N-1} + F_N}{2} \right)$$

where, U : energy (J) {kgf·m}

Δ : deflection (mm)

F : load at side loading time (N) {kgf}

Figure. Load-Deflection Characteristics at the Time of Side Loading



Note ⁽³⁾ In the side-loading test, the load and the energy are, in general, satisfied at the same time in few cases, and either one of load or energy reaches the value of relating formula indicated in Table 2 and Table 3. If the load has reached the specified value before the energy reaches the specified value, for example the load decreases once to the specified value or lower due to breakage of fitting bolt, generation of crack on the weld and other reasons, but thereafter when the energy has reached or exceeded the specified value, the load shall reach the specified value again.