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Performance Criteria for Falling Object Protective Structure (FOPS) for Industrial Machines

SAE Standard
Revised September 1987

Submitted for Recognition as an American National Standard

SAE The Engineering Society For Advancing Mobility Land Sea Air and Space®
400 Commonwealth Drive, Warrendale, PA 15096

OFF-HIGHWAY MACHINERY STANDARD

Submitted for recognition as an American National Standard

SAE J1043

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PERFORMANCE CRITERIA FOR FOPS ON GENERAL PURPOSE INDUSTRIAL MACHINES

1. PURPOSE: This SAE Standard establishes performance criteria for Falling Object Protective Structures (FOPS) intended to provide operators of general purpose industrial machines with overhead protection from objects such as bricks, concrete blocks, and small hand tools that may fall from heights of not more than 9 m (30 ft) above the ground, encountered in operations such as highway maintenance, landscaping, and other services on construction sites where the falling object develops an energy not to exceed 1360 J (1000 ft-lbf).

2. SCOPE: This standard applies to General Purpose Industrial Machines, as described in SAE J1116, which are equipped with Rollover Protective Structures (ROPS).

3. FACILITIES:

ed. change 3.1 A solid spherical steel or ductile iron mass of 45 kg (100 lb), hereinafter referred to as the drop object.

3.2 A means of raising the drop object to the required height.

3.3 A means of releasing the drop object so that it drops without vertical restraint. A means to guide the drop object may be used, however, it shall be so constructed that it does not retard the free vertical fall of the drop object.

3.4 A support surface of such firmness that it shall not be penetrated by the machine or test bed under the loading of the drop test.

3.5 A means of determining if the FOPS enters the Deflection Limiting Volume (DLV, see SAE J397) during the drop test. This may be either of the following:

3.5.1 A DLV in the upright attitude, made of a material which will indicate any penetration by the FOPS. (Grease may be put on the top surface of the DLV to indicate such penetration.)

3.5.2 A dynamic instrumentation system of sufficient frequency response to indicate the total FOPS deflection with respect to the DLV within an accuracy of ±5%.

NOTE: DLV should be fixed firmly to the same part of machine to which the operator seat is secured and is to remain there during the entire test.

4. MACHINE OR TEST BED CONDITION:

4.1 The FOPS to be evaluated must be attached to the machine structure as it will be in actual machine use. A complete machine is not required, however, the portion to which the FOPS is mounted must be identical to the actual structure, and the vertical stiffness of a test bed must be not less than that of an actual machine as described in paragraph 4.2. The machine or test bed shall be placed on the surface described in paragraph 3.4.

4.2 If the FOPS is mounted on a machine, the following stipulations apply:

4.2.1 No limitations on customary attachments and/or payload.

4.2.2 All ground engaging tools shall be in normal carry positions.

4.2.3 All suspension systems, including pneumatic tires, shall be set at operating levels. Variable suspensions shall be in the "hard" range.

4.3 All cab elements, such as windows, removable panels, or structural fittings are to be removed so that they do not contribute to the strength of the FOPS.

5. DROP TEST PROCEDURE:

5.1 The drop object shall be placed on top of the FOPS at the location designated in paragraphs 5.2, 5.3, and 5.4.

5.2 The projected diameter of the drop object is to be entirely within the vertical projection of the DLV on the FOPS top.

5.3 Within the limitations of paragraph 5.2, the drop object shall be so placed that it has the least possible distance from the centroid of the FOPS top. (The area whose centroid is referred to is that portion of the FOPS cover that is not over major upper, structural members.) See Fig. 1.

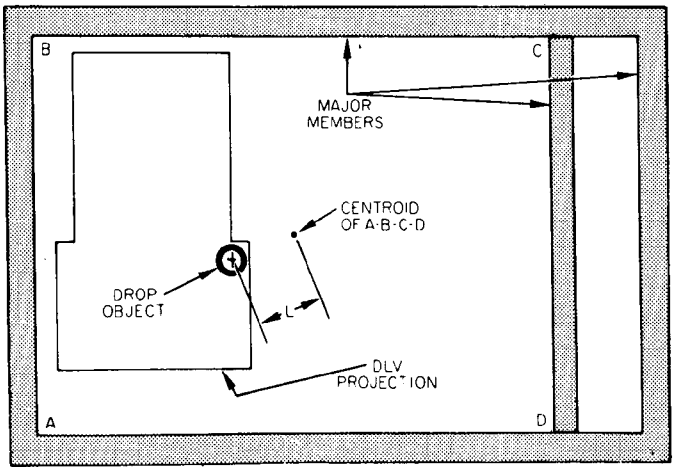

FIG. 1

5.4 Should the vertical projection of the DLV be divided into two or more segments by vertical projections of major, upper structural members, the directions of paragraphs 5.2 and 5.3 shall apply to the segment(s) containing the greatest area of the DLV projection. See Fig. 2.

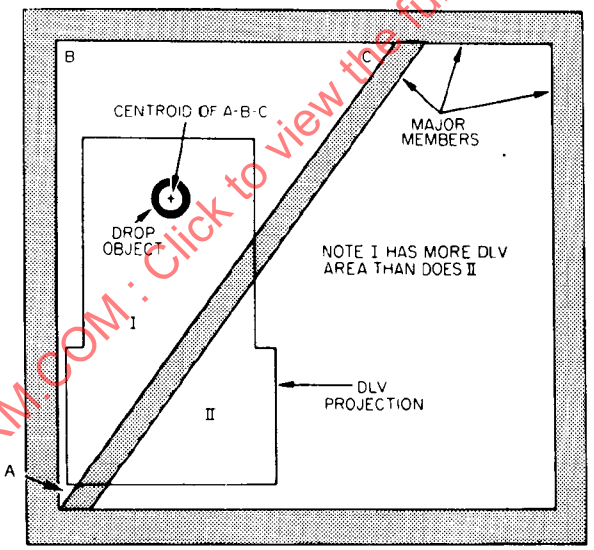

FIG. 2

NOTE: Where other materials or different thicknesses are used in different segments above the DLV, each segment in turn shall be subject to a drop test. If design features such as cutouts for windows or equipment, or variations in cover material or thickness indicate a more vulnerable location could obviously be selected within the vertical projection of the DLV, the drop location should be adjusted to that location. In addition, if cutouts in the FOPS cover are intended to be filled with devices or equipment to provide adequate protection, those devices or equipment must be in place during the drop test.

5.5 The drop object is to be raised vertically 3 m (10 ft) above the position indicated in paragraphs 5.2, 5.3, or 5.4.

5.6 The drop object is to be released so that it falls onto the FOPS (see paragraph 3.3).

5.7 The center of initial impact of the drop object shall fall within a circle of 100 mm (4 in) radius. The center of this circle is to coincide with the vertical centerline of the object as positioned per paragraphs 5.1-5.4, but not on any major, upper horizontal member. There is no limitation on location of subsequent (rebound) impacts.

6. PERFORMANCE REQUIREMENTS:

6.1 The DLV shall not be entered by any deflection of the FOPS, or by the drop object. The FOPS top shall completely cover and overlap the vertical projection of the DLV.

6.2 The FOPS shall also meet the applicable performance criteria for a rollover protective structure (SAE J1040). (Identical, but not necessarily the same, structures are to be used for the FOPS and ROPS evaluations. Should the same structure be used for both evaluations, the drop test procedure shall precede the ROPS loading, with removal of impact dents or replacement of the FOPS cover permissible.)

6.3 The drop test shall be performed with all ROPS and FOPS members at -18°C (0°F) or below, or the material used in the FOPS cover shall exhibit one of the Charpy V notch impact strengths at -30°C (-20°F) shown in Table 1. See SAE J1119 for explanation of impact toughness on materials less than 4 mm (0.15 in) thick.

TABLE 1 - CHARPY V NOTCH IMPACT STRENGTHS

Specimen Size, mm	J	ft-lb	Specimen Size, mm	J	ft-lb
10 x 10[a]	11.0	8.0	10 x 6	8.0	6.0
10 x 9	10.0	7.5	10 x 5[a]	7.5	5.5
10 x 8	9.5	7.0	10 x 4	7.0	5.0
10 x 7.5[a]	9.5	7.0	10 x 3.3	6.0	4.5
10 x 7	9.0	6.5	10 x 3	6.0	4.5
10 x 6.7	8.5	6.5	10 x 2.5[a]	5.5	4.0

[a]Indicates preferred size. Specimen size shall be no less than the largest preferred size that the material will permit.

Reference: ASTM A 370, Standard Methods and Definitions for Mechanical Testing of Steel Products.

7. LABELING: The FOPS shall be labeled according to SAE J1164. The protection afforded (see Section 1) should be described in the operator's manual and/or referenced on the label.

8. REFERENCES: Available from the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096:

SAE J397, Deflection Limiting Volume - ROPS/FOPS Laboratory Evaluation.

SAE J1040, Performance Criteria for Rollover Protective Structures (ROPS) for Construction, Earthmoving, Forestry, and Mining Machines.

SAE J1119, Steel Products for Rollover Protective Structures (ROPS) and Falling Object Protective Structures (FOPS).

SAE J1164, Labeling of ROPS and FOPS.

Available from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103:

ASTM A370, Standard Methods and Definitions for Mechanical Testing of Steel Products.

Available from American National Standards Institute, 1430 Broadway, New York, NY 10018:

ISO 3449, Earthmoving Machinery - Falling Object Protective Structures Laboratory Test and Performance Requirements.

The phi (Ø) symbol is for the convenience of the user in locating areas where technical revisions have been made to the previous issue of the report. If the symbol is next to the report title, it indicates a complete revision of the report. If there are no phi symbols, the document contains no revisions.

RATIONALE:

Certain application environments for Off-Road, Self-Propelled General Purpose Industrial Machines may cause the user to desire overhead protection from small falling objects such as bricks and hand tools; in some instances, this protection may be required by regulation. These environments include areas around highway overpasses and construction sites where falling distance would be less than 9 m (30 ft).

This standard demonstrates the ability of the FOPS canopy to withstand impacts from dropped objects, as described above, by using a rounded (spherical) object of fixed mass and drop height; thereby providing a repeatable test criterion. The canopy and its supporting structure must additionally meet SAE J1040 ROPS requirements to demonstrate operator protection in event of a rollover. Since a ROPS test is destructive in nature, the drop test is to be performed first when the same structure is used for both tests.

The original document used similar format and wording to SAE J231. The present revision continues this pattern, but clarifies several areas by additional wording and through use of notes taken from ISO 3449 Earthmoving Machinery - Falling Object Protective Structures - Laboratory Tests and Performance Requirements. It seems desirable to maintain a high degree of consistency between these documents. However, this does not in any way detract from the need of different test requirements. Many General Purpose Industrial Machines are small-sized and can approach the lower limits of power and mass (15 kw and 700 kg) for application of ROPS. They also have differing application environments and duty cycles from large construction or earthmoving machines. Therefore, the need for higher levels of FOPS protection would be unlikely for many machine types and applications. However, there may be certain applications where the user may desire or require SAE J231 FOPS (protection from falling trees or rocks).

RELATIONSHIP OF SAE STANDARD TO ISO STANDARD:

Not applicable.

REFERENCE SECTION:

Available from the Society of Automotive Engineers, Inc., 400 Commonwealth Drive, Warrendale, PA 15096:

SAE J397, Deflection Limiting Volume - ROPS/FOPS Laboratory Evaluation.
SAE J1040, Performance Criteria for Rollover Protective Structures (ROPS) for Construction, Earthmoving, Forestry, and Mining Machines.
SAE J1119, Steel Products for Rollover Protective Structures (ROPS) and Falling Object Protective Structures (FOPS).
SAE J1164, Labeling of ROPS and FOPS.

Available from the American Society for Testing and Materials, 1916 Race Street, Philadelphia, PA 19103:

ASTM A370, Standard Methods and Definitions for Mechanical Testing of Steel Products.