SAE International™

SURFACE VEHICLE RECOMMENDED PRACTICE

SAE J1356

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Superseding J1356 AUG2002

Minimum Performance Criteria for Falling Object Guards for Excavators

1. Scope

1.1 This SAE Recommended Practice applies only to excavators, as defined in SAE J/ISO 6165, working above ground, near an excavated or free standing bank or mine face which is higher than the top of the cab, or in demolition applications of free standing buildings or objects higher than the top of the cab.

1.2 The evaluations are for resistance to penetration of guards to the point of infringement of the Deflection Limiting Volume (DLV, see SAE J397). The performance requirements of a representative specimen (that is, within the manufacturer's specifications), are based on the performance of proven structures under laboratory evaluation procedures.

1.3 The areas protected include the top of the operator station (Top Guard), for protection from falling objects, and the front of the operator station (Front Guard), for protection from objects which approach the front of the cab.

1.4 Although falling object guards meeting the following criteria may not give crush protection under all conceivable circumstances in which the machine could be struck from above or the front, it is expected that crush protection will be ensured under at least the loading condition specified in the tests listed in Section 5.

1.5 Purpose—This document establishes a consistent, repeatable test procedure and performance requirements for evaluating guards intended to provide excavator operators with reasonable protection from falling objects such as rocks.

2. References

2.1 Applicable Publications—The following publications form a part of the specification to the extent specified herein. Unless otherwise indicated, the latest issue of SAE publications shall apply.

2.1.1 SAE Publications—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

SAE J397—Deflection Limiting Volume—Protective Structures Laboratory Evaluation
SAE J1119—Steel Products for Rollover Protective Structures (ROPS) and Falling Object Protective Structures (FOPS)
SAE J/ISO 6165—Earthmoving Machinery—Basic Types—Vocabulary

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2.1.2 ASTM—Available from ASTM, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

ASTM A 370—Test Methods and Definitions for Mechanical Testing of Steel Products

2.2 Related Publication—The following publication is provided for information purposes only and is not a required part of this document.

2.2.1 SAE PUBLICATION—Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-001.

SAE J/ISO 3449—Earthmoving Machinery—Falling-Object Protective Structures—Laboratory Tests and Performance Requirement

3. Facilities

3.1 Top Guard

3.1.1 A standard laboratory drop test object, made of steel, as shown in Figure 1.

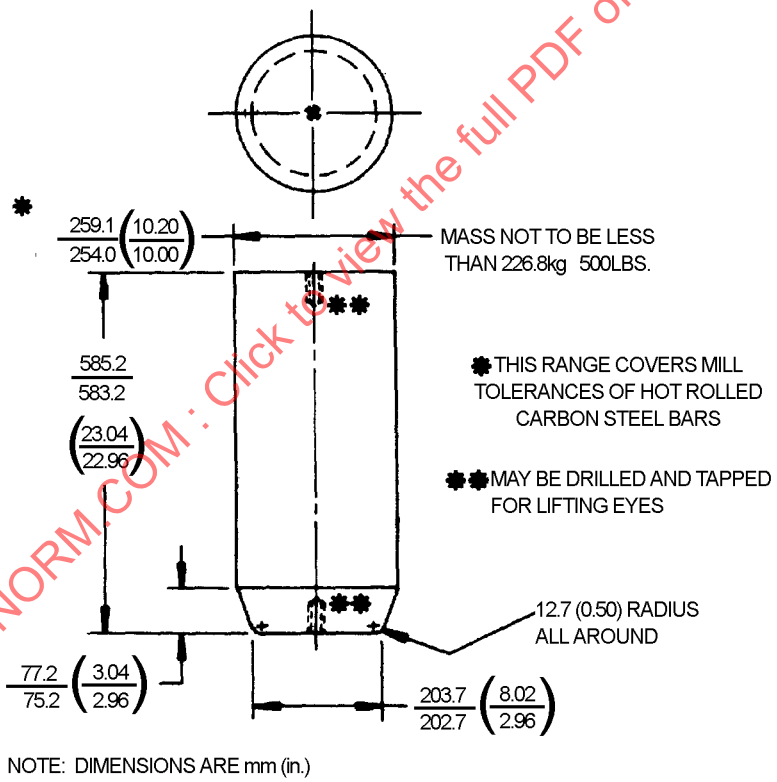


FIGURE 1—DROP TEST OBJECT

3.1.2 A means of raising the object to the required height.

3.1.3 A means of releasing the object so that it falls without restraint.

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

3.1.5 A means of determining if the test object or Top Guard enters the DLV, during the drop test. This may be either of the following:

3.1.5.1 A DLV in the upright attitude, made of material which will indicate any penetration by the test object or Top Guard. The DLV should be fixed firmly to the same part of the machine to which the operator seat is secured. Grease or similar substance may be put either on top of the DLV or on the lower surface of the Top Guard cover to indicate penetration.

3.1.5.2 A dynamic instrumentation system of sufficient frequency response to indicate the pertinent deflection with respect to the DLV.

3.2 Front Guard

3.2.1 A standard laboratory penetration test object, made of steel, with the shape of the tapered end of the object in Figure 1. The object length shall be sufficient to avoid a diameter larger than 260 mm making contact with Front Guard during test.

3.2.2 A means of pushing the object into the Front Guard.

3.2.3 A means of measuring the force exerted to push the object into the Front Guard.

3.2.4 A means of determining if the test object or Front Guard enters the (DLV), during the push test. This may be either of the following:

3.2.4.1 A DLV in the upright attitude, made of material which will indicate any penetration by the test object or Front Guard. The DLV should be fixed firmly to the same part of the machine to which the operator seat is secured. Grease or similar substance may be put either on front of the DLV or on the inner surface of the Front Guard to indicate penetration.

3.2.4.2 An instrumentation system to indicate the pertinent deflection with respect to the DLV.

3.2.5 A means to measure the deflection distance at the same time as measuring the force as the object is pushed into the Front Guard.

4. Machine or Test Bed Condition

4.1 The Operator Guards to be evaluated must be attached to the machine as they will be in actual machine use. A complete machine is not required; however, the portion to which the Operator Guards are mounted must be identical to the structure, and the vertical stiffness of the test bed must be not less than that of an actual machine as described in 4.2.

4.2 If the Operator Guards are mounted on a machine, the following stipulations apply:

4.2.1 There are no limitations on customary attachments.

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 removable windows, normally removable panels, or nonstructural fittings, shall be removed so that they do not contribute to the strength of the Operator Guards, except as noted in 5.1.1.

4.4 The Guards to be tested shall be representative of units within the manufacturer's specifications.

5. Test Procedure

5.1 Top Guard Test

5.1.1 The standard laboratory drop test object (Figure 1) shall be placed on top of the Top Guard (small end of the object down) at the location designated in 5.1.2, 5.1.3, and 5.1.4. It is intended that the drop location include at least a portion of the vertical projection of the head area of the DLV. If it does not, two drop tests will be required; one to be located within the head area as far as possible from major, upper, structural members; and the other to be as defined in 5.1.2, 5.1.3, and 5.1.4. Also, where other materials or a different thickness are used in different areas above the DLV, each area in turn shall be subjected to a drop test.

NOTE— It is the intent of this document to impose the most severe test condition on the Top Guard. If design features such as cutouts for windows or equipment or variations in cover material or thickness indicate a more severe location could obviously be selected within the vertical projection of the DLV, the drop location should be adjusted accordingly. In addition, if cutouts in the Top Guard cover are intended to be filled with devices to provide adequate protection, those devices or equivalent must be in place during the drop test.

5.1.2 The small end of the object is to be entirely within the vertical projection of the DLV on the Top Guard.

5.1.3 Within the limitation of 5.1.2, the object shall be so placed that it has the least possible distance from the centroid of the Top Guard. (The area whose centroid is referred to is that portion of the Top Guard that is not over major, upper, structural members.) (See Figure 2.)

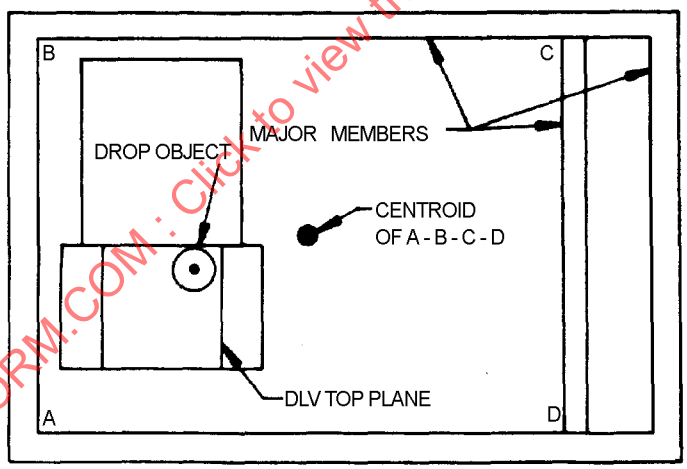


FIGURE 2—DROP TARGET EXAMPLE

5.1.4 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 5.1.2 and 5.1.3 shall apply to the segment containing the greatest area of the DLV projection (see Figure 3).

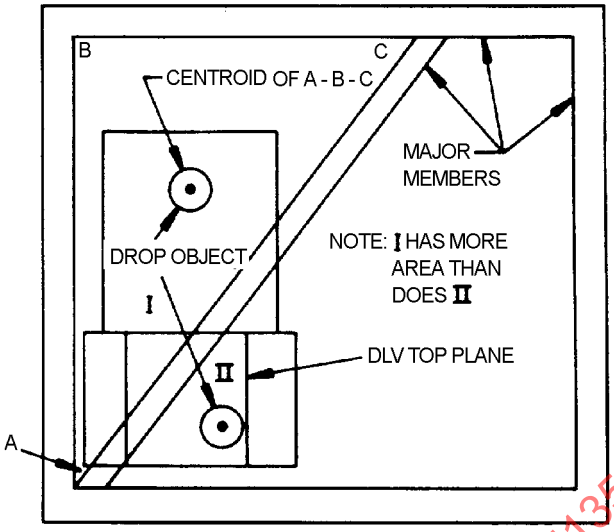


FIGURE 3—DROP TARGET EXAMPLE

5.1.5 The object is to be raised vertically 5.2 m (17 ft) above the position(s) indicated in 5.1.1, 5.1.2, 5.1.3, and 5.1.4.

5.1.6 The object is to be released so that it falls without effective restraint onto the Top Guard.

5.1.7 As it is unlikely that the free fall will result in the object hitting at the exact location and/or in the attitude of 5.1.1, 5.1.2, 5.1.3, and 5.1.4, the following limits are placed on deviations:

5.1.7.1 The initial impact of the small end of the object shall be entirely within a circle of 200 mm (8 in) radius. (The center of this circle is to coincide with the vertical centerline of the object as positioned per 5.1.1 to 5.1.4, but not on any major, upper, horizontal member.)

5.1.7.2 The first contact between the object and the Top Guard shall be only along the small end of the object and/or the radius contiguous to that end (see Figure 1).

5.1.7.3 There is no limitation on location or attitude of subsequent impacts due to rebounding.

5.2 Front Guard Test

5.2.1 The small end of the standard laboratory penetration test object shall be placed against the Front Guard at the location designated in 5.2.2, 5.2.3, and 5.2.4.

5.2.2 The small end of the object is to be entirely within the horizontal projection of the DLV on the Front Guard.

5.2.3 Within the limitation of 5.2.2, the object shall be placed so that it is the least possible distance from the front of the DLV and from the centroid of the Front Guard (the area whose centroid is referred to is that portion of the Front Guard that is not in front of major structural members). The object shall be placed so that it pushes midway between the two elements. (See Figure 4.)

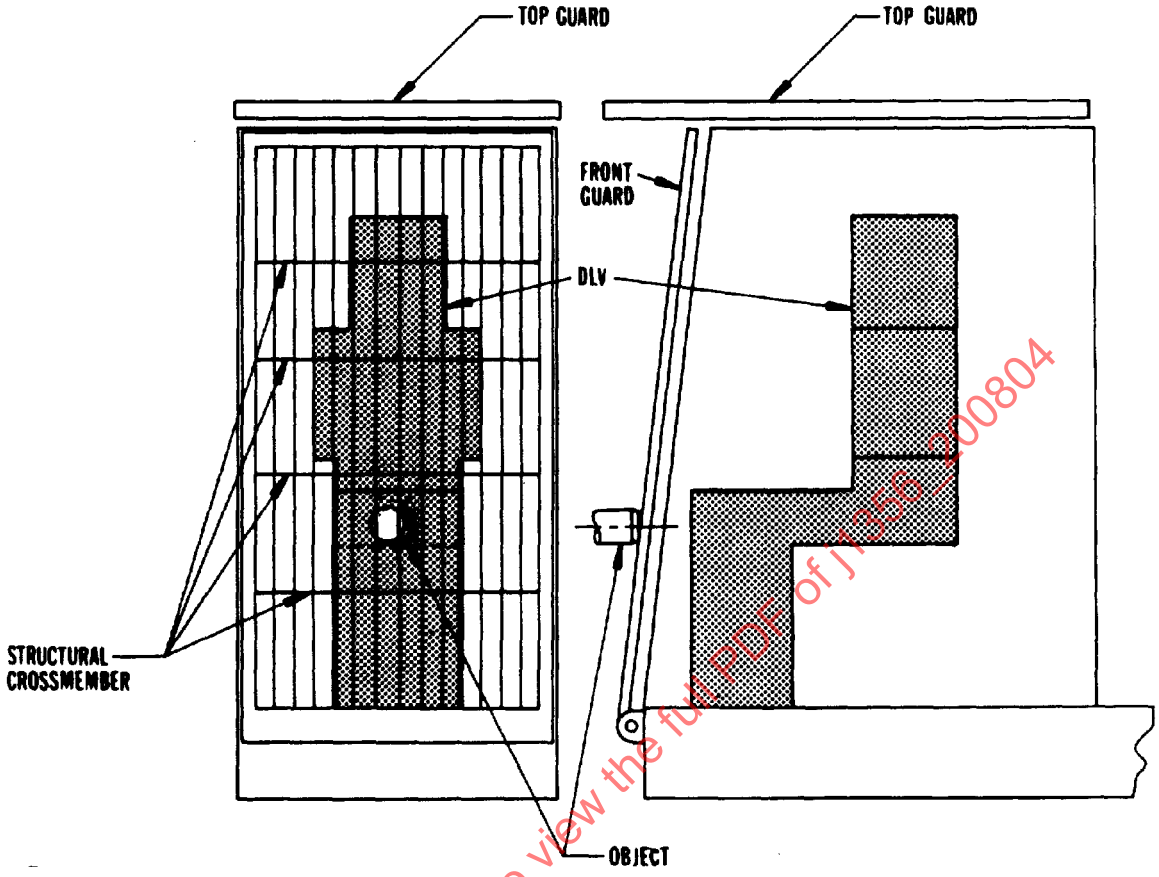
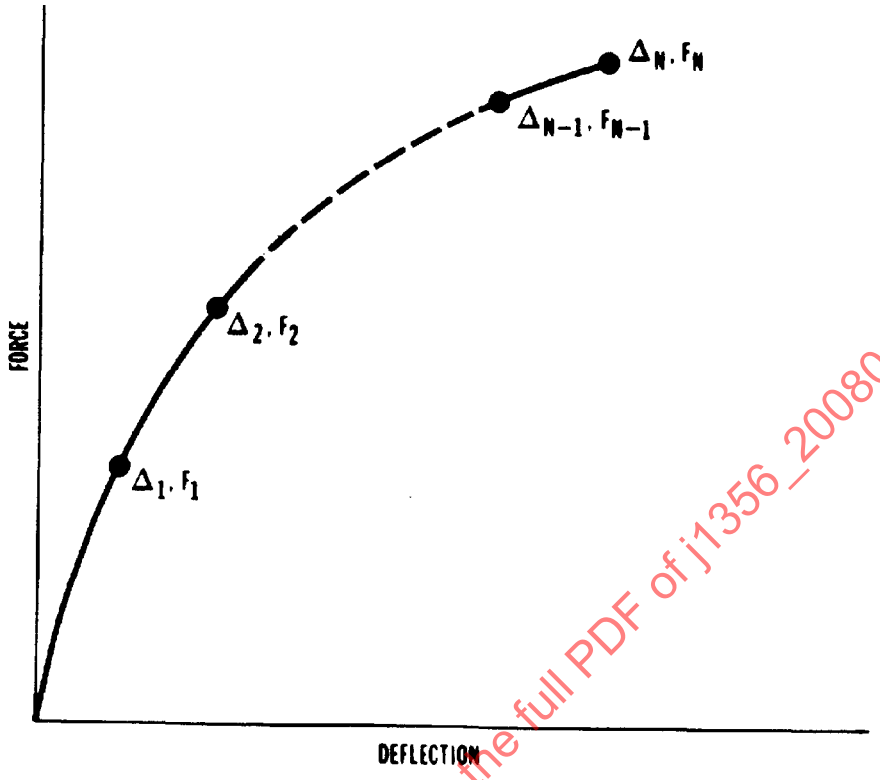


FIGURE 4—DROP TARGET EXAMPLE

5.2.4 Should the horizontal projection of the DLV be divided into two or more segments by major structural members, the directions of 5.2.2 and 5.2.3 shall apply to the segment containing the greatest area closest to the DLV projection. (See Figure 4).

5.2.5 The object is to be pushed horizontally into the Front Guard at the location(s) indicated in 5.2.2, 5.2.3, and 5.2.4.

5.2.6 The rate of application of deflection (load) shall be such that it can be considered static. At deflection increments no greater than 13 mm (0.5 in), measured at the point of application of the load, record force and deflection. This loading is to continue until the Front Guard has achieved the energy requirements. (See Figure 5 for method of calculating energy.) The deflection used in calculating energy is to be that of the Front Guard along the line of action of the force. The line of action of the load object shall be maintained within a circle of 50 mm (2 in) radius of the initial contact point.



$$\text{AREA} = \frac{\Delta_1 F_1}{2} + (\Delta_2 - \Delta_1)\left[\frac{F_1 + F_2}{2}\right] + \cdots + (\Delta_N - \Delta_{N-1})\left[\frac{F_{N-1} + F_N}{2}\right]$$

FIGURE 5—METHOD FOR CALCULATING ENERGY

6. Performance

6.1 No portion of the DLV or any extension of the horizontal top plane of the DLV shall be entered due to any deflection of the Top Guard under the first or any subsequent impacts of the drop test object.

6.2 The DLV shall not be entered during the Front Guard test before 11 526 J (8500 ft-lb) of energy have been absorbed.

6.3 The test shall be performed with the Guards at –18 °C (0 °F) or below or the material used in the Operator Guards shall exhibit one of the Charpy V notch impact strengths at –30 °C (–20 °F) shown in Table 1. (SAE J1119 presents more data on specifics of CVN specimen size-test temperature interaction that meets the intent of the basic requirements of Table 1. SAE J1119 also gives information on chemistries, manufacturing processes, and tensile properties of steel suitable for use in Operator Guards but only the CVN impact strengths are mandatory.)