SAE International

SURFACE VEHICLE STANDARD

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Volumetric Rating of Excavator Mounted, Bucket Linkage Operated Grapples

RATIONALE

This revision is to correct an error in Equation 6. Additionally, dates were removed from references, and they were reordered.

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1. SCOPE AND APPLICATION

This standard specifies a procedure for approximating the volume of materials contained in the grapple of bucket linkage operated grapples mounted to excavators. The volume ratings are based on the inside dimensions of the grapple and representative volumes extending beyond the grapple.

The method employs the technique of dividing the complex shape of the material in the grapple into simple geometric forms to allow volume calculations of different grapple configurations.

The rating method is intended to provide a consistent means of comparing grapple capacities. It is not intended to define actual capacities that might be observed in any specific application.

2. REFERENCES

2.1 Related Publications

The following publications are provided for information purposes only and are not a required part of this SAE Technical Standard.

2.1.1 ISO Publications

Available from American National Standards Institute, 25 West 43rd Street, New York, NY 10036-8002, Tel: 212-642-4900, www.ansi.org.

ISO 7451 Earth moving machinery - Volumetric ratings for hydraulic excavator buckets and backhoe loader buckets

ISO 7546 Earth moving machinery - Loader and front-loading excavator buckets - Volumetric ratings

ISO 9248 Earth-moving machinery - Units for dimensions, performance and capacities, and their measurement accuracies

3. RESTRICTIONS AND LIMITATIONS

The effect on volumes of local discontinuities such as tine teeth, tooth adapters, wear components and gussets shall be ignored.

4. DEFINITIONS, SYMBOLS AND TERMINOLOGY

4.1 GRAPPLE COMPONENTS

(See Figure 1.)

4.1.1 Hinge Pin

The pivot pin that connects the upper and lower jaws.

4.1.2 Inner Sheet

The inside face that composes the inside of the jaw.

4.1.3 Lower Jaw

The half of the grapple not attached to the machine's bucket linkage.

4.1.4 Outer Sheet

The sheet that composes the outside of the jaw.

4.1.5 Stiff Link Bracket

The bracket attached to the machine's arm used for attaching the stiff link.

4.1.6 Stiff Link

The link that positions the lower jaw.

4.1.7 Tine Tip

The end of the tine.

4.1.8 Tine

A finger that is that portion of the jaw that interlocks with the opposing jaw.

4.1.9 Upper Jaw

The half of the grapple that is attached to the machine's bucket linkage.

4.1.10 Wear Plate

Plates that are attached to the inner and outer sheets of a grapple expressly as a sacrificial component to accommodate wear and therefore protect the grapple structure.

4.2 OPEN POSITION

The position of the grapple jaws when the host machine's bucket cylinder is fully retracted, or retracted as much as the grapple allows.

4.3 CLOSED POSITION

The position of the grapple jaws when the host machine's bucket cylinder is fully extended, or extended as much as the grapple allows.

4.4 GRAB POSITION

The position of the grapple tines in which the area A_G is maximized.

4.5 RATED GRAPPLE VOLUME V_R

Maximum grapple capacity in the grab position.

4.6 GRAB POSITION AREA A_G

The side area defined by the grapple shape in the grab position. (See Figure 2)

4.7 END AREA A_E

The area defined as the distance between the tine tips with the grapple jaws in the grab position and the average of the widths of the lower and upper jaws.

4.8 ENCLOSED VOLUME V_C

The volume constrained by the upper and lower tines of the grapple.

4.9 END VOLUME V_E

The volume of material with a 1:2 inclination that is situated on the end of the enclosed volume.

4.10 SIDE VOLUME V_S

The volume of material with a 1:1 inclination that is situated on the side of the enclosed volume.

4.11 UPPER JAW WIDTH A

The width of the upper jaw at the tip of the jaw. (See Figure 5)

4.12 LOWER JAW WIDTH B

The width of the lower jaw at the tip of the jaw. (See Figure 5)

4.13 MAXIMUM OPENING C

The maximum distance between the jaw tips when fully opened. (See Figure 5)

4.14 MINIMUM THICKNESS D

The thickness of the grapple when closed, measured from the outermost of upper jaw inner sheet to the outermost of the lower jaw inner sheet.

4.15 MAXIMUM THICKNESS E

The height of the grapple when open, measured from the outermost of upper jaw.

4.16 TIP RADIUS F

The distance from tine tip to the hinge pin.

4.17 JAW DEPTH G

The distance from an line defined by the tine tip and the back edge of the jaw inner sheet to the furthest portion of the jaw shape curve. (See Figure 5)

5. CALCULATION

5.1 Enclosed Volume

The enclosed volume is calculated as follows:

With the grapples jaws opened to the grab position

$$V_C = A_G W_A \quad \text{(Eq.1)}$$

where:

A_G = area in the grab position (See Figure 2) and

$$w_A = \frac{(A + B)}{2} \quad \text{(Eq. 2)}$$

5.2 End Volume

The end volume is approximated by creating a pyramid with a slope of 1:2, whose base area and shape are the same as the end area and shape. Use the following formula to calculate the end volume:

When $L_o \geq W_A$ then:

$$V_E = \left(\frac{W_A{}^3}{12}\right) + \left(\frac{W_A{}^2}{8}\right) \bullet (L_o - W_A) \quad \text{(Eq. 3)}$$

Otherwise when $L_o \leq W_A$ then:

$$V_E = \left(\frac{L_o{}^3}{12}\right) + \left(\frac{L_o{}^2}{8}\right) \bullet (W_A - L_o) \quad \text{(Eq. 4)}$$

where:

L_o = distance between tine tips when jaws are opened to maximize A_G (See Figure 3)

5.3 Side Volume

The side volume is calculated using a method similar to the end volume, except the grab area is the equivalent area as a square. Use the grab area in the following formula to calculate the side volume:

$$V_s = \frac{W_{sq}{}^3}{6} \quad \text{(Eq.5)}$$

where:

$$W_{sq} = \sqrt{A_G} \quad \text{(Eq.6)}$$

5.4 Total Volume

The total volume is the summation of the enclosed volume, the end volume and twice the side volume. It is expressed in the following calculation. (See Figure 4.)

$$V_R = V_C + V_E + 2V_S \quad \text{(Eq.7)}$$

6. EXPRESSION OF THE VOLUMETRIC RATING

6.1 Volumetric Rating of a Grapple

The volumetric rating of the bucket shall be the total volume as calculated in 5.4.

6.2 Designation of the Commercial Capacity

The commercial capacity shall not exceed ±3% of the calculated value. (See Table 1)

TABLE 1 - ALLOWABLE CAPACITY INCREMENTS

	Values in Cubic Meters
Range of Rated Capacity	Increments
Up to 1.5	0.05
>1.6 to 3.5	0.1
> 3.6 to 8	0.25
8 and larger	0.5

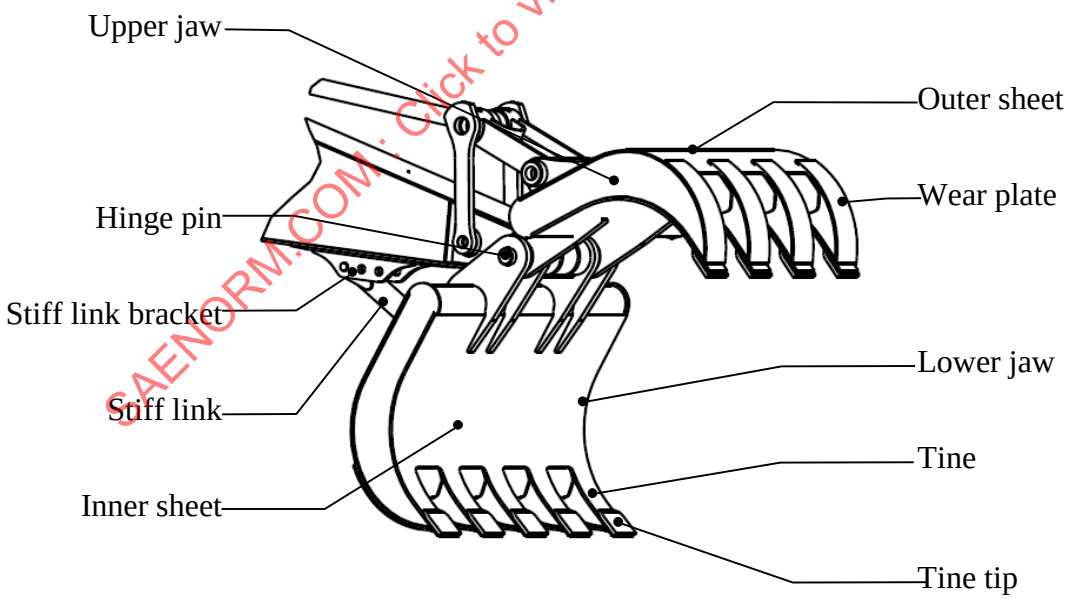

FIGURE 1 - GRAPPLE NOMENCLATURE

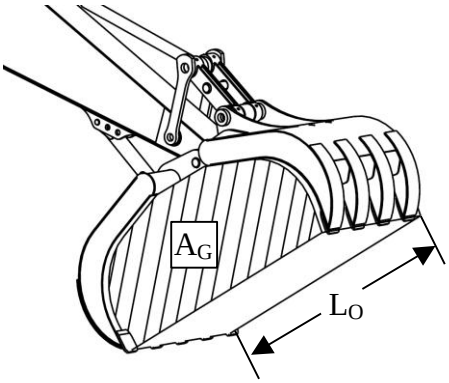

FIGURE 2 - GRAPPLE AREA IN THE GRAB POSITION

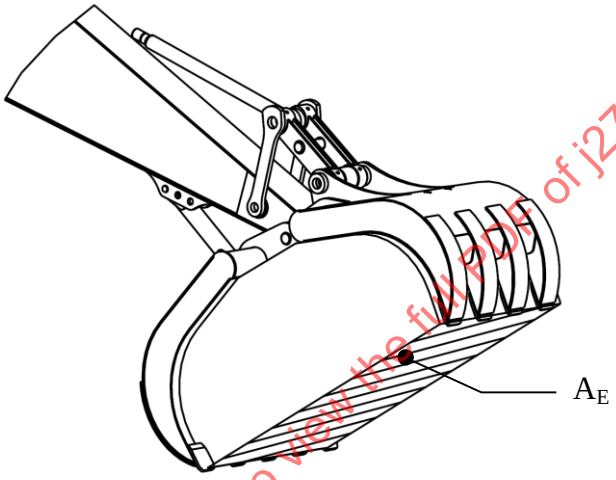

FIGURE 3 - GEOMETRIC REPRESENTATION OF END AREA