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An American National Standard

Standard Test Method for Measuring Baseball Bat Performance Factor[1]

This standard is issued under the fixed designation F 1881; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This specification defines a method for determining bat performance by measuring the Coefficient of Restitution (COR) of the bat-ball collision using a ball with a known COR then deriving a bat performance factor.

1.2 *This standard does not purport to address all the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

F 1887 Test Method for Measuring the Coefficient of Restitution (COR) of Baseballs and Softballs[2]

F 1888 Test Method for Compression-Displacement of Baseballs and Softballs[2]

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *balance point, n*—the distance to the center of mass measured from the knob.

3.1.2 *bat-ball coefficient of restitution (COR), n*—the COR of a specific ball colliding with a stationary bat as defined in this test method. See *coefficient of restitution (COR).*

3.1.3 *bat performance factor, n*—the ratio of performance change a bat introduces to a ball collision, compared to a ball colliding with a solid wall as in the ASTM Ball COR test.

3.1.4 *center of percussion (COP), n—also known as the center of oscillation,* the length of a simple pendulum with the same period. Forces and impacts at this location will not induce reactions at the pivot point.

3.1.5 *coefficient of restitution (COR), n*—a measure of impact efficiency calculated as the relative speed of the objects after impact divided by the relative speed of the objects before impact.

3.1.6 *elevated speed, n*—ball speeds in excess of the standard 88 fps.

3.1.7 *moment of inertia (MOI), n*—a measure of mass distribution relative to an axis of rotation. It is the product of the mass multiplied by the square of the distance to the mass, summed over the entire bat.

3.1.8 *period, n*—the time required for a pendulum to oscillate through one complete cycle.

4. Significance and Use

4.1 This test method offers a laboratory means to compare the overall performance of a bat as it relates to batted-balls speeds.

4.2 Use of this test method can provide sports governing bodies a means to compare the anticipated batted-ball speed, thus batted-ball distance for the purposes of controlling the game and safety.

4.3 Batted-ball speed can be related to bat performance factor (BPF) using the following formula:

$$k = \left(\frac{w}{W}\right) + \left(\frac{w(R-a)^2}{(I - Wa^2)}\right) \quad (1)$$

where:

V = bat swing speed, mph. The speed is measured at the point of impact, at the sweet-spot of the bat, otherwise specified as the COP. Impacts at the COP offer essentially the highest batted-ball speeds due to the optimization of momentum transfer. The BPF value has been measured at this point and represents the maximum performance of the bat; therefore, the following calculations are correct only when the bat swing speed at the point impact are used. The swing speed at the COP can be as much as 20 % slower than bat speeds measured at the end of the bat. Typical adult values are 60 mph for average players and 70 mph for average collegiate level ball players. It is recognized that a players swing speed varies depending on skill level, conditioning, and bat swing weight (MOI).

[1] This test method is under the jurisdiction of ASTM Committee F-8 on Sports Equipment and Facilities and is the direct responsibility of Subcommittee F08.26 on Baseball and Softball Equipment and Facilities.

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[2] *Annual Book of ASTM Standards,* Vol. 15.07.

v = pitch speed, mph, the horizontal speed of the ball incoming to the batter,
W = bat weight, oz,
w = ball weight, oz,
I = MOI, oz-in.^{2}; typical value for an average bat is 9 000,
e = bat-ball COR = BPF × ball COR. One must chose a ball COR to determine the batted ball speed,
a = distance from pivot to center of mass (balance point); typical value is 14 in.,
R = COP; the radius of rotation typical value for an average bat is 22 in., and
k = ball-bat inertia ratio, convenient means to collect terms. Typical value for the average bat is 0.35.

$$\text{batted ball speed} = \frac{V(1 + e) + v(e - k)}{(1 + k)} \quad (2)$$

NOTE 1—Ball COR varies with relative impact speed.

5. Apparatus

5.1 *Bat Center of Percussion Test Apparatus*:

5.1.1 *Ruler*, suitable for measuring lengths up to 42 in. to the nearest 0.125 in. (3 mm).

5.1.2 *Scale*, suitable for measuring weight up to 48 oz (1360 g) to the nearest 0.1 oz (2.8 g).

5.1.3 *Stopwatch*, suitable device for measuring time to the nearest tenths of seconds (0.1 s).

5.1.4 *Stand*—A frame large enough to allow a bat held in a vertical position to swing freely (see Fig. 1).

5.1.5 *Collar-Clamp*—A light weight clamp or collar that can hold the weight of a bat and provide a fixed pivot location. Collar shall be rotationally balanced (see Fig. 1). A simple hook-loop band used with sharp pointed screw may be used as a pivot.

5.2 *Bat-Ball COR Test Apparatus*:

5.2.1 *Test Balls*—Official balls approved for play marked with the actual Coefficient of Restitution (COR) from a previously run test. Each individual ball used in this test method shall be marked with the actual tested and verified ball COR when tested in accordance with Test Method F 1887.

5.2.1.1 *Compression*—300 to 375 lb at ¼-in. deflection (1335 to 1668 N).

5.2.1.2 *Weight*—5.0 to 5.25 oz (142 to 149 g).

5.2.1.3 *Size*—9 to 9.5-in. circumference (22.9 to 23.5 cm).

5.2.1.4 *COR*—0.525 to 0.555.

5.2.2 *Ball Cannon*—A device capable of shooting a ball at a speed of 88 ft/s with a maximum aiming error of ± 0.125 in. (6 mm) at the point of impact. The ball shall not have a spin rate in excess of 50 rpm. Typical pitching machines cannot yield the aiming accuracy required by this test method. Cannon exhaust air must not be allowed to pass to the bat. The cannon shall not blow out a match located in the impact location when it is dry-fired (fired without a ball). The ball cannon can be any distance from impact location, as long as it can meet the ball aim requirements and provide six valid impacts in 12 shots or less.

5.2.3 *Bat Speed Gate*—A light trap, device, or an equivalent, capable of measuring an edge traveling at speeds in excess of 88 ft/s (26.8 m/s) with an accuracy of 0.5 ft/s or better (0.2 m/s). The first sensor shall trigger when the bat rotates no less than 15° and no more than 20° from its start position. It is suggested the second trigger be 3 in. away from the first and must not be any further than 3.6 in. away in a 6-in. (15.24-cm) radius.

5.2.4 *Ball Speed Gate*—A light trap, device, or an equivalent, capable of measuring a sphere traveling at speeds in excess of 88 ft/s (26.8 m/s) with an accuracy of 0.5 ft/s or better (0.2 m/s). The device shall measure across a length of no less than half the ball diameter to avoid centering error. For example, when testing balls, the device shall sense an object across a 2-in. (5-cm) line. The first sensor shall trigger when the ball is no more than 12 in. (30.5 cm) from the bat surface. It is suggested the second trigger to 3.6 in. away from the first and must not be any further than 8 in. away.

5.2.5 *Bat Pivot Support*—A turntable with clamps to support and align the bat in the path of the ball. The clamp surfaces shall be a 45° Vee clamp with a radius no greater than 2 in. (5 cm). The rotating clamp and shaft assembly shall not weigh more than 6 lb (2.7 kg) and shall spin freely in a pair of ball bearings (see Fig. 2). The polar Moment of Inertia (MOI) for the clamp turntable assembly shall not exceed 192 oz/in.^{2} (35 117 g/cm^2).

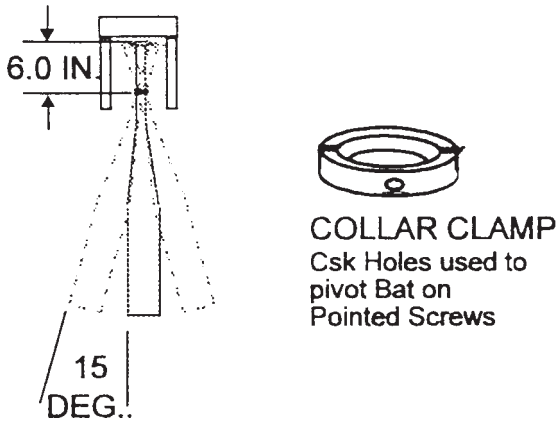

FIG. 1 MOI Fixture

6. Determination of Bat Features and Test Location

6.1 *Weight*—Measure the weight of the bat to the nearest 0.01 oz (0.28 g).

6.2 *Balance Point*—Measure and record the overall bat length to the nearest 0.063 in. (2 mm) and overall bat weight as specified in 6.1. Place bat on balance point stand as shown in Fig. 3. Adjust height of knob stand to keep bat axis level. Knowledge of the knob and barrel diameters can be helpful here. Measure and record the barrel end weight of the bat, and calculate the balance point of the bat using the following formula: