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AMERICAN SOCIETY FOR TESTING AND MATERIALS
100 Barr Harbor Dr., West Conshohocken, PA 19428
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Standard Test Method for Measuring Softball Bat Performance Factor[1]

This standard is issued under the fixed designation F 1890; 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 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

1.3 *This standard does not purport to address all of 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 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 outermost edge of the knob end of the bat.

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 Test Method F 1887.

3.1.4 *ball cover, n*—the leather or equivalent material used to cover the ball core.

3.1.5 *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.

3.1.6 *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.

3.1.7 *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 formulae:

4.3.1 V = *bat swing speed, mph*—speed measured at the point of impact, at the sweet spot of the bat, otherwise specified as the COP. Impacts as 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 top level non-super major softball players. It is recognized that a players swing speed varies depending on skill level, conditioning, and bat swing weight (MOI).

4.3.2 v = *pitch speed, mph*—horizontal speed of the ball incoming to the batter. Typical slow pitch values are 10 mph while fast pitch speeds vary significantly with the level of play.

4.3.3 W = *bat weight, oz.*

4.3.4 w = *ball weight, oz.*

4.3.5 I = *MOI, oz-in.*^{2}—typical value for an average bat is 9000.

4.3.6 e = *bat-ball COR* = BPF × ball COR. One must choose a ball COR to determine the batted ball speed.

4.3.7 a = distance from pivot to center of mass (balance

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

point); typical value is 14 in.

4.3.8 R = COP, the radius of rotation. Typical value for an average bat is 22 in.

4.3.9 k = ball-bat inertia ratio, a convenient means to collect terms. Typical value for the average bat is 0.35.

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

4.3.10 Batted ball speed $= \dfrac{V(1+e) + v(e-k)}{(1+k)}$

4.3.11 Table 1 offers sample calculations to show the relationship of BPF and ball COR.

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 *Stop watch*, or other suitable device for measuring time to the nearest tenth of a second (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, which can hold the weight of a bat and provide a fixed pivot location. Collar shall be balanced rotationally (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 softballs approved for play, individually tested in accordance with ASTM standards TBD and marked with their resulting COR and compression-displacement values. Balls may be used without the cover material to reduce variations in the test data. In this case, the ball COR must be tested in accordance with ASTM Standard TBD without the cover material. Test balls must meet the following specifications.

5.2.1.1 *Compression*—350 to 375 lb at ¼-in. deflection (1557 to 1668 N).

5.2.1.2 *Weight*—6.5± 0.5 oz (185 ± 15 g).

5.2.1.3 *Size*—12.125± 0.125 in. circumference.

5.2.1.4 *Core Material*—Polyurethane.

5.2.1.5 *COR*—0.47 ± 0.005 (0.465 to 0.475).

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. 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. Cannon shall not blow out a match located in the impact location when cannon is dry fired (fired without a ball). 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.

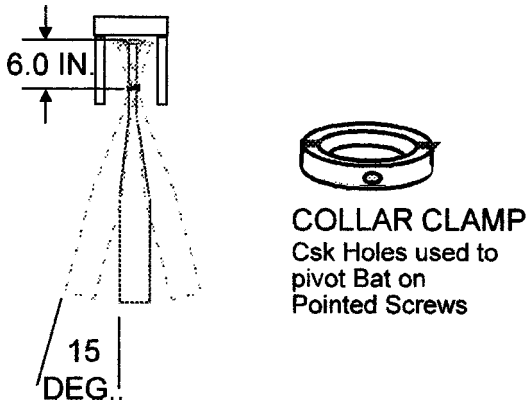

FIG. 1 MOI Fixture

5.2.3 *Bat Speed Gate*—Light trap, or equivalent, device capable of measuring an edge traveling at speeds in excess of 88 ft/s (26.8 m/s) with an accuracy of 0.5 fps 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. (mm) away from the first and must not be any further than 3.6 in. (mm) away on a 6-in. (15.24-cm) radius.

5.2.4 *Ball Speed Gate*—Light trap, or equivalent, device capable of measuring a sphere traveling at speeds in excess of 88 ft/s (26.8 m/s) with an accuracy of 0.5 fps (0.2 m/s) or better. The device shall measure across a length of no less than half the ball diameter to avoid centering error. For example, when testing softballs, 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 be 3.6 in. away from the first and must not be any further than 8 in. (mm) away.

5.2.5 *Bat Pivot Support*—A turntable that rotates in the horizontal plane 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

TABLE 1 Sample Calculations

Ball COR	Ball Weight, *w*, oz	Bat Weight, *W*, oz	Bat MOI, *I*, oz-in.-in.	Bat COP, *R*, in.	Balance Point, *a*, in.	BPF	Inertia Ratio, *k*	Bat-Ball COR, *e*	Swing Speed *V*, mph	Pitch Speed, *v*, mph	Batted Ball Speed, mph
0.50	6.5	30	9000	22	14	1.2	0.350	0.60	60	10	72.96
0.47	6.5	30	9000	22	14	1.2	0.350	0.56	60	10	71.10
0.50	6.5	30	9000	22	14	1.3	0.350	0.65	60	10	75.56
0.47	6.5	30	9000	22	14	1.3	0.350	0.61	60	10	73.53
0.50	6.5	30	9000	22	14	1.2	0.350	0.60	70	10	84.81
0.47	6.5	30	9000	22	14	1.2	0.350	0.56	70	10	82.68
0.47	6.5	32	9200	19	14	1.2	0.259	0.56	70	10	89.41
0.47	6.5	32	9200	22	16	1.2	0.435	0.56	70	10	77.18