Designation: F 2219 – 04

An American National Standard

Standard Test Methods for Measuring High Speed Baseball Bat Performance Factor[1]

This standard is issued under the fixed designation F 2219; 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 bat-ball coefficient of restitution (BBCOR), deriving the bat performance factor (BPF), deriving the ball exit speed ratio (BESR), and calculating a batted-ball speed (BBS). It is applicable to baseball and softball bats of any construction or material. The method provides a quantitative measure of bat dynamic performance that may be used for comparison purposes.

1.2 The BBCOR, BPF, BESR, and BBS are each calculated from measurements taken in the laboratory on test equipment meeting the requirements defined in this specification.

1.3 The values stated in English units are to be regarded as the standard.

1.4 *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:* [2]

F 1881 Test Method for Measuring Baseball Bat Performance Factor

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

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

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *balance point (BP)*, *n*—distance to the center of mass of a bat when measured from the distal end of the bat knob.

3.1.2 *ball exit speed (V_f)*, *n*—outbound speed of a ball following impact with a bat as defined in these test methods.

3.1.3 *ball exit speed ratio (BESR)*, *n*—ratio of ball exit speed (v_r) to ball inbound speed (v_i) plus one-half, as determined by these test methods.

3.1.4 *ball inbound speed (v_i)*, *n*—inbound speed of a ball prior to impact with a bat as defined in this test method.

3.1.5 *bat-ball coefficient of restitution (BBCOR)*—COR of a specific ball colliding with a bat as defined in these test methods. See *coefficient of restitution (COR)*.

3.1.6 *bat performance factor (BPF)*, *n*—ratio of BBCOR to ball COR as defined in these test methods.

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

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

3.1.9 *cycle*, *n*—one complete performance of the oscillation of the bat, specifically, one full swing of the bat.

3.1.10 *moment of inertia (MOI)*, *n*—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.

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

4. Significance and Use

4.1 This test method offers a laboratory the means to measure the performance of baseball and softball bats.

4.2 Use of this test method can provide sports governing bodies a means to compare calculated batted-ball speed and other physical properties of the bat for the purposes of controlling the game.

5. Apparatus

5.1 *Bat COP Apparatus*:

5.1.1 *Ruler*, suitable for measuring lengths up to 42 in. (1067 mm) to the nearest 0.031 in. (0.79 mm).

5.1.2 *Weight Scale*, suitable for measuring weight up to 48 oz (1360 g) to the nearest 0.0035 oz (0.1 g).

5.1.3 *Electronic Timer*, suitable device sufficiently accurate for measuring time to the nearest 1 μs (0.000001 s).

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

Current edition approved July 1, 2004. Published July 2004. Originally approved in 2002. Last previous edition approved in 2002 as F 2219 – 02$^{\epsilon 1}$.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

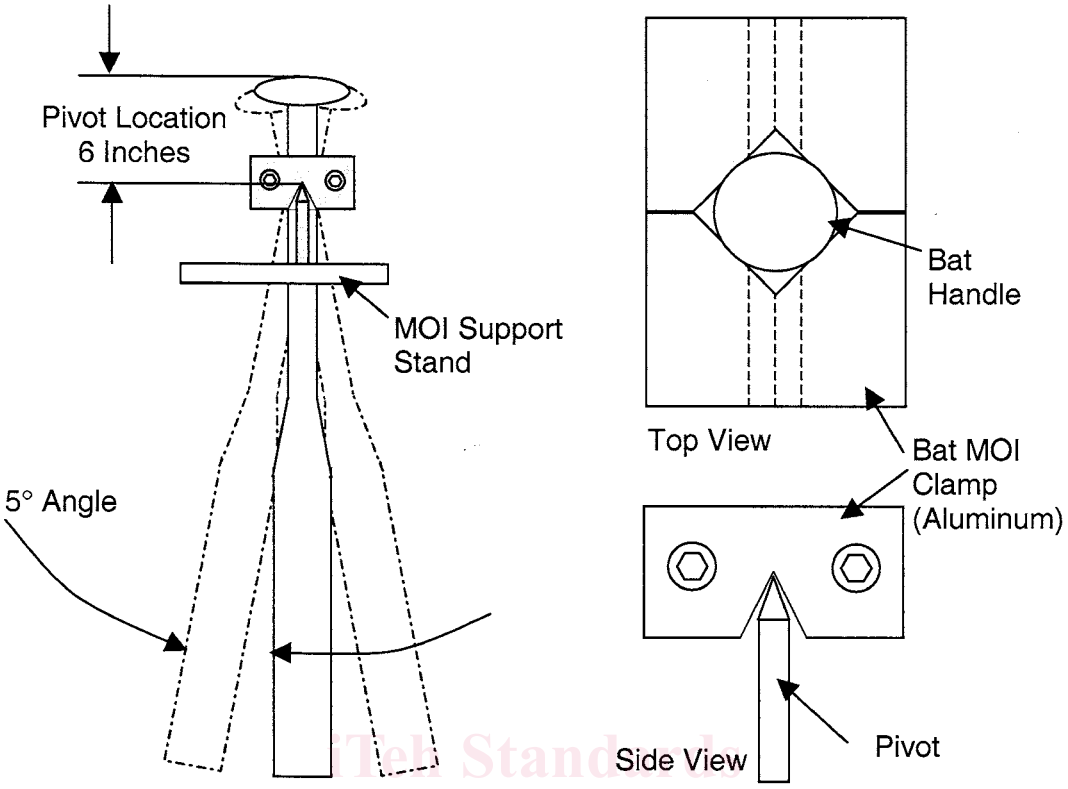

FIG. 1 MOI Fixture

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

5.1.5 *Bat Collar-Clamp*—A part of the MOI stand that allows quick, accurate mounting of the bat without a variable MOI effect due to the clamp with a maximum MOI of 4 oz-in^2 (0.8 kg-cm^2) measured about the bat pivot location; 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).

5.2 *Test Balls*—Official baseballs and softballs approved for play and tested in accordance with the following procedures.

5.2.1 *Baseballs*:

5.2.1.1 *Compression*—300 to 375 lb at 0.25-in. deflection (1335 to 1668 N at 6.4 mm). Compression values determined in accordance with Test Method F 1888. Balls to be labeled with compression value.

5.2.1.2 *Weight*—5.00 to 5.25 oz (142 to 149 g). Balls to be labeled with weight value.

5.2.1.3 *Size*—9.00 to 9.50 in. circumference (228.6 to 241.3 mm). Balls to be labeled with size value.

5.2.1.4 *Ball COR*—.525 to .550, as determined in accordance with Test Method F 1887. Balls to be labeled with COR and test speed in ft/s.

5.2.2 *Softballs*:

5.2.2.1 *Compression*—350 to 375 lb at 0.25-in. deflection (1557 to 1668 N at 6.4 mm deflection), as determined in accordance with Test Method F 1888. Balls to be labeled with compression value.

5.2.2.2 *Weight*—6.75 to 7.00 oz (191.0 to 198.1 g). Balls to be labeled with weight value.

5.2.2.3 *Size*—12.00 to 12.25 in. circumference (304.8 to 311.1 mm). Balls to be labeled with weight value.

5.2.2.4 *Ball COR*—.430 to .440, as determined in accordance with Test Method F 1887. Balls to be labeled with COR and test speed in ft/s.

5.3 *Bat-Ball COR Test Apparatus*:

5.3.1 *Ball Cannon*—A device capable of shooting a ball at speeds up to 161.7 ft/s (49.1 m/s). The ball shall not have a spin rate in excess of 10 rpm. Typical pitching machines cannot yield the aiming accuracy required by this test method. Cannon exhaust air must not cause motion of the bat in the absence of an impact. 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 twelve shots or less.

5.3.2 *Ball Speed Gate*—A light trap device, or an equivalent, capable of measuring a sphere traveling at speeds in excess of 161.7 ft/s (49.1 m/s) with an accuracy of ±1.61 ft/s or better (0.49 m/s). The device shall measure across a length of no less than half the ball diameter to avoid centering error. For example, the device shall sense an object across a 2.0 in. (50.8 mm) line. The first sensor shall trigger when the ball is no more than 18.0 in. (457.2 mm) from the bat surface. The second sensor shall trigger between 12.0 in. (304.8 mm) and 14.0 in. (355.6 mm) from the first sensor. The second sensor is located between the first sensor and the bat surface. The distance between sensors must be measured and maintained within ±0.005 in. (±0.13 mm) (see Fig. 2). The device must be

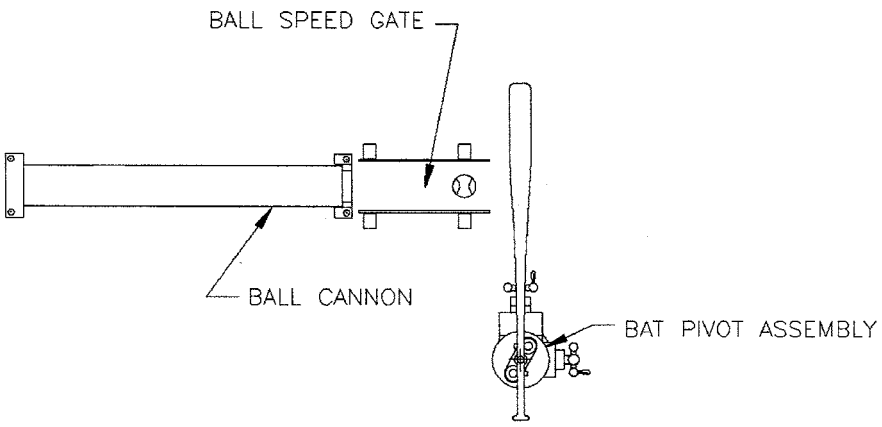

FIG. 2 Bat Testing Machine

able to measure the ball exit speed. This requires the device to reset and arm quickly enough to capture the ball traveling back through the speed gate.

5.3.3 *Bat Pivot Support*—A turntable, rotating 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 2.0 in. (50.8 mm). The rotating clamp and shaft assembly shall not weigh more than 6 lb (2.7 kg) and shall spin freely via ball bearings (see Fig. 2). The polar MOI for the clamp turntable assembly shall not exceed 192 oz-in.^{2} (35 117 g-cm^2). The actual MOI of the clamp turntable assembly shall be determined and used in the performance calculations.

6. Calibration and Standardization

6.1 *Ball Speed Gate*—The distances between the sensors of the speed gates must be known and recorded to the stated tolerances. The accuracy of the timers used in the velocity sensors must be adequate to provide the stated velocity accuracy at maximum stated speeds. The timers used shall be calibrated on at least a yearly basis.

6.2 *Calibration Rod*—A calibration rod tested at two different pivot locations shall be used to determine if the MOI Stand is capable of accurately measuring the MOI of a bat. The rod shall be a 1-in. (25.4-mm) diameter by 24-in. (609.6-mm) long steel rod weighing 85.65 oz (2.43 kg). The MOI of this rod measured with the pivot location at 8 in. (20.32 cm) should be 5 487 oz-in^2 (1003 kg-cm^2) and at a pivot location of 2 in. (50.8 mm) should be 12 682 oz-in^2 (2319.5 kg-cm^2). Deviations more than 50 oz-in^2 (9.15 kg-cm^2), after accounting for the MOI of the clamp fixture, shall be rectified before bats are tested.

6.3 *Reference Standards and Blanks*—A standard bat and ball shall be used for reference purposes to verify proper machine operation.

7. Conditioning

7.1 *Ball and Bat Conditioning*:

7.1.1 Balls shall be stored at the environmental conditions in 7.1.2 and 7.1.3 until their weight change over 24 h is less than 0.1 % and wood bats shall be stored at these environmental conditions for at least 24 h prior to testing. Non-wood bats shall be stored at these test environmental conditions for at least 2 h prior to testing.

7.1.2 Temperature is to be maintained at 72 ± 4°F (22 ± 2°C).

7.1.3 Relative humidity is to be maintained at 50 ± 10 %.

7.1.4 Bats and balls are to be tested within 1 h after removal from controlled area.

7.2 *Test Room Conditions*:

7.2.1 The test room will be controlled environmentally.

7.2.2 Temperature is to be maintained at 72 ± 4°F (22 ± 2°C).

7.2.3 Relative humidity is to be maintained between 20 and 60 %.

8. Procedure

8.1 *Determination of Bat Features and Test Location*:

8.1.1 *Balance Point*—Measure and record the overall bat length to the nearest 0.0625 in. (1.58 mm). Place bat level on balance point stand as shown in Fig. 3. Record the weight measured by the 6-in. (Wt_6) and the 24-in. (Wt_{24}) scales to the nearest 0.035 oz (1.0 g). Eq 1 calculates the balance point relative to the distal end of the bat knob:

$$BP = \left[\frac{(6Wt_6) + (24Wt_{24})}{(Wt_6 + Wt_{24})}\right] \quad (1)$$

where:

BP = balance point from distal end of the bat knob,
Wt_6 = weight of the bat measured 6 in. from the knob,
Wt_{24} = weight of the bat measured 24 in. from the knob, and
W_t = Wt_6+ Wt_{24} = total weight of the bat.

8.1.2 *Bat MOI Set-Up*—Apply MOI collar-clamp to bat handle so that the pivot location (point of the vee on underside of the clamp) is 6 ± 0.031 in. (152.4 ± 0.8 mm) from the distal end of the bat knob (see Fig. 1). Hang bat in MOI Stand, making sure the bat hangs vertically and can swing freely about the pivots. If bat does not hang vertically, correct by centering bat to the pivots.

8.1.3 *COP Test*—Rotate the bat about the pivots to an angle of 5° from vertical. Release bat and allow to swing freely (see Fig. 1). Allow bat to swing through five cycles and to settle into