Designation: F1890 – 11

An American National Standard

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

This standard is issued under the fixed designation F1890; 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 test method covers a method for determining bat performance by measuring the bat-ball coefficient of restitution (BBCOR), deriving the bat performance factor (BPF) and calculating a batted ball speed (BBS). It is applicable to 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, 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 inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered 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 requirements prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F1887 Test Method for Measuring the Coefficient of Restitution (COR) of Baseballs and Softballs

F1888 Test Method for Compression-Displacement of Baseballs and Softballs

F2398 Test Method for Measuring Moment of Inertia and Center of Percussion of a Baseball or Softball Bat

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

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

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

3.1.3 *bat performance factor (BPF), n*—ratio of BBCOR to ball COR as defined in this test method.

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 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.

3.1.5 *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.

3.1.6 *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.

4. Significance and Use

4.1 This test method offers a laboratory means to compare the performance of a softball bat.

4.2 Use of this test method can provide sports governing bodies a means to compare calculated BBS and other physical properties of bats.

5. Apparatus

5.1 *Test Balls*—Official softballs approved for play and tested in accordance with the following procedures. Perform ball compression test of Test Method F1888 prior to ball COR test of Test Method F1887.

5.1.1 *Compression*—350 to 375 lb at 0.25-in. deflection (1557 to 1668 N at 6.4-mm deflection) in accordance with Test Method F1888. Balls to be labeled with compression value.

5.1.2 *Weight*—6.25 to 6.75 oz (177.2 to 191.4 g). Balls to be labeled with weight value.

5.1.3 *Size*—12.00 to 12.25-in. (304.8 to 311.1-mm) circumference. Balls to be labeled with size value.

5.1.4 *Core Material*—Polyurethane.

[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.

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[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.

5.1.5 *Ball COR*—0.450 to 0.470 in accordance with Test Method F1887. Balls to be labeled with COR and test speed in ft/s.

5.2 *Bat-Ball COR Test Apparatus:*

5.2.1 *Ball Cannon*—A device capable of shooting a ball at a speed of 88 ft/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.

5.2.2 *Bat Speed Gate*—A light trap device, or an equivalent, capable of measuring an edge traveling at speeds of between 5 and 15 ft/s with a resolution of one hundredth of 1 ft/s (0.01 ft/s) with an accuracy of at least ±1 % when the distance between the first and second sensor is between 3 in. (76.2 mm) and 3.6 in. (94.1 mm). The first sensor shall trigger when the bat rotates no less than 25° and no more than 30° from its start position. It is suggested the second trigger be 3 in. (76.2 mm) away from the first and must not be any further than 3.6 in. (91.4 mm) away on a 6-in. (15.24-cm) radius.

5.2.3 *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 (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 2.0-in. (50.8-mm) line. The first sensor shall trigger when the ball is no more than 12 in. (30.5 cm) from the bat surface. The second sensor shall trigger between 3.6 in. (91.4 mm) and 8 in. (203.2 mm) from the first sensor. The second sensor is located between the first sensor and the bat surface.

5.2.4 *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. 1). 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 *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 and Test Room Conditions:*

7.1.1 Test balls shall be placed in an environmentally controlled space for at least 14 days immediately before testing. 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 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 between 40 and 60 %.

7.1.4 Temperature and relative humidity are to be measured and recorded hourly within ±0.5°F (±0.3°C) and ±2 % RH over conditioning and test duration.

8. Procedure

8.1 *Determination of Bat Features and Test Location*—Determine bat balance point (BP), bat MOI, and bat COP in accordance with Test Method F2398.

8.2 *Bat Test Procedure:*

8.2.1 Ready and calibrate ball and bat speed gates in accordance with the manufacturer's instructions.

8.2.2 Select a test ball in accordance with 5.1, and record the actual values of compression, weight, size, and COR of the ball in accordance with 5.1.

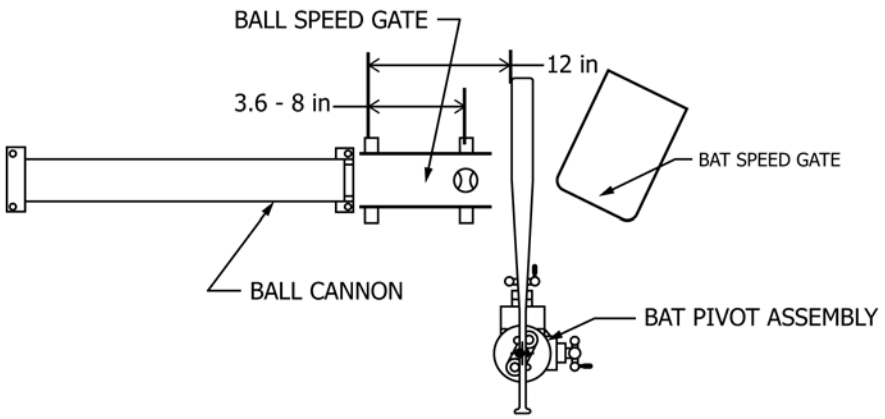

FIG. 1 Bat Testing Machine

8.2.3 Set ball cannon to fire the ball at the desired impact speed of 88 ft/s (26.8 m/s). Valid test speeds are considered to be those within ±1 % of the targeted test speed.

8.2.4 Mount bat in the clamps on the bat pivot support. The distal end of the bat knob must be 6 in. (152.4 mm) from the axis of rotation of the turntable assembly.

8.2.5 The ball impact must be centered vertically and horizontally on the bat diameter at the previously measured COP.

8.2.6 Position the bat against the start position reference, which must place the bat axis perpendicular to the ball line of travel. (See Fig. 1.)

8.2.7 Verify that all speed traps are reset and ready to take data.

8.2.8 Load selected test ball in ball cannon. Attempt to load test ball so that its impact with the bat will be between the stitches of the ball.

8.2.9 Shoot the ball at the bat, observing the necessary safety precautions.

8.2.10 Record ball inbound speed and bat rebound speed. Do not use data where the ball inbound speed deviates by more than the tolerances stated in 8.2.3 from the targeted test speed.

8.2.11 Continue testing for six valid impact readings or for twelve total impacts. For a given test ball, rotate the ball in the cannon between impacts so that the impact area of the ball is different for each impact. A single test ball may be tested once on each impact area of the ball with no rest period between impacts. Following this series of up to four impacts on a single ball, a rest period of at least 10 min following the last impact is required prior to retesting, using the same ball. If six valid impacts are not achieved prior to twelve total impacts, fix the set-up to alleviate cause of invalid impacts. Verify support system for the ball cannon, ball speed gate, and bat pivot support are rigid.

9. Calculation of Results

9.1 Calculate the BBCOR for each valid impact using Eq 1:

$$BBCOR = \left(1 + \frac{I + I_p}{wR^2}\right)\left(\frac{DRt}{drT}\right) - 1 \quad (1)$$

where:

D = distance between bat speed sensors, in. (cm),
d = distance between ball speed sensors, in. (cm),
I = MOI of bat, oz-in.^{2} (g-cm^2),
I_p = MOI of the pivot, oz-in.^{2} (g-cm^2),
R = COP distance, in. (cm),
r = radius to bat speed sensors, in. (cm),
T = time for bat to travel through bat speed sensors, s,
t = time for ball to travel through ball speed sensors, s, and
w = weight of the ball used in each event, oz (g).

9.2 *Calibration*—Determine the value of the combinations (*D/dr*) using Eq 2 as follows. Place a large calibration mass (MOI ≥ 30 000 oz-in.^{2}) in the bat position on the pivoting stage. Measure its MOI and COP in accordance with Test Method F2398. Shoot a ball of known COR and weight (w). Measure t and T. Determine (*D/dr*) from ball COR as follows:

$$\frac{D}{dr} = \frac{1 + Ball\ COR}{\left(1 + \frac{I}{wR^2}\right)\left(\frac{Rt}{T}\right)} \quad (2)$$

9.3 Calculate the BPF for each valid impact using Eq 3:

$$BPF = \frac{BBCOR}{Ball\ COR} = \frac{\left(\left(1 + \frac{I}{wR^2}\right)\left(\frac{D}{dr}\right)\left(\frac{Rt}{T}\right) - 1\right)}{Ball\ COR} \quad (3)$$

9.4 Calculate the average BPF for the test bat from the six valid impacts using Eq 4. When different balls are used to test the same bat, always be sure to calculate the BBCOR and BPF using the actual size, weight, compression, and COR of the ball used in each of the six valid impacts:

$$BPF_{avg} = \frac{((BPF)_1 + (BPF)_2 + \ldots + (BPF)_6)}{6} \quad (4)$$

9.5 Calculate the BBS value of the test bat using Eq 5 and 6:

$$k = \frac{w_o R^2}{I + I_p} \quad (5)$$

$$BBS = \frac{V(1+e) + v(e-k)}{(1+k)} \quad (6)$$

where:

V = bat swing speed (mph) at the COP,
v = pitch speed (mph), the horizontal speed of the ball incoming to the batter,
W = bat weight, oz,
w_o = weight of test ball, oz (g),
e = BBCOR,
R = COP, in., and
k = ball-bat inertia ratio.

9.6 Calculate the average batted-ball speed (BBS) value of the test bat from the six valid impacts using Eq 7.

$$BBS_{avg} = \frac{(BBS)_1 + (BBS)_2 + \ldots + (BBS)_6}{6} \quad (7)$$

10. Report

10.1 Report the following information:

10.1.1 Name of the test facility and test operator,

10.1.2 Test date,

10.1.3 Hourly measurements of test conditions, including:

10.1.3.1 Humidity and temperature of the ball and bat conditioning and test room environments,

10.1.3.2 Number of hours ball and bat were in conditioning environment.

10.1.4 Test equipment used for this test method,

10.1.5 Test ball information in accordance with 5.1, including the compression, weight, size, and COR of the test ball,

10.1.6 Bat model, length, weight tested, and any other pertinent data, such as condition of the bat or modification to the bat,

10.1.7 Bat MOI and COP, and MOI of the bat pivot support,

10.1.8 For each impact (including invalid impacts) ball inbound speed, bat rebound speed, BBCOR, and BPF,

10.1.9 *Final Average Bat Performance Factor*—Assuming current ball COR measurement variations are ±0.01, the BBCOR uncertainty is currently ±0.02. This results in a BPF

uncertainty of ±0.05. To reflect this uncertainty, the BPF assigned to each bat will be the measured average BPF reduced by the 0.05 uncertainty. Expected future improvements in measurement equipment and product control will reduce the above uncertainty,

10.1.10 Any and all unique observations including, but not exclusively, any damage to the bat or test ball, misdirected ball impacts, and any odd noises or vibrations, and

10.1.11 Calibration certificate numbers for measurement devices and velocity timers.

11. Precision and Bias

11.1 Precision and bias evaluations have not been conducted for this test method. When such data are available, a precision and bias section will be added.

12. Keywords

12.1 bat performance; BBCOR; BBS; BPF; COR; softball bats; softballs