Designation: ~~F1890 – 11~~ F1890 – 17

An American National Standard

Standard Test Method for Measuring Softball and Baseball 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~~ A method for determining bat performance by measuring the bat-ball coefficient of restitution ~~(BBCOR),~~ (BBCOR) and deriving the bat performance factor ~~(BPF) and calculating a batted ball speed (BBS).~~ (BPF). It is applicable to softball and baseball 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,~~ BBCOR and ~~BBS~~BPF are ~~each~~ calculated from measurements taken in the laboratory on test equipment meeting the requirements defined in this ~~specification.~~method.

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~~ safety, health, and ~~health~~environmental practices and determine the applicability of regulatory ~~requirements~~limitations prior to use.*

1.5 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

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

3.1.2 *coefficient of restitution (COR), n*—the relative speed of the objects after impact divided by the relative speed of the objects before impact.

3.1.3 *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).~~

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

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 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.~~impact location on the bat that produces no reaction force at the pivot point and causes the bat to rotate about the pivot point, taken 6 in. (152 mm) from the knob end of the bat.

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[1] This test method is under the jurisdiction of ASTM Committee F08 on Sports ~~Equipment~~ Equipment, Playing Surfaces, 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.

~~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~~ a pivot point, taken 6 in. (152 mm) from the knob end of the bat.

4. Significance and Use

4.1 ~~This~~These test ~~method offers~~methods offer a laboratory means to quantitatively compare the performance of ~~a softball bat.~~softball and baseball bats.

~~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~~ Softballs or baseballs as determined by those specifying the bat test requirements 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*—~~*Softballs:* ~~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.~~

5.1.1.1 *Compression*—350 to 375 lb (1557 to 1688 N) (Test Method F1888.)

5.1.1.2 *Weight*—6.25 to 6.75 oz (177.2 to 191.4 g).

5.1.1.3 *Size*—12.00 to 12.25-in. (304.8 to 311.1-mm) circumference (Test Method F1888).

5.1.1.4 *Ball COR*—0.465 to 0.475 (Test Method F1887).

~~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.~~

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

5.1.2.1 *Compression*—175 to 200 lb (778 to 890 N) (Test Method F1888 using 0.20 in. (5.08 mm) deflection).

5.1.2.2 *Weight*—5.00 to 5.25 oz (141.8 to 148.8 g).

5.1.2.3 *Size*—9.00 to 9.50 in. (228.6 to 241.3 mm) circumference (Test Method F1888).

5.1.2.4 *Ball COR*—0.545 to 0.555 (Test Method F1887).

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.~~ at least 88 ft/s (26.8 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.

5.2.2 *Bat Speed Gate*—A ~~light trap~~ 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~~0.01 ft/s (0.003 m/s) and 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).~~ ±1 %. The first sensor shall trigger ~~when~~after the bat rotates ~~no less than 25° and no more than 30°~~ between 5 to 10° from its start position. ~~It is suggested the second trigger be~~The second sensor shall trigger 30 to 35° after the second sensor. Reference Fig. 1~~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.~~ .

5.2.2.1 *Optional Bat Speed Sensor*—Device to measure bat rotational speed for at least 100° after impact. Device shall read speeds up to 3000°/s with an accuracy of at least 1°/s (found to be achievable using an optical encoder). Bat speed is taken from the slope of the linear least-squares fit to the bat rotation angle versus time data between 5 and 95° after impact.

5.2.3 *Ball Speed Gate*—A ~~light trap~~ 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~~ The distance between the two sensors shall be determined to within ±0.03 in. (±0.76 mm) and must be between 6 and 12 in. (152 and 305 mm). Prior to impact, the sensor closest to the bat must be between 4 and 6 in. (102 and 152 mm) from the ~~first sensor.~~bat. Reference Fig. 1~~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~~ v-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~~300 oz-in.^{2} ~~(35 117 g-cm~~ (5498 kg-mm^2). ~~The actual MOI of the clamp turntable assembly shall be determined and used in the performance calculations.~~

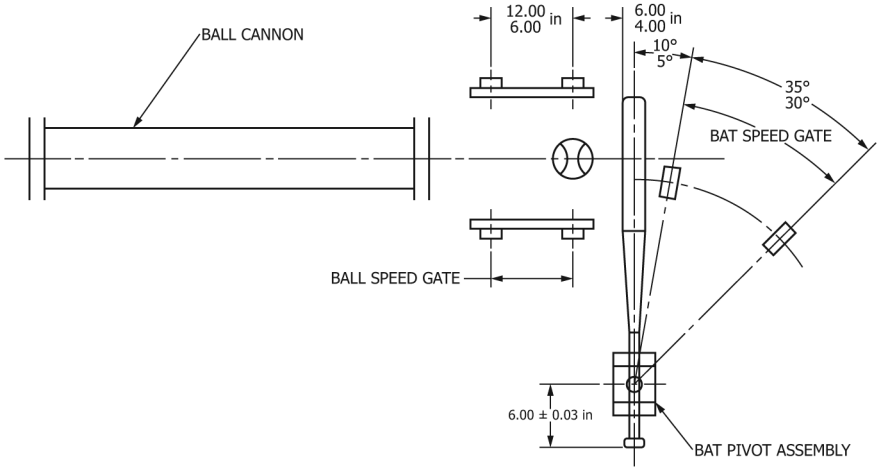

FIG. 1 Bat Testing Machine

6. Calibration and Standardization

6.1 *Ball Speed Gate*—The distances between the sensors of the speed gates must be ~~known~~measured 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.

6.3 *Calibration:*

6.3.1 Determine the balance point (BP), MOI, and COP of a large calibration mass (MOI ≥ 30 000 oz-in.^{2} (549 000 kg-mm^2)) in accordance with Test Method F2398.

6.3.2 Mount the large calibration mass in the bat pivot support clamps per 8.2.4.

6.3.3 Select a test ball in accordance with 5.1 as determined by those specifying the bat test, and record the actual values of compression, weight, size, and COR of the ball in accordance with 5.1.

6.3.4 Shoot the ball at the calibration mass COP, observing the necessary safety precautions and in accordance with Section 8 except as noted.

6.3.5 Determine $K_{calibration}$ as follows:

$$K_{calibration} = \frac{1+Ball\ COR}{\left(1+\frac{I+I_p}{mR^2}\right)\left(\frac{t}{d}\right)\left(\frac{D}{T}\right)\left(\frac{R}{r}\right)} = \frac{1+Ball\ COR}{\left(1+\frac{I+I_p}{mR^2}\right)\left(\frac{V_{bat}}{v_i}\right)} \quad (1)$$

where:

Ball COR = ball COR (Test Method F1887) of the ball used in each impact,
I = moment of inertia (MOI) of mass, Test Method F2398, oz-in.^{2} (kg-m^2),
I_p = moment of inertia (MOI) of bat pivot, oz-in.^{2} (kg-m^2),
R = COP distance, Test Method F2398, in. (m),
r = radius to bat speed sensors, in. (m),
T = time for bat to travel through bat speed sensors, s,
t = time for ball to travel through ball speed sensors, s,
D = distance between bat speed sensors, in. (m),
d = distance between ball speed sensors, in. (m),
v_i = ball inbound speed, in./s (m/s),
V_{bat} = bat recoiling speed at the impact location, in./s (m/s), and
m = weight of the test ball used in each impact, oz (g).

6.3.6 Calculate the average $K_{calibration}$ for the calibration mass from six valid impacts.

6.3.7 The average $K_{calibration}$ must fall between 0.98 and 1.02. If average $K_{calibration}$ is out of range, check ball and bat speed gates, Ball COR, I, R, m, I_{pivot}.

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.

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~~knob end of the bat ~~knob~~ must be 6 ± 0.03 in. (152.4 ± 0.76 mm) from the axis of rotation of the turntable assembly. Impact location(s) to be determined by those specifying the test requirements.

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

8.2.6 ~~Position~~Locate the bat against the start position ~~reference, which must place the bat axis perpendicular to the~~ reference to obtain a ball rebound parallel to the inbound ball line of travel. (See Fig. 1.)

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

8.2.8 ~~Load selected~~Orient the test ball in ball ~~cannon. Attempt to load test ball~~ cannon so that its impact with the bat will ~~be~~occur 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.~~

8.2.10.1 *Optional*—Record ball rebound speed. The ball rebound angle immediately after impact should be within ±10° of the inbound ball path.

8.2.11 ~~Continue testing for six~~ Six valid impact readings ~~or for twelve total impacts.~~are required per impact location. 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.~~

8.2.11.1 If identifying maximum performance is desired, the performance at the peak location should be at least 0.5 % greater than the performance at the adjacent bat axial locations.

9. Calculation of Results

9.1 Calculate the BBCOR for each valid impact using Eq ~~1~~2:

$$BBCOR_{bat\ out} = \left(1 + \frac{M_e}{m}\right)\left(\frac{t}{d}\right)\left(\frac{D}{T}\right)\left(\frac{Q}{r}\right) - 1 \tag{2}$$

where:

$$BBCOR = \left(1 + \frac{I + I_p}{wR^2}\right)\left(\frac{DRt}{drT}\right) - 1 \tag{3}$$

$$M_e = \frac{I + I_p}{Q^2} \tag{3}$$

~~where:~~and:

~~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),~~