~~Designation:F2845–10~~ Designation: F2845 – 11

Standard Test Method for Measuring the Dynamic Stiffness (DS) and Cylindrical Coefficient of Restitution (CCOR) of Baseballs and Softballs[1]

This standard is issued under the fixed designation F2845; 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 procedure describes a method of measuring the dynamic stiffness (DS) and cylindrical coefficient of restitution (CCOR) of baseballs and softballs providing similar impact forces and ball deformation as are observed in a bat-ball collision.

1.2 This procedure is for a ball that is intended for the game of baseball or softball.

1.3 The test method is based on ball speed measurements before and after impact with a cylindrical test surface and the impact force between the ball and impacted surface.

1.4 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.

1.5 *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]

E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods

E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *baseball or softball*, *n*—any ball defined by the rules for the game of baseball or softball, respectively.

3.1.2 *cylindrical coefficient of restitution (CCOR)*, *n*—the ratio of the rebound to incoming speed of a ball impacting a solid rigid cylinder.

3.1.3 *dynamic stiffness (DS)*, *n*—a normalized measure of the ball impact force having units of stiffness (lb/in. or kN/m). It is obtained by dividing the square of the peak force between the ball and impact surface by the ball mass and the square of the incoming ball speed.

4. Summary of Test Method

~~4.1A load cell or array of cells is mounted between a cylindrical solid steel impact surface and a rigid wall. The ball speed is measured before and after impact with the impact surface and the force is measured throughout the impact event.~~

~~4.2*Method A*—The cylindrical impact surface for softballs is 2.25 ± 0.01 in. (57.2 ± 0.3 mm) in diameter. The ball inbound speed is 95 mph (42.5 m/s).~~

~~4.3*Method B*—The cylindrical impact surface for baseballs is 2.62 ± 0.01 in. (66.7 ± 0.3 mm) in diameter. The ball inbound speed is 115 mph (51.4 m/s).~~

4.1 A load cell or array of load cells is mounted between a cylindrical solid steel impact surface and a rigid wall. The ball speed is measured before and after impact with the impact surface and the force is measured throughout the impact event.

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[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 May 1, 2010. Published June 2010. DOI: 10.1520/F2845-10.~~

Current edition approved April 1, 2011. Published May 2011. Originally approved in 2010. Last previous edition approved in 2010 as F2845 – 10. DOI: 10.1520/F2845-11.

[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. Significance and Use

5.1 1 The ball dynamic stiffness is a measure of a ball's hardness. Its measurement is conducted to represent bat-ball impact forces. It is normalized by the ball weight and speed to minimize the influence of manufacturing and test variations from the measure.

5.2 The cylindrical coefficient of restitution is a ball property of relative velocity change caused by impact with a cylindrical surface.

5.3 This test method compares the performance of baseballs and softballs after impact with a cylindrical test surface.

5.4 Sports associations can use DS and CCOR measurements in specifications for official baseballs and softballs.

6. Apparatus

6.1 *Strike Plate*:

6.1.1 *Load Cell*—A device capable of measuring force up to 10 kip (45 kN) within ±1 %. The peak load-cell reading after ball impact due to oscillation shall not exceed 5 % of the measured peak impact force.

6.1.2 *Impact Surface*—~~A 4 ± 0.1-in. (102 ± 2-mm) long solid steel half cylinder of diameter prescribed by Method A or B.~~ —A 4 ± 0.1-in. (102 ± 2-mm) long solid steel half cylinder. For softballs, the diameter of the half cylinder is 2.25 ± 0.01 in. (57.2 ± 0.3 mm). For baseballs the diameter of the half cylinder is 2.62 ± 0.01 in. (66.7 ± 0.3 mm).

6.1.3 *Mounting*—The load cell and impact surface shall be secured to a massive rigid ~~wall,~~wall and fastened sufficiently secure to prevent movement during ball impact. Thread-locking liquids help prevent fasteners from coming loose and reduce load-cell oscillations.

6.2 *Ball Throwing Device*—A ball throwing device capable of delivering the ball through the electronic speed monitor within ±1 mph ~~(±0.14 in./s, ±0.5~~(±0.5 m/s) of the desired speed. Balls shall be oriented to impact the strike surface between the stitches.

6.3 *Electronic Speed Monitors*[3]—An electronic ball-speed measuring system consisting of two vertical light screens mounted 12 ± 0.03 in. (305 ± 0.8 mm) apart, and a photoelectric sensor located at each screen that triggers a timing device on ball passage to measure the time for the ball to traverse the distance between the two vertical planes before and after impact with the strike plate. Accuracy shall be ±0.1 mph ~~(±0.014 in./s , ±0.05~~(±0.05 m/s).

6.4 *Data Acquisition*—The signal from the load cell shall be sampled at a frequency of at least 100 kHz while it is in contact with the ball.

7. Preparation of Apparatus

7.1 Mount the cylindrical impact surface and load cell on a rigid wall. Verify all fasteners are tightened according to laboratory procedure to minimize load-cell oscillation.

7.2 Position the speed monitors so that the first speed monitor (light screen) is 12 ± 0.1 in. (305 ± ~~2~~3 mm) from the strike plate (see Fig. 1).

8. ~~Conditioning~~ Calibration and Standardization

8.1 *Ball Speed Gate*—The distance between the sensors of the speed gates should be measured and recorded. The timers used for speed measurements should be calibrated on at least a yearly basis.

8.2 *Load Cells*—The load cells used to measure the impact force should be calibrated on at least a yearly basis.

[3] The sole source of supply of the apparatus (IBeam Sensor or equivalent) known to the committee at this time is Automated Design Corporation, 1404 Joliet Road, Suite B, Romeoville, IL 60446, http://www.automateddesign.com/. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee, which you may attend.

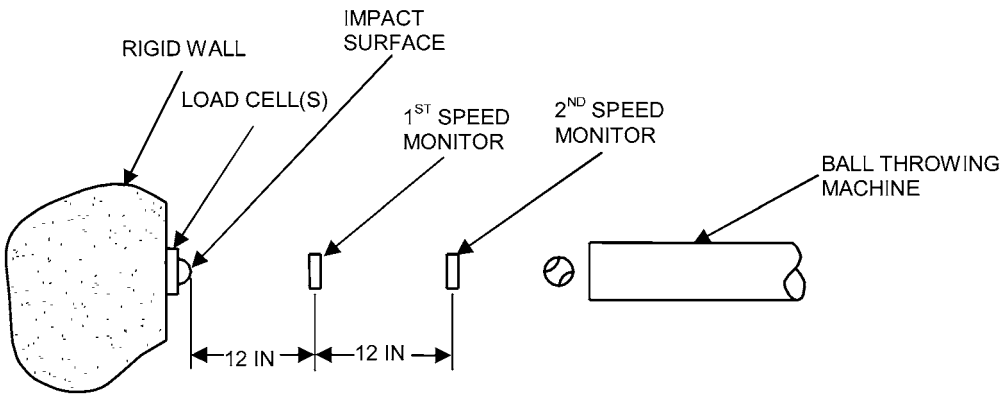

FIG. 1 Test Apparatus

9. Conditioning

9.1 *Ball Conditioning and Test-Room Conditioning*:

89.1.1 Test balls shall be stored in an environmentally controlled space for at least 14 days immediately before testing.

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

89.1.3 Relative humidity (RH) is to be maintained between 40 and 60 %.

89.1.4 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 durations.

9.10. Procedure

9.1Select10.1 Set the desired test method according ball throwing device to 4.2 or 4.3.

9.2Set the ball throwing device to the test target speed within ± 1 95 mph (42.5 m/s) for softballs and 115 mph (51.4 m/s) for baseballs. Results from inbound speeds exceeding ±1 mph (±0.14 in./s , 0.5 m/s). Results from shots above or below this speed range will not be used. (±0.5 m/s) of the target speed will not be used.

10.2 Record the inbound speed, rebound speed, force-time data and peak impact force.

9.3A10.3 A minimum 1-min rest period is required between each shot. A non-contact temperature sensor shall be used to verify the ball temperature remains within the specified test-room temperature range.

9.4The10.4 The ball shall be rotated after each impact among its four ears or surfaces with maximum spacing between the stitches.

910.5 Verify proper alignment by observing the rebound path of the ball after impact. The ball rebound angle after impact with the impact surface should be within ±5° of the inbound ball path.

910.6 Compare the impulse from the ball speed and impact force.

910.6.1 Calculate the impulse from the impact force by:

$$L_F = \int F(t)dt \tag{1}$$

$$L_F = \int_{t_0}^{t_1} F(t)dt \tag{1}$$

F(t)

where:

L_F = force impulse, lb-s (N-s), and force impulse (area under the force-time curve), lb-s (N-s),

$F(t)$ = force measurement during impact, lb (N).force measurement during impact, lb (N),

t_0 = time when $F(t)$ exceeds 20 lb (89 N) (s), and

t_1 = time after the peak force is reached when $F(t)$ is less than 20 lb (89 N) (s).

910.6.2 Calculate the impulse from the ball speeds by:

$$L_S = \frac{m}{c_L}(V + S) \tag{2}$$

where:

L_S = speed impulse, lb-s (N-s),

m = ball mass, oz (g),

V = incoming speed, mph (m/s),

S = outgoing ball speed, mph (m/s), and

c_L = unit conversion factor, 350.99 US (1000 SI).[4]

910.6.3 Calculate the impulse ratio by:

$$K = \frac{L_S}{L_F} \tag{3}$$

where:

K = impulse ratio,

L_S = speed impulse, lb-s (N-s), and

L_F = force impulse, lb-s (N-s).

9.7The10.7 The speeds and forces from the six valid impacts for each ball are averaged to determine the DS and CCOR for a ball.

9.7.1For10.7.1 For an impact to be valid the ball inbound speed and rebound trajectory must be within the allowable respective tolerance for speed and trajectory and the impulse ratio must fall between 0.9 and 1.1.

9.7.2For10.7.2 For a ball test result to be valid, the standard deviation of the six impulse ratios of a ball must be less than 0.02.

9.7.3For10.7.3 For cases of excessive invalid hits due to the impulse ratio requirements, check light-gate and load-cell calibrations and ball-weight measurement.

[4] The conversion factor is found from (16 oz/lb)(32.174 ft/s²)(1 mi/5280 ft)(3600 s/hr) = 350.99 (oz/lb s)(mi/hr) US or (1000 g/kg) = 1000 SI.