Designation: F1887 – 14

An American National Standard

Standard Test Method for Measuring the Coefficient of Restitution (COR) of Baseballs and Softballs[1]

This standard is issued under the fixed designation F1887; 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 is intended to standardize a method of measuring the coefficient of restitution (COR) of baseballs and softballs.

1.2 This procedure is established to provide a single, repeatable, and uniform test method.

1.3 This procedure is for a ball that is intended for use in the game of baseball or softball.

1.4 The test method is based on ball speed measurements before and after impact with either of two test surfaces: wood or metal.

1.5 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.6 *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:*

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

3.1.2 *coefficient of restitution (COR), n*— a numerical value determined by the exit speed of the ball after contact divided by the incoming speed of the ball before contact with a massive, rigid, flat wall of either wood or metal.

4. Summary of Test Method

4.1 *Method A*—The strike plate is a rigid metal surface, and ball speed is measured before and after impact with the strike plate.

4.2 *Method B*—The strike plate is a rigid wood surface, and ball speed is measured before and after impact with the strike plate.

5. Significance and Use

5.1 The ball coefficient of restitution is a ball dynamic property of relative velocity change caused by impact with a rigid wall.

5.2 This test method is suitable for obtaining data in research and development, quality control, and classifying balls by liveliness.

5.3 Sports associations can use coefficient of restitution standards in specifications for official baseballs and softballs.

5.4 This same test procedure can be utilized at impact speeds other then that prescribed in this procedure and so noted in any reported test results.

6. Apparatus

6.1 *Strike Plate, Method A:*

6.1.1 *Material,* 5.08-cm (2-in.) thick steel.

6.1.2 *Size,* 61 by 61 cm (24 by 24 in.).

6.1.3 *Mounting,* secured flush to a massive rigid wall of cinder block or concrete, minimally 20.3-cm (8-in.) thick, and bolted at all four corners sufficiently secure to prevent movement during ball impact.

6.2 *Strike Plate, Method B:*

6.2.1 *Material,* 10.2-cm (4-in.) thick northern white ash wood with moisture content between 10 and 15 % with a flat smooth surface.

6.2.2 Same as 6.1.2.

6.2.3 Same as 6.1.3.

6.3 *Ball Throwing Device*—A ball throwing device capable of delivering the ball through the electronic speed monitor at

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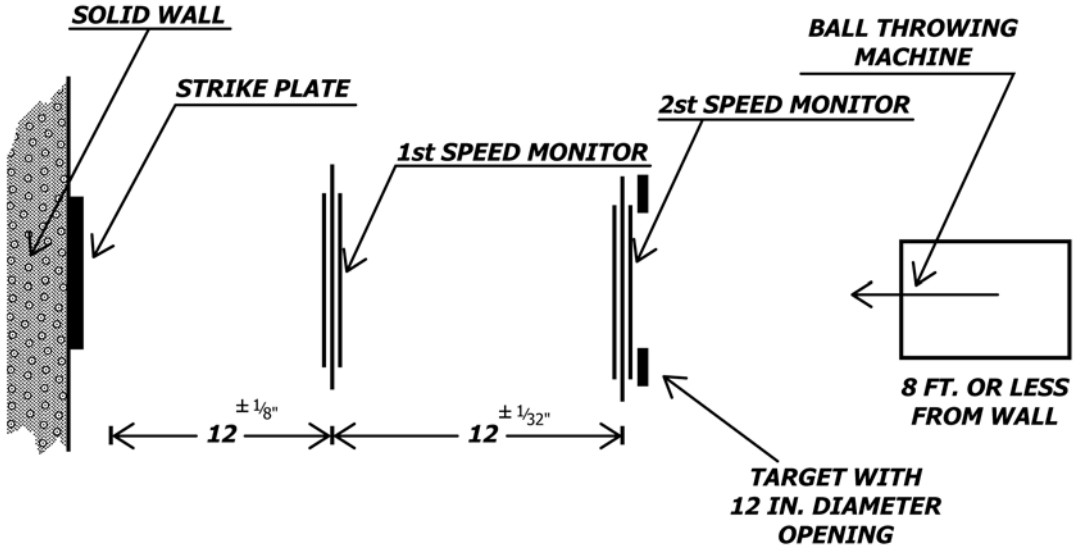

FIG. 1 Test Apparatus

26.82 m/s (60 mph) with a maximum tolerance of ±0.30 m/s. The machine should be calibrated using the electronic speed monitor.

6.4 *Electronic Speed Monitors*—An electronic ball speed measuring system consisting of two vertical light screens mounted 30.48 cm (12 in.) apart with a tolerance of ±0.32 cm, 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. Resolution shall be ±0.03 m/s.

6.5 *Ball Trajectory Target*—A lightweight target with a 30.48-cm (12-in.) diameter circular opening positioned at the second light screen and centered on the ball line of travel between the throwing device and the center of the strike plate.

7. Preparation of Apparatus

7.1 Mount the strike plate on a rigid wall such that the center is approximately 1.22 cm (4 ft) from the floor. Tighten all mounting bolts before each test. Torque to 81.35 N-m (60 ft-lb) min.

7.2 Position the first speed monitor (light screen) 30.48 ± 0.32 cm (12 ± 0.125 in.) from the strike plate (see Fig. 1).

7.3 Position the second speed monitor (light screen) 30.48 ± 0.079 cm (12 ± 0.312 in.) from the first speed monitor.

7.4 Position the ball throwing device such that the ball impacts the strike plate within 15.24 cm (6 in.) of the center and on rebound, passes through the 30.48 cm (12 in.) target mounted at the second light screen.

8. Conditioning

8.1 *Ball Conditioning and Test Room Conditions:*

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

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

8.1.3 Relative humidity is to be maintained between 40 and 60 %.

8.1.4 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.

9. Procedure

9.1 The ball throwing device is set to deliver the ball at 26.82 ± 0.305 m/s (60 mph). All shots above or below this tolerance range will not be used.

9.2 Each ball is shot at the strike plate a minimum of six times to a maximum of 12 times. A minimum 30-s rest period is required between each shot.

9.3 Only those speed readings for impacts falling within the 6-in. target at the strike plate, within the 12-in. target at the second speed monitor, and thrown within the prescribed speed range will be used in the calculation of COR.

9.4 The average of the six acceptable COR values for each ball is used to determine the ball COR.

9.4.1 Formulae:

$$\mathrm{COR} = Vb/Va = \frac{1}{6}\left[\frac{Vb1}{Va1}+\frac{Vb2}{Va2}+\frac{Vb3}{Va3}+\frac{Vb4}{Va4}+\frac{Vb5}{Va5}+\frac{Vb6}{Va6}\right] \quad (1)$$

where:

Va = incoming speed, and
Vb = exit speed.

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 Relative humidity and temperature of the ball conditioning and test room environments,

10.1.3.2 Number of hours ball was in conditioning environment.

10.1.4 Test equipment used for this test method,

10.1.5 Test ball information, model, weight tested, and any other pertinent data such as condition of the ball,

10.1.6 For each event impact (including invalid impacts), ball inbound speed, rebound speed,

10.1.7 Average ball COR in accordance with Section 9 of this standard,

10.1.8 Any and all unique observations, including but not exclusively, any damage to the ball, and

10.1.9 Calibration certificate numbers for measurement devices and velocity timers.

11. Precision and Bias[2]

11.1 The precision of this test method is based on an interlaboratory study conducted in 2012. Six laboratories participated in this study. Each of the six labs reported as many as three replicate test results for each of 78 different balls. Every "test result" reported represents an individual determination. Except for the very limited number of replicates reported, Practice E691 was followed for the design and analysis of the data.

11.1.1 *Repeatability (r)*—The difference between repetitive results obtained by the same operator in a given laboratory applying the same test method with the same apparatus under constant operating conditions on identical test material within short intervals of time would in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in 20.

11.1.1.1 Repeatability can be interpreted as the maximum difference between two results, obtained under repeatability conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

11.1.1.2 Repeatability limits are listed in .

11.1.2 *Reproducibility (R)*—The difference between two single and independent results obtained by different operators applying the same test method in different laboratories using different apparatus on identical test material would, in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in 20.

11.1.2.1 Reproducibility can be interpreted as the maximum difference between two results, obtained under reproducibility conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

11.1.2.2 Reproducibility limits are listed in Table 1.

11.1.3 The above terms (repeatability limit and reproducibility limit) are used as specified in Practice E177.

11.1.4 Any judgment in accordance with statements 11.1.1 and 11.1.2 would normally have an approximate 95 % probability of being correct, however the precision statistics obtained in this ILS must not be treated as exact mathematical quantities which are applicable to all circumstances and uses. The limited number of laboratories reporting replicate results

TABLE 1 COR

MATERIAL	Xbar	sr	sR	r	R
AS1	0.39667	0.00179	0.00438	0.00500	0.01226
AS2	0.46814	0.00274	0.00548	0.00767	0.01535
AS3	0.48080	0.00283	0.00573	0.00793	0.01604
AS4	0.39850	0.00196	0.00516	0.00550	0.01444
AS5	0.44961	0.00137	0.00374	0.00382	0.01047
AS6	0.54680	0.00177	0.00429	0.00496	0.01202
AB1	0.55502	0.02148	0.02148	0.06015	0.06015
AB2	0.56559	0.00211	0.00571	0.00591	0.01598
AB3	0.56478	0.00313	0.00313	0.00876	0.00876
AB4	0.56458	0.00284	0.00495	0.00795	0.01387
AB5	0.56607	0.00458	0.00458	0.01283	0.01283
AB6	0.56844	0.00342	0.00543	0.00958	0.01521
BS1	0.40100	0.00316	0.00872	0.00886	0.02441
BS2	0.47173	0.00361	0.00371	0.01010	0.01040
BS3	0.47380	0.00171	0.00334	0.00480	0.00936
BS4	0.39022	0.00030	0.00030	0.00084	0.00084
BS5	0.44678	0.00235	0.00235	0.00659	0.00659
BS6	0.54827	0.00334	0.00334	0.00937	0.00937
BB1	0.55884	0.00433	0.00599	0.01212	0.01678
BB2	0.55756	0.00700	0.00700	0.01960	0.01960
BB3	0.56273	0.00405	0.00828	0.01134	0.02319
BB4	0.55937	0.00504	0.00504	0.01411	0.01411
BB5	0.56718	0.00485	0.00811	0.01358	0.02270
BB6	0.56314	0.00725	0.00725	0.02031	0.02031
CS1	0.39931	0.00142	0.00675	0.00399	0.01890
CS2	0.47396	0.00170	0.00504	0.00477	0.01411
CS3	0.47616	0.00067	0.00186	0.00188	0.00520
CS4	0.39578	0.00338	0.00669	0.00946	0.01873
CS5	0.44549	0.00187	0.00741	0.00524	0.02074
CS6	0.55945	0.00334	0.00334	0.00935	0.00935
CB1	0.55716	0.00198	0.00424	0.00554	0.01188
CB2	0.55874	0.00284	0.00924	0.00796	0.02588
CB3	0.55752	0.00144	0.00668	0.00402	0.01869
CB4	0.55817	0.00167	0.00859	0.00468	0.02405
CB5	0.56214	0.00145	0.00567	0.00406	0.01587
CB6	0.56267	0.00247	0.00933	0.00692	0.02612
DB1	0.55239	0.00177	0.00364	0.00495	0.01020
DB2	0.55990	0.00115	0.00477	0.00321	0.01335
DB3	0.55709	0.00364	0.00492	0.01020	0.01378
DB4	0.56084	0.00205	0.00222	0.00574	0.00621
DB5	0.55951	0.00367	0.00409	0.01027	0.01146
DB6	0.56387	0.00159	0.00707	0.00444	0.01978
ES1	0.40711	0.00346	0.00346	0.00970	0.00970
ES2	0.47146	0.00123	0.00123	0.00346	0.00346
ES3	0.48304	0.00238	0.00238	0.00667	0.00667
ES4	0.40202	0.00233	0.00507	0.00653	0.01421
ES5	0.44263	0.00100	0.00100	0.00279	0.00279
ES6	0.55238	0.00157	0.00240	0.00441	0.00671
EB1	0.56669	0.00418	0.00418	0.01170	0.01170
EB2	0.56752	0.00263	0.00263	0.00735	0.00735
EB3	0.57242	0.00313	0.00313	0.00877	0.00877
EB4	0.56817	0.00108	0.00196	0.00304	0.00549
EB5	0.57354	0.00266	0.00266	0.00746	0.00746
EB6	0.56987	0.00188	0.00188	0.00526	0.00526
FS1	0.40269	0.00218	0.00218	0.00609	0.00609
FS2	0.47377	0.00597	0.00597	0.01672	0.01672
FS3	0.47610	0.00114	0.00159	0.00320	0.00444
FS4	0.40002	0.00165	0.00660	0.00462	0.01849
FS5	0.44256	0.00115	0.00475	0.00323	0.01330
FS6	0.54229	0.00114	0.00735	0.00320	0.02057
FB1	0.56677	0.00358	0.00358	0.01002	0.01002
FB2	0.56248	0.00284	0.00284	0.00795	0.00795
FB3	0.56992	0.00197	0.00197	0.00552	0.00552
FB4	0.56609	0.00319	0.00319	0.00893	0.00893
FB5	0.57055	0.00349	0.00349	0.00978	0.00978
FB6	0.57260	0.00311	0.00604	0.00872	0.01690
GS1	0.39575	0.00134	0.00134	0.00376	0.00376
GS2	0.47907	0.00071	0.00071	0.00197	0.00197
GS3	0.48905	0.00066	0.00066	0.00185	0.00185
GS4	0.39476	0.00907	0.00907	0.02541	0.02541
GS5	0.43295	0.00406	0.00406	0.01137	0.01137
GS6	0.54005	0.00461	0.00461	0.01291	0.01291
GB1	0.55873	0.00311	0.00311	0.00872	0.00872
GB2	0.53785	0.01471	0.01471	0.04119	0.04119
GB3	0.55688	0.00294	0.00294	0.00824	0.00824

[2] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:F08-1013. Contact ASTM Customer Service at service@astm.org.

TABLE 1 *Continued*

MATERIAL	Xbar	sr	sR	r	R
GB4	0.54438	0.01844	0.01844	0.05164	0.05164
GB5	0.56671	0.00367	0.00367	0.01028	0.01028
GB6	0.55133	0.01020	0.01020	0.02857	0.02857
Average	**0.514**	**0.003**	**0.005**	**0.010**	**0.014**

guarantees that there will be times when differences greater than predicted by the ILS results will arise, sometimes with considerably greater or smaller frequency than the 95 % probability limit would imply. In cases were no duplicates were reported by the laboratories, only Reproducibility can be estimated. The repeatability limit and the reproducibility limits listed should be considered as general guides, and the associated probability of 95 % as only a rough indicator of what can be expected.

11.2 *Bias*—At the time of the study, there was no accepted reference material suitable for determining the bias for this test method, therefore no statement on bias is being made.

11.3 The precision statement was determined through statistical examination of all reported results, from six laboratories, on 78 balls.

12. Keywords

12.1 ball liveliness; ball resilience; baseball; coefficient of restitution; softball