

ITR test conditions applicable to 2028 Overall Distance Standard test

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R&A Rules Ltd, United States Golf Association

Introduction

The Indoor Test Range (“ITR”) is a system for identifying the aerodynamic characteristics for golf balls, used by the USGA and R&A Rules Limited to calculate distance according to the Overall Distance Standard (1).

The ITR conditions published in 2004 (2) are designed to capture the aerodynamic performance for golf balls under a range of speeds and spins of a golf ball struck under the Actual Launch Conditions (“ALC”) test (1). The ALC test has reference ball speed of 175 mph and a target spin of 2520 rpm using a control ball. These conditions were originally set out such that at every Reynolds number, there were alternating groups of two or three spins (and therefore, spin parameters).

A new set of ITR conditions for the Indoor Test Range are desired to capture aerodynamic data for golf balls being tested over a range of speeds and spins appropriate to the 2028 update to the Overall Distance Standard (3). A large amount of aerodynamic data obtained since the publication of the original ITR conditions enables effective selection of the speeds and spins.

Methods

A set of 24 ITR conditions (described below) was used to obtain baseline values of lift and drag for 34 sets of aerodynamic data (i.e., 17 different golf ball types tested in pole-horizontal and pole-pole orientations). Sample balls were chosen to represent a wide range of characteristics, including drag and lift properties at high Reynolds number and lift sensitivity at low Reynolds number as compared to the population of golf balls received by R&A Rules Ltd and the USGA on an annual basis. See Figure 1.

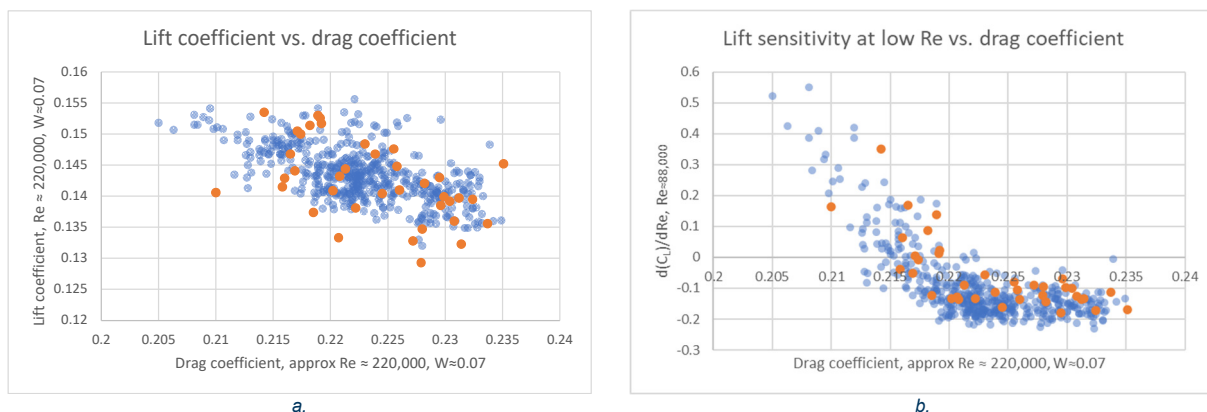


Figure 1: Lift and drag coefficient data calculated from ITR data for the sample balls used in evaluation (orange) as compared to all balls tested in 2021 (blue). (a) Lift coefficient vs. drag coefficient for balls at approximate launch conditions from the tee, 177 mph, 2520 rpm. (b) Lift sensitivity to Reynolds number at 2100 rpm, between speeds of 61-82 mph (Re 75,000 – 100,000). Reynolds numbers and spin parameters are approximate.

Selection of baseline conditions

The 24 baseline ITR conditions¹ used are depicted in Figure 2 and Table 1. The conditions were initially envisioned to encompass the range of speeds and spins that would be expected for balls to experience when struck at the ranges of launch conditions described in the 5 December 2023 Notice of Decision (3), and were based on the combination of:

1. “Original”, existing 15 ITR conditions used by R&A Rules Ltd and the USGA for the determination of conformance at 120 mph “ALC”, with some conditions modified to ‘stretch’ the range of conditions to those appropriate to higher speeds and lower spins (blue in the figure).
2. Additional ITR conditions identified from simulations of the ITR process as potentially improving the robustness of the determination of overall distance.

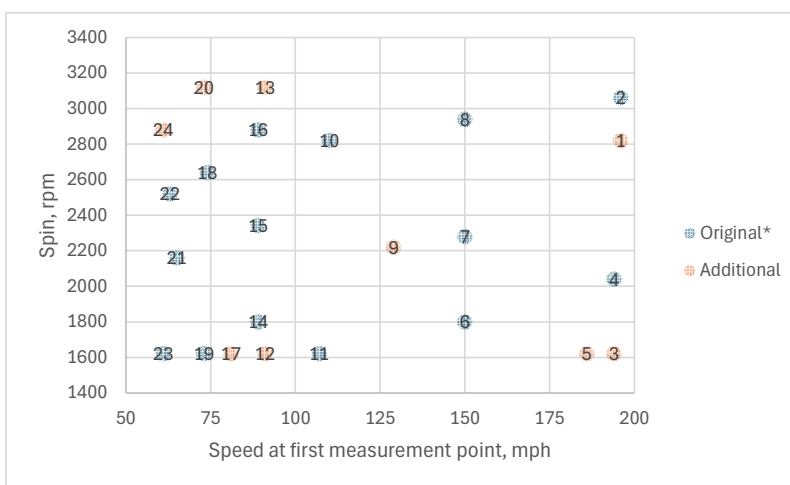


Figure 2: The 24 conditions used as a rich set of lift and drag data. Numbers correspond to the condition numbers identified in Table 1. *Original settings that have been ‘stretched’ (i.e., to increase maximum speeds and reduce minimum spins) to a range of conditions appropriate to 2028 test conditions.

The distance results using different subsets of 15 test conditions (that number being consistent with the existing ITR test) were compared to results generated using all 24 ITR baseline conditions for each ball type and orientation. A proposed selection of 15 ITR conditions was identified (Figure 3) that minimized the combination of average difference and standard deviation of differences between that smaller subset and the full 24-condition set.

Results

The average difference between the 15 proposed ITR test conditions and the 24 baseline conditions is 0.25 yards with a standard deviation of 0.41 yards at the conditions relevant to the 2028 test update (nominally 183 mph ball speed, 11 degrees, and 2220 rpm, Table 2). Detailed results are available in the appendix.

This compares favourably to the “Original” ITR conditions, whose use results in a slightly larger average and standard deviation (both equal to 0.45 yards) at the original 2004 120 mph/ALC conditions.

¹ In these charts, reported ball speeds and spin are the nominal values at the first measurement point within the Indoor Test Range for a typical golf ball: values at the exit of the ball launcher are higher, the difference is determined by the distance between the launcher exit and the first measurement point.

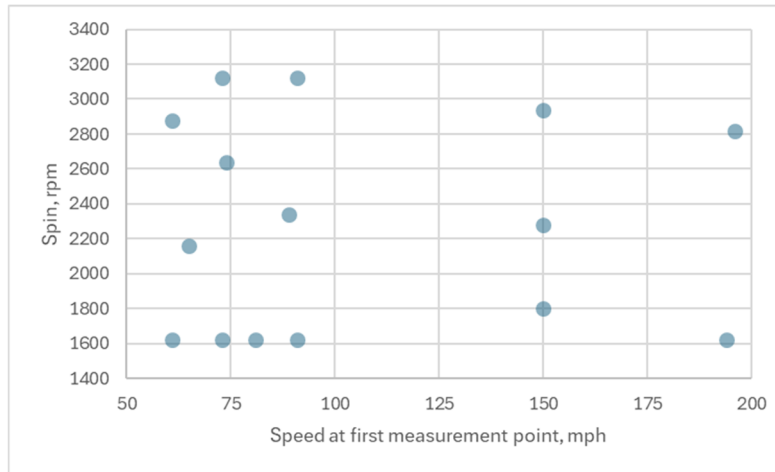


Figure 3: The 15 proposed test conditions better aligned with ranges of speeds and spins of the 2028 test.

Table 1: Test condition nominal speeds and spins used during experimental testing with the Indoor Test Range (ITR). The rich set of 24-conditions serves as the basis of comparison for reduced sets, mph values rounded to the nearest 0.5. *ft/s numbers are provided as a reference. [†]Modified to increase the maximum speed, minimum spin associated with the 2028 test conditions.

Baseline Condition	Speed, mph (ft/s)*	Spin, rpm	Original 15 conditions [†]	Proposed 15 conditions
1	195.5 (287)	2820		X
2	195.5 (287)	3060	X	
3	194.5 (285)	1620		X
4	194.5 (285)	2040	X	
5	186 (273)	1620		
6	150 (220)	1800	X	X
7	150 (220)	2280	X	X
8	150 (220)	2940	X	X
9	129 (189)	2220		
10	110 (161)	2820	X	
11	107 (157)	1620	X	
12	90.5 (133)	1620		X
13	90.5 (133)	3120		X
14	88.5 (130)	1800	X	
15	88.5 (130)	2340	X	X
16	88.5 (130)	2880	X	
17	81.5 (119.5)	1620		X
18	73.5 (108)	2640	X	X
19	72.5 (106.5)	1620	X	X
20	72.5 (106.5)	3120		X
21	65 (95)	2160	X	X
22	63.5 (93)	2520	X	
23	60.5 (89)	1620	X	X
24	60.5 (89)	2880		X

Table 2: Differences in total distance as compared to Baseline 24 for Proposed 15 (n = 38) and Original 15 settings at launch conditions appropriate to the test.

	183 mph, 11°, 2200 rpm: Proposed 15	175 mph, 10°, 2520 rpm: Original 15
Average difference, yards	0.25	0.45
Standard Deviation, yards	0.41	0.45

Gage R&R Study

Gage R&R testing was completed using the Proposed 15 settings to determine the repeatability and reproducibility of the use of these settings in comparison to the original 15 settings. Four golf ball types were tested by four operators for three trials each (a total of 48 unique tests). In each test, 12 balls were tested in a single orientation (pole-perpendicular).

The gage was then determined by simulating ball flight for typical launch conditions for 120 mph and 125 mph tests (Table 3). Standard environmental conditions were used throughout: a temperature of 75° F, 50% humidity and 30 in Hg pressure. The standard conformance bounce and roll model (2) was used for 120 mph tests, whereas the linear bounce and roll model was used for the 125 mph test (4).

Gage R&R statistics were calculated using a crossed study design, the ANOVA method of analysis. Consistent with previously published gage data, total gage was calculated based on a 99% level of inclusion (5.15 standard deviations).

Table 3: Gage R&R results for Proposed 15 ITR settings.

Launch conditions	Ball Speed, mph (ft/s)	Launch Angle, deg.	Spin Rate, rpm	Gage R&R, Time, s	Gage R&R, Carry, yards	Gage R&R, Total, yards
Current ALC	175 (256)	10	2520	±0.12	±2.32	±1.84
2028 ALC	183 (268)	11	2220	±0.12	±2.49	±1.81

Previous testing with the original 15 settings reported gage R&R value of ±2.20 yards for total distance (5). The recent testing indicates that the Proposed 15 conditions compare favourably to the original 15 ITR test conditions.

Conclusion

A Proposed set of 15 conditions has been identified for testing golf balls to the 2028 Overall Distance Standard. Using the larger set of 24 conditions as the baseline for comparison, this reduced set of 15 conditions closely predicts the total distance on a ball-by-ball basis. It has been shown that the variability associated with these ITR test conditions is equivalent or lower than for the original test.

As the volume of data grows with the use of this new set of 15 conditions, additional research will be undertaken to identify whether a subset of these 15 ITR conditions will achieve equivalent levels of accuracy while allowing greater test efficiency.

References

1. **R&A Rules Ltd, USGA.** *Overall Distance Standard and Symmetry Test Protocol TPX3006 Rev. 3.0.* St Andrews, Liberty Corner : R&A Rules Ltd, United States Golf Association, 2019.

2. **USGA.** *Addenda to the ITR Technical Description and Operation Manual - Phase II.* Far Hills : United States Golf Association, 2004.
3. **R&A Rules Ltd, USGA.** *Notice of Decision - Update to the Conformance Testing of Golf Balls to the Overall Distance Standard (ODS).* St Andrews, Liberty Corner : R&A Rules Ltd, United States Golf Association, 2023.
4. **USGA, R&A Rules Ltd.** *Proposed Bounce Model for Use in Evaluating Optimum Overall Distance.* Liberty Corner, St Andrews : United States Golf Association, R&A Rules Ltd, 2021.
5. **USGA.** *Change Control Study Results.* Far Hills, New Jersey : USGA, 2016.
6. **USGA, R&A Rules Ltd.** *Notice to Manufacturers - Screening Golf Balls for Overall Distance and Symmetry.* Liberty Corner, St Andrews : R&A Rules Ltd, United States Golf Association, 2014.

Appendix: Detailed comparisons

Table 4: Launch conditions and total distance results using Baseline (24) and Proposed (15) conditions. *ft/s numbers are provided as a reference. mph values rounded to the nearest 0.5 mph. Speed values have been rounded to the nearest mph. Sets 2 and 3, 11 and 12, 21 and 22, and 30 and 31 represent multiple tests of the same aerodynamic type.

	Speed, mph (ft/s)*	Angle, deg.	Spin, rpm	Baseline 24, yards	Proposed 15, yards
1	185.0 (271.0)	10.6	2190	330.4	330.5
2	180.5 (264.4)	10.9	2140	327.6	327.6
3	180.5 (264.4)	10.9	2140	325.5	325.1
4	179.5 (263.5)	10.6	2270	317.1	317.1
5	186.0 (272.9)	10.5	2310	329.9	330.6
6	179.5 (263.1)	11.0	2180	323.1	323.6
7	184.0 (269.9)	10.7	2260	329.6	329.4
8	181.0 (265.8)	11.3	2010	314.1	314.5
9	182.0 (266.9)	10.8	2150	318.3	318.4
10	179.5 (263.1)	10.8	2260	313.1	313.3
11	179.0 (262.8)	11.0	2140	323.8	323.4
12	179.0 (262.8)	11.0	2140	323.6	323.8
13	185.0 (271.4)	10.4	2240	332.5	332.7
14	184.5 (270.7)	10.4	2280	328.7	329.1
15	181.5 (266.1)	10.9	2160	320.6	321.0
16	181.5 (266.4)	10.8	2290	324.9	325.6
17	177.5 (260.2)	11.0	2150	307.9	308.3
18	182.5 (267.9)	11.1	2050	328.6	329.0
19	183.5 (268.8)	10.4	2440	321.7	321.9
20	185.0 (271.0)	10.6	2190	328.6	328.5
21	180.5 (264.4)	10.9	2140	318.3	317.3
22	180.5 (264.4)	10.9	2140	321.4	321.0
23	179.5 (263.5)	10.6	2270	316.1	316.3
24	186.0 (272.9)	10.5	2310	330.4	330.9
25	179.5 (263.1)	11.0	2180	320.4	321.2
26	184.0 (269.9)	10.7	2260	319.2	318.9
27	181.0 (265.8)	11.3	2010	315.3	315.7
28	182.0 (266.9)	10.8	2150	318.7	319.2
29	179.5 (263.1)	10.8	2260	315.1	315.4
30	179.0 (262.8)	11.0	2140	321.6	322.2
31	179.0 (262.8)	11.0	2140	320.3	321.3
32	185.0 (271.4)	10.4	2240	328.7	329.4
33	184.5 (270.7)	10.4	2280	328.3	328.5
34	181.5 (266.1)	10.9	2160	319.6	319.6
35	181.5 (266.4)	10.8	2290	320.9	321.8
36	177.5 (260.2)	11.0	2150	306.8	307.2
37	182.5 (267.9)	11.1	2050	328.4	329.1
38	183.5 (268.8)	10.4	2440	323.5	323.6