FIH Approved Sports Equipment

SELF-WETTING HOCKEY BALLS

Performance & quality requirements

VER. 1.0

1 Introduction

For many years, top-level hockey has been played on synthetic turf fields that are irrigated prior to use. This irrigation is done to provide fast, predictable, and consistent playing surfaces, allowing athletes to perform to the best of their ability.

Irrigating fields, however, requires significant quantities of water, a natural element that is becoming increasingly scarce already in many parts of the world. Irrigation also requires an expensive system implementation, increases the operational costs of the hockey venue, and increases the carbon footprint each time it is applied. Recognizing that extensive water usage is becoming unsustainable, FIH announced in 2018 that it was challenging the synthetic turf industry to develop turfs that play the way athletes want but without using significant quantities of water.

A key part of ensuring that these new types of non-irrigated hockey synthetic turfs have the playing characteristics top-level hockey desires is the use of hockey balls that allow to mimic the interactions as experienced on an irrigated field. To assist, self-wetting hockey balls have been developed. These are balls that release water in a controlled manner during active play so that a film of water droplets is generated on the ball's surface to aid it movement on non-irrigated turfs.

This FIH standard defines the properties required from self-wetting balls seeking FIH approval.

Self-wetting hockey balls are considered suitable for use on:

- Non-irrigated (Dry) Turfs (in dry or wet conditions)
- National category turfs (in dry or wet conditions)
- Global category turfs (in wet conditions)

Note: the use of self-wetting balls in any specific competition is subject to the agreement of the competition organisers.

2 Approval process

For a brand of ball to be registered as an FIH Approved Self-wetting Hockey Ball the following process needs to be followed:

1. The ball manufacturer shall become a member of the FIH Quality Programme (see www.fih.hockey/QP A for details).

2. The ball manufacturer shall submit representative samples of the ball they wish to have approved to a test institute able to undertake all the necessary tests to the standards of accuracy and reproducibility stipulated by the FIH.

3. The balls shall be tested by a test institute, accredited by, or agreed in advance with, the FIH. Ideally the test institute shall operate an ISO 17025 quality programme and the tests detailed in this Standard shall be within the scope of the ISO 17025 accreditation.

4. The test methods used by the test institute shall ensure the uncertainty of the measurements are within the accuracy bands detailed in this Standard. The uncertainty of each test method used shall be reported and compliance of a ball to this Standard shall be within the specified ranges when adversely considering uncertainty.

5. The results obtained shall be reported in English and be sent to the FIH by the test institute, for review.

6. Balls found to meet the quality levels detailed in this Standard shall be granted the right to be designated *FIH Approved Self-Wetting Hockey Balls*.

7. The cost of testing shall be agreed between the test institute and ball manufacturer.

Notes:

1. As experience is gained upon the use of self-wetting balls, it is possible that the test requirements currently specified will change.
2. In specific cases, and subject to FIH derogation, a possible failure of a given test result can be overruled.

Definitions

The following definitions apply to this standard:

Self-wetting ball	a hockey ball designed to release water as it rolls across the playing surface to aid the ball/surface interactions
Unused ball	a new self-wetting ball that has not been primed or immersed in water (i.e. as dispatched from the factory)
Primed ball	a self-wetting ball that has been filled (primed) with water.
Empty ball	a primed ball that has discharged its water and is no long self-wetting. This is simulated in the laboratory using the method described in Annex B.

Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 12235 (2013): Surfaces for sports areas —Determination of vertical ball behaviour

BS 5993 (1994): Specification for cricket balls

Sampling

Manufacturer wishing to submit balls for approval testing shall send 20 dry balls, representative of at least four weeks production, to the selected test institute.

From every 20 balls sampled two batch samples, each with nine balls shall be chosen at random by the test institute.

The two untested balls from a compliant lot shall be archived by the Test Laboratory and be accessible for a minimum period of four years from the date of test.

Pass / fail criteria

To obtain a 'PASS' – all nine tested balls must comply fully with the requirements of this Standard. Should any of the balls in the sample of nine balls fail to meet all the requirements of the Standard, a further sample of nine balls shall be taken from the same original batch of

20 balls and they shall be tested for all aspects of this Standard. If more than one ball from the first set, or any one ball from the second set fails any test, the entire consignment is non-compliant and reported as failing to comply with this Standard

Testing

Testing shall be undertaken in the following sequence

- colour
- mass
- shape
- self-wetting water release
- water reloading capacity
- moment of inertia
- ball rebound
- hardness
- performance retention

7.1 Sample Batch A

The balls batch A shall be tested for:

- colour
- mass
- shape
- self-wetting water release
- water reloading capacity
- moment of inertia

7.2 Sample Batch B

The balls in batch B shall be tested for:

- ball rebound
- hardness
- performance retention

Water priming

Prior to testing the dry balls shall be primed with water using the procedure specified by the manufacturer, If no procedure is specified the following procedure shall be used:

- Fill a 10 L bucket with 5 L of clean tap water, having a temperature of between 10 °C and 25 °C. Add the 9 balls to the bucket.
- Place a metal disc with air perforations over the balls to ensure each ball is completely immersed.
- Immerse the balls for priming time defined by the manufacturer, ensuring all the balls remain fully immersed.

Note Air bubbles highlight the uptake of water by the balls. In cases where an immersion tube is provided by the manufacturer it is recommended to circulate the balls by manually moving them one by one from outlet to inlet.

- After the immersion period, remove each ball wipe it with a towel to dry the outside

Requirements

9.1. Composition

Balls shall be manufactured from materials that are known to be not harmful to human health or the environment. Specific attention shall be paid to international and national regulations such as the European Communities' REACH Regulations.

When submitting a ball type for approval the manufacturer shall provide a signed statement of conformity that they meet this requirement.

9.2. Colour

Balls shall be a single colour. Unless otherwise agreed with the FIH this shall be white or yellow (RAL 1016, 1018 or 1026) RAL Colour Charts – www.RALcolor.com.

9.3. Mass

This requirement is to ensure balls are neither too heavy, nor too light and do not suffer unacceptable changes in mass due to the release of water.

9.3.1 Test method

The mass of each ball shall be determined to an accuracy of 0.01 g. The reported mass shall correspond to the mean mass for the 9 balls tested.

Empty balls shall be prepared by taking a fully primed ball and rotating it using the procedure described in Annex B.

9.3.2 Requirements – see note 1

a	Maximum mass of ball after fully priming with water	169 g
b	Minimum mass of an empty ball after (simulated) use	150 g
Maximum percentage difference between the weight of the fully primed ball and the weight of the empty ball (a-b)/a x 100%		20%

Note: The Rules of Hockey specify the weight of a ball shall be between 156g and 163g. Dispensation for this requirement is granted for self-wetting balls.

9.4 Spherical size and shape

These requirements are to ensure the balls comply with the Rules of Hockey.

9.4.1 Test method

The dimensions of each specimen ball shall be measured to an accuracy of ± 0.001 mm.

Five balls shall be selected. On each ball ten random diameter measurements shall be made to calculate the mean diameter value. The radial distance shall then be calculated by dividing the diameter value by two.

9.4.2 Requirements

The nominal outer ball surface (i.e. excluding excursions and incursions) shall lie on or outside a perfect sphere having a radius 35.625 mm (diameter = 71.250 mm, circumference 224.00mm)) and on or inside a second sphere having a radius 37.400 mm (diameter = 74.800 mm, circumference 235.00) sharing the same centre as the first.

The maximum difference in radial distance from the centre of the spheres between any two points on the nominal ball surface shall be no more than 0.375 mm (diameter = 0.750 mm).

9.4.3 Surface Irregularities

Any radial step from one hemisphere to the next shall be no more than 0.1 mm in height.

9.4.4 Other permissible features

A permissible surface feature is any other (i.e. not the mould seam) significant continuous region of local positive or negative radial deviation from the nominal ball surface. To be significant the maximum chord length between any 2 points on the edge of the feature must be greater than 1 mm.

The edges of a feature are defined by the points at which the feature surface is within ± 0.05 mm of the ball's nominal surface, and within which radial deviation exceeds ± 0.1 mm.

Any incursion or excursion from the nominal ball surface with a radial deviation greater than 0.1 mm and maximum chord length less than 1 mm is considered a surface blemish.

9.4.5 Dimples

There shall be 200 or more dimples symmetrically distributed across the mould split plane of the ball. All dimples shall exhibit zero excursions.

The maximum chord length between any two edge points shall be 4 mm and the difference in maximum chord length between dimple features shall be less than 0.5 mm.

The maximum radial incursion depth shall be 0.5 mm with respect to the nominal sphere.

9.4.6 Other features that exhibit excursion (e.g. moulding inlet marks)

There shall be a maximum of two symmetrically placed features on any ball.

Symmetry shall be maintained across the mould split plane (i.e. zero or two features, not one).

The maximum chord length between any two edge points shall be 12 mm.

When measured along a chord between any two edge points:

- the maximum cumulative distance for any excursion(s) above 0.1 mm must be no more than 2 mm.
- the maximum cumulative distance for incursion(s) above 0.1 mm must be no more than 2 mm.

9.5 <u>Self-wetting water release</u>

This requirement is to ensure balls are actually able to fulfil the criteria of a self-wetting ball.

9.5.1 Test method

The self-wetting release is measured to an accuracy of 0.1 g. It is measured according to the procedure outlined in Annex C. Three balls shall be tested and the mean result calculated.

9.5.2 Requirements

Parameter	Water release (g)
Total released water quantity after 10 trajectories	Between 1.5 – 5

Minimal water quantity released between the 6^{th} and 10^{th} trajectories	min 0.3

9.6 Reloading capacity

This requirement is to ensure balls can be recharged in an acceptable time period.

9.6.1 Test method

The balls reloading capacity shall be measured to an accuracy of 0.1 g, using the procedure outlined in Annex D. The 3 balls used for the self-wetting release test shall be used.

9.6.2 Requirements

Parameter	Reloading capacity (in g)
Mass after immersion procedure (5 min) m_{re}	156–169

9.7 Moment of Inertia

9.7.1 Test method

The Moment of Inertia is measured to an accuracy of 10 g cm^2. Tests shall be made on fully primed ball using the procedure detailed in Annex E.

Tests shall be made on 3 randomly selected balls out of Batch A.

9.7.2 Requirements

The variation between the accelerations for both starting positions (a_1 and a_2) for each ball shall be below 15 %,

Note this (symmetry test for moment of inertia and at the same time addressing the point of gravity).

The Moment of Inertia for each ball shall be 2200 ± 300 g cm^2.

9.8 Ball rebound

9.8.1 Test method

The rebound of the ball shall be measured in general accordance with EN 12235, without taking into count the correction factor (K^1) in the specified formula, and to an accuracy of ± 0.1 mm.

Three balls taken from Batch B shall be tested at 23°C, a different three at 5°C and the final three at 40°C

Balls shall be conditioned at the specified temperature for a minimum of 240 minutes prior to testing. Following removal from the conditioning chamber tests shall be made within 3 minutes, ensuring the ball temperature does not change by more than the specified tolerance.

9.8.2 Requirements

Test temperature		
5 ± 1°C	23 ± 2°C	40 ± 2°C
600 mm to 850 mm	550 mm to 800 mm	500 mm to 750 mm

Maximum variation in (mean) ball rebounds across test temperatures	≤ 175 mm
Maximum variation in (mean) ball rebounds at 23 ± 2°C	≤ 50 mm

9.9 Hardness

9.9.1 Test method

The Hardness of the ball shall be determined following BS 5993: 1994: Annex G. Balls shall be conditioned at the specified temperature for a minimum of 240 minutes prior to testing. Following removal from the conditioning chamber tests shall be made with 3 minutes, ensuring the ball temperature does not change by more than the specified tolerance.

9.9.2 Requirements

Test temperature	Hardness (g)
5 ± 1°C	130 – 220
23 ± 2°C	130 – 200
40 ± 2°C	130 – 180

9.10 Performance retention

9.10.1 Conditioning test method

The ball shall be subjected to 100 repetitive impacts using the apparatus detailed in of BS 5993: Annex G over a period of 15 ± 5 minutes, the ball being free to rotate between impacts. The ball shall be allowed to recover for 10 minutes and then tested within the next five minutes for shape and rebound.

The balls shall then be then left to cool for a minimum of 3 hours and then the hardness test shall be carried out but at a temperature of +23°C.

9.10.2 Shape after conditioning

The nominal outer ball surface (i.e. excluding excursions and incursions) shall lie on or outside a perfect sphere of radius 35.625 mm and on or inside a second sphere of radius 37.000 mm sharing the same centre as the first.

Ten random diameter measurements are performed to then take the average diameter value. The radial distance than follows by dividing the latter value by two.

The maximum difference in radial distance from the centre of the spheres between any two points on the nominal ball surface, and the average radial distance must be no more than 0.375 mm (diameter of 0.750 mm).

9.10.3 Rebound

The maximum decrease in the mean ball rebound after conditioning shall be 100 mm.

9.10.4 Hardness

The maximum change in ball hardness after conditioning shall be ± 15 %.

Annex A – Information to be included in an application for a ball to be approved

1	Applicant's company name	
2	Company address	
3	Company website	
4	Company contact	
5	Contact phone	
7	Contact email	
8	Name and address of ball manufacturer (if different to applicant)	
9	Copy of manufacturer's ISO 9001 certification or similar quality assurance programme	
10	Copy of the operating instructions supplied with the ball, explain how it should be primed, and the frequency of recharging, etc.	
11	Copy of test institute report showing ball's compliance with FIH Self-wetting Hockey Ball Standard	
12	Signed statement of conformity that the ball is manufactured from materials that are known to be not harmful to human health or the environment.	

Annex B : Determination of the mass of an empty ball

B.1 Scope

This test determines the mass of a ball after simulated use.

B.2 Apparatus

- An analytical balance able to measure the mass of the ball to an accuracy of 0.01 g.
- A lathe with a rotation speed of 800 ± 50 rpm to which a primed self-wetting ball can be fixed and rotated.

B.3 Procedure

- Fully prime the ball in accordance with the manufacturer's instructions.
- Fix the ball into the lathe and rotate it at 800, for 90 ± 3 seconds.
- Remove the ball from the lathe, wipe it to remove any excess water, before determining its mass.
- Repeat the procedure using nine different balls, can calculate the mean mass.

Annex C: Determination of water release

C.1 Scope

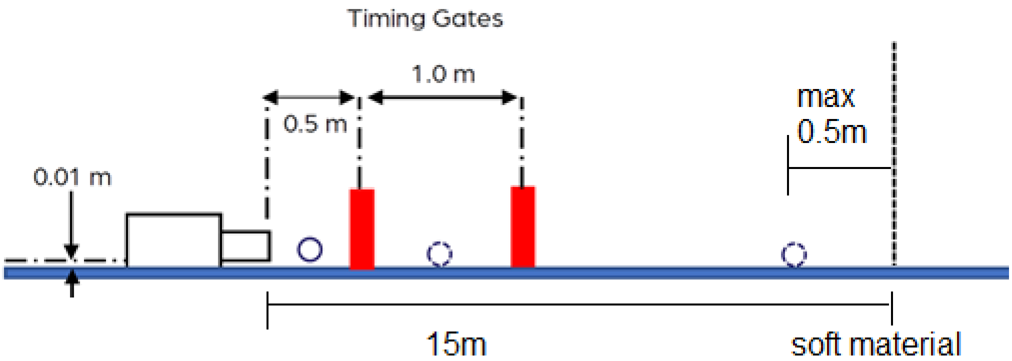
This test allows to determine the self-wetting release of a self-wetting ball. An air cannon launches the self-wetting ball horizontally at 15 m/s and the variation in mass in measured over a 15-metre distance on a concrete surface.

C.2 Apparatus

An air cannon capable of launching a hockey ball with minimum spin at (15 ± 1) m/s. The air cannon must be able to launch the ball horizontally (± 1°) form a height of (10 ± 1) mm above the top of the concrete floor.

C.3 Procedure

- Place the air cannon on the concrete floor (blue in figure below) so it is horizontal (± 1°) and the end of the canon is (10 ± 1) mm above the top of this floor. Place two timing gates on this floor at respective distances of (0.5 ± 0.005) m and (1.5 ± 0.005) m. Put at 15 ± 0.005 m a role of soft material to stop the forward rolling of the ball and to enable its subsequent pick up between 14.5 and 15.0 m.



- Adjust the pressure of the air cannon so that the speed of the self-wetting hockey ball through the pair of timing gates is (15 ± 1) m/s.
- For each self-wetting ball, launch the ball 10 times and wipe off the released water between two launches the self-wetting ball with a towel. Before each launch weight the mass of the self-wetting ball (after wiping).

C.3 Calculation of results

- For each self-wetting ball, take the difference between the initial mass, before any launch and the final mass, after 10 launches of the ball. Calculate the mean difference in mass of the 3 balls; this is the total released water quantity.
- For each self-wetting ball, calculate the change in mass of the last 5 launches. (this is launch 6-10). The minimal value of the 3 balls is then calculated, this is 6-10 minimal released water quantity.

Annex D: Determination of water reloading capacity

D.1 Scope

This test allows to determine the capacity to reload self-wetting balls in 5 minutes.

D.2 Apparatus

A lathe with a rotation speed of 1200 ± 250 rpm is able to fix and rotate a hockey ball.

D.3 Procedure

Fix and rotate each hockey ball at 1200 ± 250 rpm, for 150 seconds or until no more water is being dispersed from the ball, whichever is longer

Note: This test is best undertaken after the determination of water release.

After these rotations, wipe the balls with a towel, weigh them, and write down the masses.

Fill a 10 L bucket with 5 L of clean tap water, with a temperature between 10 °C and 25 °C. Add the 3 balls to the bucket. Alternatively, use the (tube) recipient received by the manufacturer and fill this recipient with the by the manufacturer specified volume of water. If a bucket is used, load a metal piece with air perforations at the upper region of the water surface to ensure complete immersion of each ball.

Make sure that during an immersion period of 5 minutes the balls are not floating. If this would be the case, the metal piece needs to be repositioned or extra loaded, and balls manually moved to enable circulation and pushed downwards. Air bubbles highlight the uptake of water by the balls. In case the recipient from the manufacturer is used it is recommended to circulate the balls by manually moving them one by one from outlet to inlet.

After the immersion period, wipe the balls with a towel, weigh them, and write down the masses (m_{re}).

Repeat the procedure on nine different balls and calculate the mean result.

Annex E: Determination of Moment of Inertia

E.1 Scope

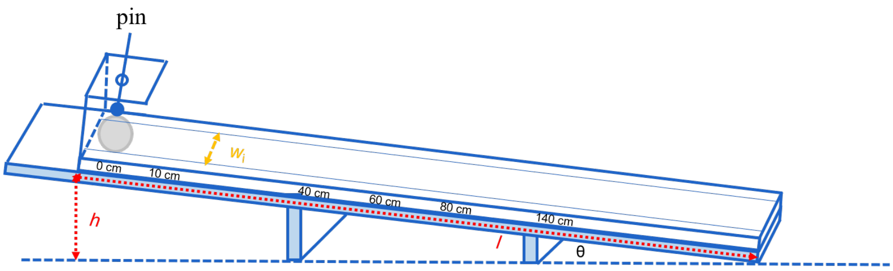
This test allows to obtain a Moment of Inertia by rolling a ball after point fixation in a specific starting position, as defined with respect to the mould seam along an inclined surface. In starting position 1 the mould seam is parallel to the rolling direction and in starting position 2 this mould seam is perpendicular to the rolling direction. For position 2, a 90° rotation is done so that the mould seam is visible in the highest surface area of the ball, in top view, which is not the case for position 1.

The direct measurement is the (ball) position variation with time during the rolling from which the acceleration can be calculated: a_1 for starting position 1 and a_2 for starting position 2. A larger acceleration value is a measure of a lower moment of inertia.

Upon knowing the (average) mass and (average) radius of the ball and calculating the average acceleration a one can obtain a moment of inertia I for the given ball roll configuration results.

E.2 Apparatus

- An inclined bar characterized by a length l of 200.0 ± 0.1 cm is installed in a closed room with limited wind disturbance on a rigid levelled table and is attached on top of a metal support with a length of 220.0 ± 0.1 cm, with the right sides of the bar and support ending on the same position. On the left side of the bar a metal framework is mounted so that a ball can placed on this bar, this ball touching on its left side the vertical part of the metal framework. The metal framework is equipped with a pneumatic pin to fix and release the ball in the absence of further contact with the metal framework.
- The framework height up to the bottom left edge of the bar, h, is 6.5 cm ± 0.2 cm.
- The bar is made of polystyrene, has a depth of 0.7 ± 0.1 cm, a width of 7 cm ± 1 cm, and contains 2 contact lines in the same direction as the ball roll direction, defining an inner width W_i of 4 ± 0.1 cm.



- A high-speed video system is capable of operating at 1000 frames per second. The resolution (at 1000 frames per second) shall be able to achieve a calibration factor of less than 1 mm per pixel in the plane of motion of the ball, and the shutter speed shall be fast enough to avoid any image blurring.
- An angle measuring device is available such as a digital protractor or similar with a minimum accuracy of ± 1° over a measuring range of 0–180°.

D.3 Procedure

- The h value is measured and noted (in cm) and fixed during the testing.

- The positions of 0, 10, 40, 50, 60, and 80 cm along the rolling direction are marked, with the 0 position aligned with the pneumatic pin (so that upon including a ball the latter position denotes the centre of the ball). To mark the 6 positions a graduated ruler is fixated and oriented toward the camera system.
- A high speed camera system is installed at a distance of 1.5 m ± 0.1 m from the inclined bar with the centre of the lens focused at the 40 ± 5 cm position with the height at the centre of ball put at that position.
- The high speed camera is switched on and the time registration (in seconds) commences.
- By taking away the point contact by stop pressing the pneumatic pin, the ball is allowed to roll down from the inclined bar starting at 0 cm first 3 times according to starting position 1 and then 3 times according to starting position 2. The times for the positions 0, 10, 40, 50, 60, and 80 cm are recorded during the 6 ball rolls.
- Before each release it is verified if the ball can move freely at its given starting position. If this is not the case the ball is repositioned slightly to allow for a velocity variation upon removing the point contact.
- On a regular basis, it is verified that the 0 cm position is clearly visible to accurately determine the first time of each ball roll.

E.3 <u>Calculation of results</u>

- Rescale for each ball roll the times so that the first time (at 0 cm) is always 0 seconds. Hence, for all times the starting time is subtracted from the measured values with the apparatus.
- For each ball, calculate the average of the 3 rescaled times at each position for both starting positions so that average time values result for 0, 10, 40, 50, 60, and 80 cm for both starting positions for every ball roll.
- Plot for each ball both the resulting (average) position vs. (rescaled) time data according to the equation *position* = $cte_{1,i}\ t^2 + cte_{2,i}\ t$ (i=1 and i=2, i being the ball starting position). The corresponding R^2 values must be above 0.98.
- Calculate for each ball for a given position i the acceleration a_i from $2*cte_{1,i}$. Hence, for position 1 a_1 results and for position 2 a_2 (both in cm s^{-2}).
- Calculate for each ball the variation using the following equation:

  Variation (%) = $100*(1-\min(a_1,a_2)/\max(a_1,a_2))$
- Calculate for each ball the average of a_1 and a_2 to obtain the overall a.
- Calculate $\boldsymbol{sin\ (\theta)}$ as the ratio of h and l (200.0 ± 0.1 cm), with the θ the angle of the inclination.
- Calculate for each ball $\boldsymbol{f_1 = \frac{a}{g\ sin\ (\theta)}}$ and $\boldsymbol{f_2 = \frac{1}{f_1} - 1}$
- Calculate for each ball a moment of inertia via $I = f_2\ m\ R^2$ with m the (average) mass in g and R the (average) radius in cm. Hence, the unit for I is g cm^2.

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