Hockey Turf & Field Standards

Addendum 01

Requirements for Dry (non-irrigated) Turfs

May 2023

VER. 1.0

INTERNATIONAL HOCKEY FEDERATION
FÉDÉRATION INTERNATIONALE DE HOCKEY

fih.ch/ qp

1. Introduction

For many years top-level hockey has been played on surfaces that are watered prior to use. This ensures the turfs provide fast, predictable, and consistent playing surfaces, allowing athletes to perform to the best of their ability.

Watering fields, however, uses significant quantities of water, which is becoming increasing scarce in many parts of the world. Watering also requires an expensive irrigation system, increases a venue's operational costs and increases hockey's carbon footprint each time it is used.

Recognising that the use of water is becoming unsustainable, the 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. Good progress has been made and innovative products are now entering the market. These are being described as 'Dry (*non-irrigated) Turfs'.*

A key part of ensuring these new types of dry hockey turfs have the playing characteristics hockey desires is being able to measure and quantify their performance. The *FIH Hockey Turf and Field Standards* are the internationally recognised quality standards for hockey fields. Part 1 describe the sports performance, player welfare, surface durability and environmental characteristics required from FIH Approved hockey turfs. The standard has five categories of turf with the *Global* category being the one intended for top-level competitions.

Currently, the *Global* category requires turfs to be watered prior to use, as this ensures they have the qualities the players desire. Removing the requirement to water means this certainty will no longer exist, so new requirements are needed to ensure the turfs still provide acceptable levels of performance. Independent research[1] commissioned by the FIH identified four key properties:

Ball speed retention: a measure of how quickly a ball slows as it rolls across a surface. The primary objective of this test is to ensure that dry turfs allow the ball to retain the same speed as that found on wet turfs.

Ball rebound pace and rebound angle: ariel passes are an intrinsic part of the modern game. Dry turfs should allow balls to rebound (angle and speed) in a similar way to wet turfs.

Stick-surface friction: the ability of a hockey stick to glide across the turf in a smooth, controlled, and comfortable way was identified as a key attribute of wet turfs. Ensuring dry turfs have similar characteristics was identified as a key requirement.

3D Surface stiffness: the ability to pop a ball up from the surface and execute aerial (3D) skills was identified as another positive attribute of global category wet turfs. Retaining this ability is another important requirement of dry turfs.

2. FIH Innovation category

Based on this research, new tests and performance requirements have been developed and they are described in this addendum.

Using these new test methods measurements have been made on a range of existing hockey turfs to establish how they perform. Based on these measurements an innovation category of performance has been established. This innovation category is designed to ensure that dry turfs:

- Replicate, as far as possible, the playing qualities of wet hockey turfs

[1] Non-watered Hockey Turf; Labosport Ltd and Loughborough University, 2023

- Provide satisfactory levels of foot grip
- Provide acceptable levels of player comfort
- Have acceptable durability

Ideally, dry turfs will have similar playing characteristics to wet hockey turfs, but this may not be possible in all aspects so, the FIH Innovation Category is sub-divided into a target range, based on the performance of wet hockey turfs, and a wider range intended to ensure that the surfaces have performance that is better than that provided by national category hockey turfs.

As fields are surfaced with dry hockey turfs, the FIH, in conjunction with our National Hockey Associations will seek player feedback. This will help establish how good the performance of dry turfs are and where the limits of acceptable performance can be set. With this information, we will be able to amend our *Hockey Turf and Field Standards* to include the new performance properties and to remove the requirement for global category turfs to be watered prior to use. It is currently envisaged that this will be done no later than Q3/Q4 2024.

Notes:

1. As experience is gained from the use of dry turfs it is possible that the test requirements currently specified will change.
2. Certain tests are included, but do not have pass/fail criteria. This is to enable data to be collected so additional requirements can be introduced in the future if a need is identified.
3. Ball roll and ball roll deviation tests have been retained to enable field test date to be compared to laboratory performance.
4. The FIH is aware of on-going developments to some of the tests currently used to assess the performance of synthetic turf surface. These include the Advanced Artificial Athlete, a new linear shoe friction test and a new skin friction test. If applicable, the FIH will incorporate these updated test methods into its standards when they are next revised.

3. Hockey turf specification

A Dry Turf is a sports surfacing system that comprises the synthetic turf carpet and the underlying shockpad. If the Dry Turf also requires a specific type of hockey ball to achieve the desired performance, the ball is also considered to be part of the Dry Turf system.

There are no restrictions on how a dry hockey turf may be made other than they shall not contain any form of granular infill material (i.e. they shall be non-filled).

If a manufacturer wishes to offer a dry hockey turf on more than one shockpad, each combination of turf and shockpad should be tested to verify performance.

Manufacturers are encouraged to consider end-of-life disposal when designing dry hockey turfs. Where possible they should aim to use polymers from the same family for each of the turf's components to ease future end-of-life recycling.

4. Test institutes

Product testing to allow FIH certification of innovation category hockey turfs should be undertaken by FIH accredited test institutes that have the necessary test equipment and shown to produce reproducible results when compared to other accredited test institutes. A list of test institutes able to test innovation category hockey turfs may be obtained from facilities@fih.hockey.

5. Sample preparation

A key component of a dry hockey turf is its frictional properties. It is therefore very important that the properties measured are not artificially influenced by the presence of processing agents (e.g. spin oils) applied during the manufacturing process.

If processing agents are used, the manufacturer should remove them (by washing, etc) prior to sending samples to a test institute for assessment. On receipt, the test institute should check the samples to confirm no processing agents or surface lubricants are present. If the test institute is in doubt, they shall thoroughly re-wash the samples prior to commencing the test programme. Washed samples shall be allowed to dry under standard laboratory conditions for a minimum of 120 hours, or until a constant mass is achieved.

6. Test conditions

Innovation category hockey turfs shall be tested under the following conditions. Tests highlighted in grey are currently specified in the *FIH Hockey Turf and Field Standards*:

Property		Tested under dry conditions	Tested under wet conditions
Ball speed retention		✓	✓
Oblique ball	Pace	✓	✓
	Rebound angle	✓	✓
Stick / surface friction		✓	✓
Dynamic stiffness		✓	✓
Surface heat retention		✓	N/A
Ball roll		✓	✓
Ball roll deviation		✓	✓
Vertical ball rebound		✓	✓
Shock absorption		✓	✓
Surface deformation		✓	✓
Shoe friction		✓	✓
Skin friction		✓	

Dry tests shall be undertaken under standard laboratory conditions of 23 ± 2° and a nominal humidity of 50 %RH. Test specimens shall be conditioned for a minimum of 3 hours prior to test.

Wet tests shall be undertaken under standard laboratory conditions of 23 ± 2°. Test specimen shall be wetted by evenly applying a volume of water, using a hose fitted with a spray nozzle, that thoroughly soaks the specimen (if in doubt this should be at least equal to the volume of the test specimen). Tests shall commence 5 ± 1 minutes after the application of the water. All tests shall be completed within 15 minutes of the application of water. If required, the wetting procedure shall be repeated to allow further testing.

The quality of water applied (l/m^2) to each wet test specimens should be consistent and be reported in the official FIH test report.

7. Test balls

Tests shall either be undertaken using an:

- FIH Global Approved Hockey Ball having a rebound on concrete of 800 ± 50 mm.

Or

- A specific type of hockey ball (e.g. a self-wetting ball) nominated by the hockey turf manufacture.

The same ball shall be used for all tests, and the type of ball used to undertake the test programme shall be described in the FIH test report.

If a self-wetting hockey ball is used, it shall be primed with water in accordance with the ball manufacturer's instructions, prior to each series of tests.

8. Innovation category requirements

8.1 Ball speed retention

When tested using the procedure described in Annex A the retained ball speed shall be:

Innovation range	Target performance based on wet hockey turfs
60 % to 80%	64 % to 72 %

In addition, the percentage difference between the dry and wet results shall be calculated and reported as a % change from the dry result.

8.2 Oblique ball rebound pace

When tested using the procedure described in Annex B the oblique ball rebound pace shall be:

Innovation range	Target performance based on wet hockey turfs
≥ 54 %	58 % to 65 %

In addition, the percentage difference between the dry and wet results shall be calculated and reported as a % change from the dry result.

8.3 Oblique ball rebound angle

When tested using the procedure described in Annex B the oblique rebound angle shall be:

Innovation range	Target performance based on wet hockey turfs
30 ° to 40 °	30 ° to 37 °

In addition, the percentage difference between the dry and wet results shall be calculated and reported as a % change from the dry result.

8.4 Stick / surface friction

When tested using the procedure described in Annex C the stick/ surface friction shall be as follows:

Innovation range	Target performance based on wet hockey turfs
≤ 0.90	0.80 – 0.85

8.5 3D surface stiffness

When tested using the procedure described in Annex D the surface stiffness shall be:

Innovation range	Target performance based on wet hockey turfs
≤ 350 N/mm	≤ 300 N/mm

8.6 Ball roll deviation

When tested in accordance with Clause 5.1.3 of the FIH Hockey Turf and Field Standards: the hockey ball roll deviation shall be:

Innovation range	Target performance based on measurements on wet hockey turfs
≤ 0.50 m @ 9.5 m	≤ 0.30 m @ 9.5 m

Tests shall be made using a ball as described in Clause 7 of this addendum.

8.7 Ball roll

When tested in accordance with EN 12334 the ball roll shall be ≥ 10.0 m. Tests shall be made using a ball as described in Clause 7 of this addendum.

8.8 Vertical ball rebound

The hockey ball rebound shall be measured in accordance with EN 12335 and shall be between 100 mm and 400 mm. Tests shall be made using a ball as described in Clause 7 of this addendum.

8.9 Shock absorption

When measured in accordance with EN TS 16717 the Shock Absorption shall be between 45 % SA and 60 % SA.

8.10 Surface deformation

When measured in accordance with EN TS 16717 the Surface Deformation shall be between 4 mm and 9 mm.

8.11 Shoe friction

When measured in accordance with EN 15301-1 using the dimple test sole, the rotation resistance shall be as follows:

Innovation range	Target performance based on wet hockey turfs
25 Nm to 45 Nm.	30 Nm to 45 Nm.

In addition tests shall also be made and the results reported as follows:

- Using the smooth rubber test sole

- At an elevated temperature of 50°C. A conditioning oven should be pre-heated to a temperature of (50 °C + 2) °C. The tests specimen should then be placed inside the oven so it is stable, free from strain and exposed to air on all sides. After (240 ± 5) min, the test specimen should be removed from the oven and placed on the test floor. The Shoe/Surface friction, should be immediately measured using the dimpled test sole, ensuring the temperature of the test specimen does not fall below 48°C.

8.12 Skin / surface friction

The value of skin/surface friction shall be determined and be reported using the procedure specified in FIFA TM. 08. Tests shall be made under dry conditions.

Innovation range	Target performance based on wet hockey turfs
Skin friction value to be reported	≤ 0.75µ

Note: Ideally, dry hockey turfs will have surface properties that do not result in turf burns, when players slide on the surface, but this may not be possible. If players are concerned about turf burns and abrasions they should consider wearing protective under-garments.

8.13 Surface heat retention

Hockey is played in many countries that experience hot weather. Historically, watering turfs prior to play has meant they surfaces remain cool and do not become uncomfortable for players and match officials. Without water, this benefit is removed, but some manufacturers incorporate IR reflective technology into their turfs to help reduce heat build-up.

To enable those concerned about heat build-up to select surfaces that remain cooler the heat retention properties of the turf shall be measured using test method FIFA TM 14, and the temperature of the surface after (120 ± 2) minutes exposure recorded and classified as follows:

Surface temperature category 1	≤ 40 °C
Surface temperature category 2	41 °C to 50 °C
Surface temperature category 2	> 50 °C

8.14 Water permeability

Water permeability shall be measured in accordance with FIFA TM 24. Tests shall be made on the complete hockey turf (including the shockpad) and the result shall be at least 150mm/h.

8.15 Durability & carpet quality

To ensure that Innovation Category hockey turfs will have satisfactory durability they shall also comply with the following requirements of *FIH Hockey Turf and Field Standards,* 2021 edition:

Abrasion resistance	As specified in Clause 4.3.1 of the FIH Hockey Turf and Field Standards: Part 1

Carpet Strength	As specified in Clause 4.3.2 of the FIH Hockey Turf and Field Standards: Part 1
Tuft Bind – cut pile tufted carpets	As specified in Clause 4.3.3 of the FIH Hockey Turf and Field Standards: Part 1
Joint Strength	As specified in Clause 4.3.4 of the FIH Hockey Turf and Field Standards: Part 1
Dimensional Stability	As specified in Clause 4.3.5 of the FIH Hockey Turf and Field Standards: Part 1
Tensile strength of pile yarns	As specified in Clause 4.4.2 of the FIH Hockey Turf and Field Standards: Part 1
Effects of simulated wear	As specified in Clause 5.4.1 and 5.4.2 of the FIH Hockey Turf and Field Standards: Part 1

8.16 Resistance to artificial weathering

It is important that the new forms of hockey turf entering the market have adequate resistance to UV degradation. Normally resistance to UV degradation is assessed by subjecting samples of yarn to accelerated ageing in a weathering chamber; and this is still the preferred option. However, this accelerated weathering takes around 7 months to complete and the FIH recognise that this may delay the development of innovation hockey turfs. Therefore two options are available for FIH approved innovation turfs:

1. Pile yarns are tested for resistance to ultraviolet light degradation in accordance with clause 4.4.3 of the *FIH Hockey Turf and Field Standards*: Part 1.

2. The hockey turf manufacturer offers an eight-year (minimum) warranty against the premature failure of their hockey turf due to UV degradation.

If a manufacturer is opting for option 2 above, a copy of their standard warranty must be included in the FIH test report.

8.17 Toxicology & environmental properties

As specified in Clause 4.4.1 of the FIH Hockey Turf and Field Standards: Part 1.

8.18 Shockpads

Shockpads used with innovation category hockey turfs shall conform to Clause 4.5 of the *FIH Hockey Turf and Field Standards*: Part 1, or EN 15330-4; Specification for shockpads used with synthetic turf, needle-punch and textile sports surfaces.

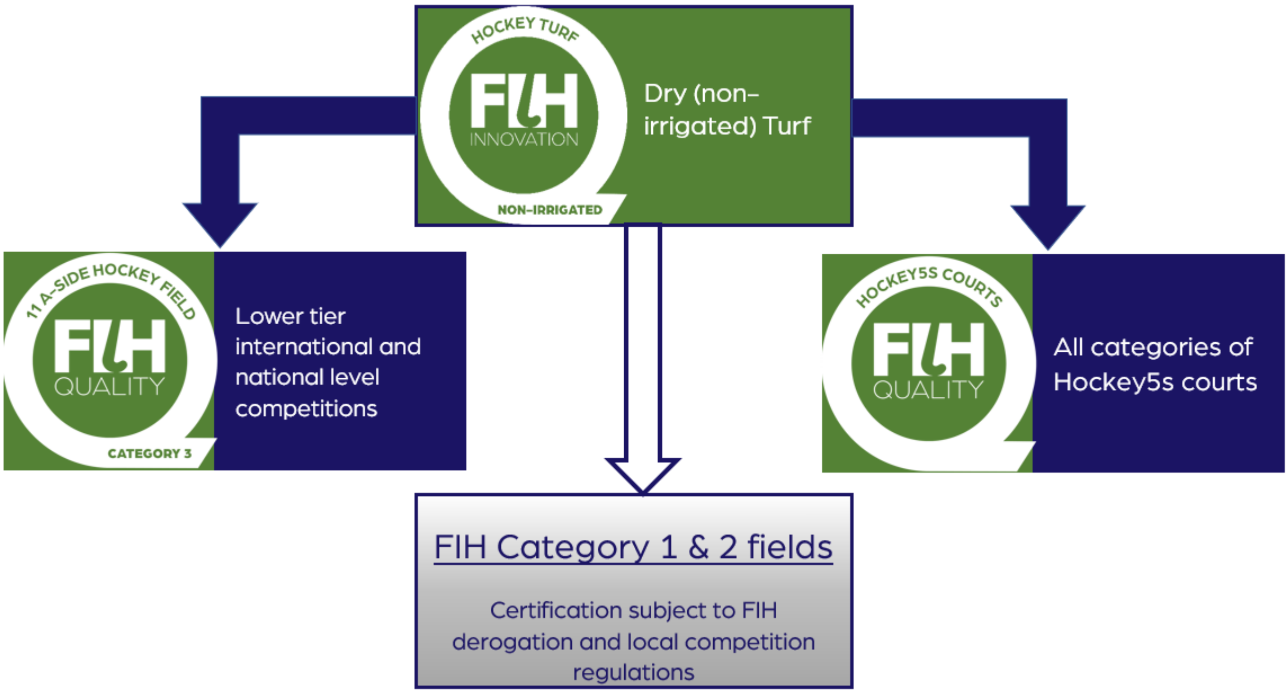
9. Field certification

Ultimately, it is the FIH's objective to see Dry Turfs used for top-level hockey tournaments, and it has already been announced that major international hockey tournaments will be played on dry turfs from 2026 onwards. Fields used for this level of competition are defined as FIH Category 1 or FIH Category 2 hockey fields.

Today, hockey turfs that have been shown to satisfy the requirements of the FIH innovation category are considered to have a level of performance that will exceed that provided by national category (sand dressed) hockey turfs. As national category turfs are laid on FIH Category 3 hockey fields, this level of field certification will initially also apply to fields having FIH innovation category turfs.

In specific cases, and subject to FIH derogation and the agreement of local competition organisers, certification of fields intended for top-level hockey events (category 1 and 2 fields), may be granted.

The rules for Hockey5s do not require the use of wet hockey turfs so courts with FIH innovation category turfs may be laid on courts requiring either Category 1, 2 or 3 certifications.



Annex A – Determination of ball speed retention

A.1 Scope

This test measures how the speed of a hockey ball changes due to its interaction with the hockey turf during a high-speed event such as a long pass. An air cannon launches a hockey ball horizontally at 15 m/s and the change in ball speed is measured over a 15-metre distance.

A.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°), from a height of (10 ±1) mm above the top of the test specimen.
- Two sets of optically triggered timing gates, accurate to 1 milli-second and able to measure the speed of the ball at two points in its travel. The timing gates in each set shall be spaced (1.0 ± 0.005) m apart.
- Hockey ball; as detailed in Clause 7.

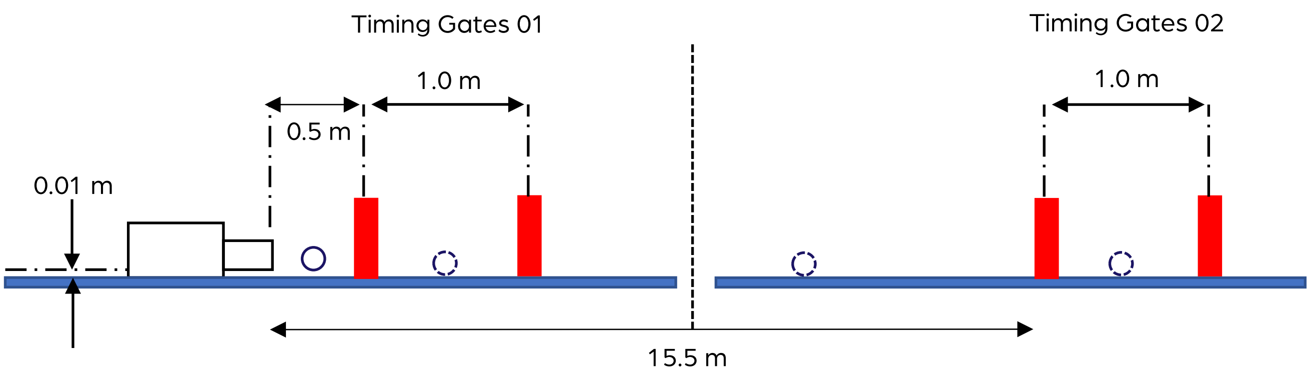
A.3 Test specimen

A sample of the hockey turf taken in the direction of manufacturing and measuring at least 17.0 m x 1.0 m.

NOTE: If the hockey turf has any form of cross direction pile, a second sample taken across the direction of manufacturing should also be tested.

A.4 Procedure

Place the air cannon on the test specimen so it is horizontal (± 1°) and the end of the cannon is (10 ±1) mm above the test specimen. Place the timing gates on the test specimen so that the first timing gate is (0.50 ± 0.005) m from the end of the air cannon, and the first timing gate on the second pair is (15.50 ± 0.01) m from the end of the air cannon.



Adjust the pressure of the air cannon so the speed of a hockey ball passing through the first pair of timing gates is (15 ±1) m/s.

Project the ball from the air cannon, ensuing there is minimal initial spin. Record the time when the ball passes through each timing gate,

Calculate the speed of the ball as it passes through the first pair of timing gates (TG01), and the second pair of timing gates (TG02).

Repeat to obtain five sets of results, before setting up the apparatus at the opposite end of the test specimen to obtain five results in the opposing direction of test.

If required, repeat on the second test specimen across the direction of manufacture.

A.5 Calculation of results

Calculate the percentage ball speed retained for each series of tests using:

$$\% \text{ ball speed retained} = \frac{\text{Speed final (TG02)}}{\text{Speed initial (TG01)}} \text{ X } 100$$

Calculate and report the mean value of the 10 tests for each direction of manufacturer.

Annex B – Determination of oblique ball rebound pace and rebound angle

B.1 Scope

High speed video is used to capture the impact event, and videogrammetry techniques are used to track the trajectory of the ball, before and after impact. Ball speed and angle, immediately prior to impact, and immediately after impact are calculated.

B. 2 Apparatus

- An air cannon capable of launching a hockey ball with minimum spin, at (14 ±1) m/s, and achieving an impact angle of (43 ± 1)°.
- A high-speed video system capable of operating at 1000 frames per second that captures the impact of the hockey ball with the test specimen. The camera's 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.
- Suitable image processing software to identify the pixel coordinates of the centre of the ball images.
- Hockey ball; as detailed in Clause 7.

B.3 Test specimen

A sample of the hockey turf and underlying shockpad measuring at least 1.5 m x 1.5 m.

If the hockey turf is intended to be loose laid over the shockpad and clamped when laid on a field, the hockey turf carpet shall be anchored on all four sides to prevent movement during the test.

If the hockey turf is intended to be bonded to the shockpad when laid on a field, the test specimen should be constructed in a similar way, and in accordance with the turf manufacturer's instructions.

B.4 Procedure

Position the high-speed video camera so it is perpendicular to the plane of motion of the ball (to avoid parallax errors). Film an object of known dimensions in the plane of the ball motion to establish a calibration factor.

Position the air cannon so it is firing the hockey ball onto the central portion of the test specimen, and the ball is impacting the test specimen at an angle of (43 ± 1)°.

NOTE: the end of the cannon nozzle should be positioned vertically approximately 0.8 m above the test specimen.

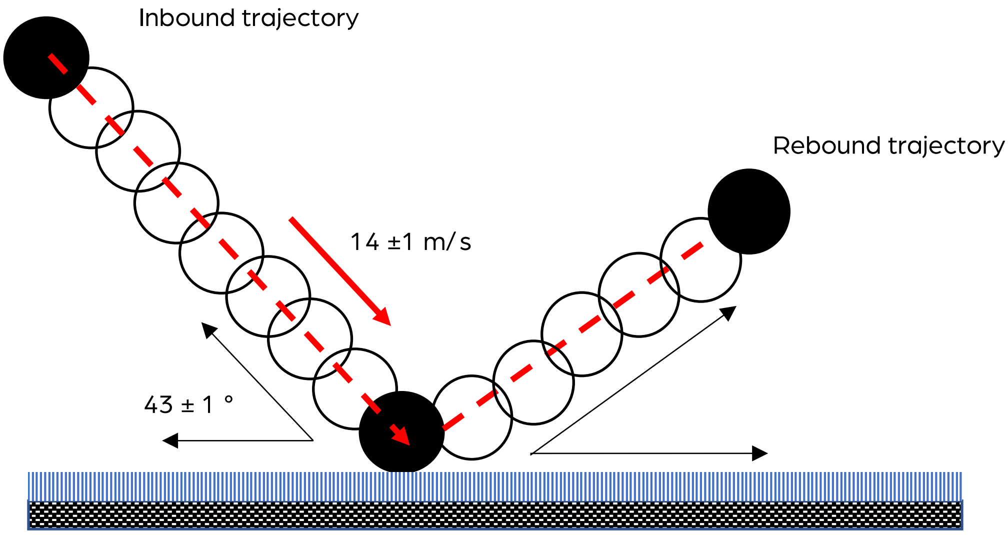
Project a ball onto the test specimen and capture its impact and rebound using the high-speed video system.

Using the image processing software identify the pixel coordinates of the centre of the ball images. Translate the pixel coordinates into real world coordinates using the calibration factor.

Using a minimum of five inbound ball coordinates, and five rebound ball coordinates, use Gauss's method of least squares analysis to calculate the average speed and angle of the inbound and rebound trajectories.

Verify the inbound speed of the ball is (14 ±1) m/s and the inbound angle is (43 ± 1)°. If the speed or angle are out of tolerance disregard the test, adjust the air cannon and repeat to obtain a valid result.

Ensuring that the ball does not strike the same position twice, repeat to obtain five sets of valid results, before repeating in the opposing direction of test.



B.5 Calculation of results

B.5.1 Oblique ball rebound pace

Calculate the angle ball pace for each test using:

$$\text{Oblique ball rebound pace (\%)} = \frac{\text{Rebound trajectory speed (m/s)}}{\text{Inbound trajectory speed (m/s)}} \times 100$$

Calculate and report the mean oblique ball rebound pace value of the 10 tests.

B.5.2 Rebound angle

For each test calculate the angle of the ball's rebound trajectory as it leaves the test specimen.

Calculate and report the mean oblique ball rebound angle of the 10 tests.

Annex C – Determination of stick/ surface friction

C.1 Scope

A weighted sledge with three hockey stick profiles is pulled at a constant velocity across the test specimen and the frictional force that acts on the hockey stick profiles measured. .

C.2 Apparatus

A shear tester apparatus that comprises a rigid frame, with a movable carriage that is driven by electric motors. The carriage shall be driven at a regulated constant velocity of (2 ± 0.1) m/s for a distance of at least 0.5 m.

NOTE: to achieve a regulated constant velocity during the measurement phase of the test, the design of the test rig must allow for the acceleration and deceleration of the carriage before after the measurement phase.

A friction sledge shall be mounted onto the movable carriage. The shape of the hockey stick head profile shall be as shown in figure C1. They shall be 3D printed using PA12-CF PA (Nylon) base reinforced with carbon fibre composite.

The three hockey stick head profiles shall be mounted to its base as shown in Figure C.2, C.3 and C.4.

The force acting on each profile shall be (46 ± 0.5) N.

NOTE: a sledge with a single hockey stick head profile may also be used providing it is stable during its movement across the sample.

The hockey sledge shall be pulled across the test specimen via a load cell with (0.2 ± 0.01) % accuracy and be sampled at a frequency of (500 ± 10) Hz through a DAC.

If tests are to be made using self-wetting balls, the sledge shall incorporate cages that ensures the balls can run freely immediately in front of the hockey stick head profiles.

NOTES:

1. A CAD drawing of the hockey stick profile, suitable to allow its 3D printing, and details of the carbon fibre composite may be obtained from the FIH (facilities@fih.hockey).

C.3 Test specimen

A sample of the hockey turf and underlying shockpad measuring at least 2.0 m x 0.5 m.

If the hockey turf has any form of direction pile patten test specimens representing the direction of manufacture and across the direction of manufacture shall be assessed.

C.4 Calibration

The frictional properties of the hockey stick sledge shall be validated prior to test.

The hockey stick sledge hall be pulled by the shear tester across a clean sheet of tempered float glass in a saturated wet condition. The carriage of the shear tester shall be driven at a regulated constant velocity of (0.5 ± 0.1) m/s for a distance of at least 0.5 m.

The calibration test shall be repeated six times and the stick/wet glass coefficient of friction using:

$$\text{Stick/wet glass coefficient of friction} = \frac{\text{Mean frictional force over 0.5 m steady state slide (N)}}{\text{Vertical force (N)}}$$

The stick/wet glass coefficient of friction shall be 0.17 ± 0.02.

C.5 Procedure

Ensure the hockey stick head profiles are totally dry following the calibration test.

Pull the sledge over the test specimen at a speed (2 ± 0.1) m/s for a minimum distance of 2 metres.

Monitor the speed of the sledge and identify a section where it is moving over a distance of at 0.5 m with a steady state slide of (2 ± 0.1) m/s.

Repeat the test to obtain five results, before reversing the test specimen to repeat the procedure in the opposing direction.

If required, repeat on the second test specimen across the direction of manufacture.

C.6 Calculation of results

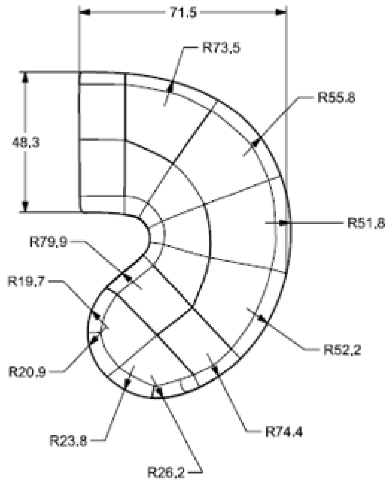
For each test analyse the date to determine the mean frictional force acting on the sledge during the tests.

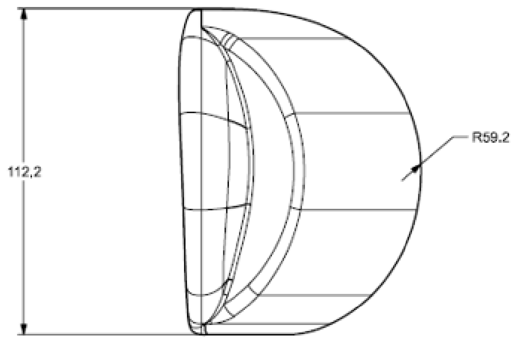
Calculate the stick/surface coefficient of friction using:

$$\text{Stick/surface coefficient of friction} = \frac{\text{Mean frictional force over 0.5 m steady state slide (N)}}{\text{Vertical force (N)}}$$

Caluate the means value of stick/surface coefficient of friction for each direction of test.

Report the minimum, maximum and mean values of stick/surface for each direction of test.





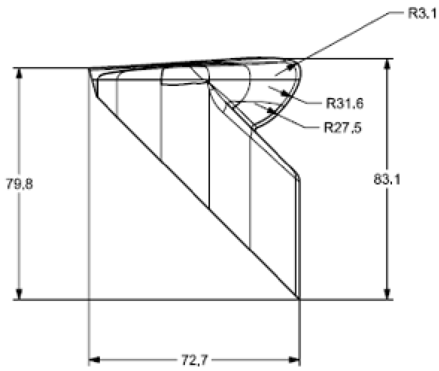


Figure C.1 hockey stick head profile

All dimensions in mm

Permitted tolerance (± 0.5) mm

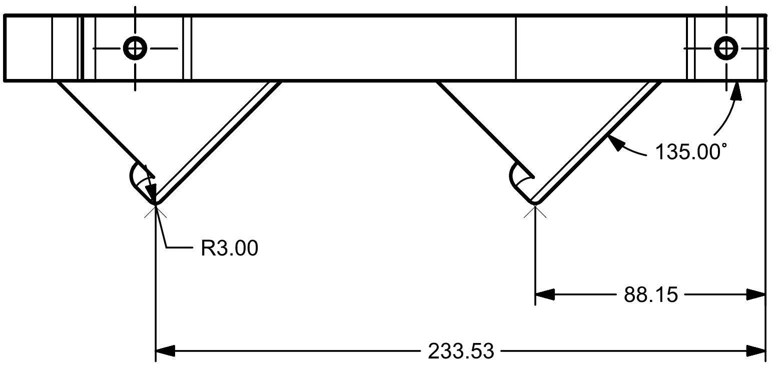


Figure C.2 mounting of hockey stick head profile on sledge (dimensions in mm)

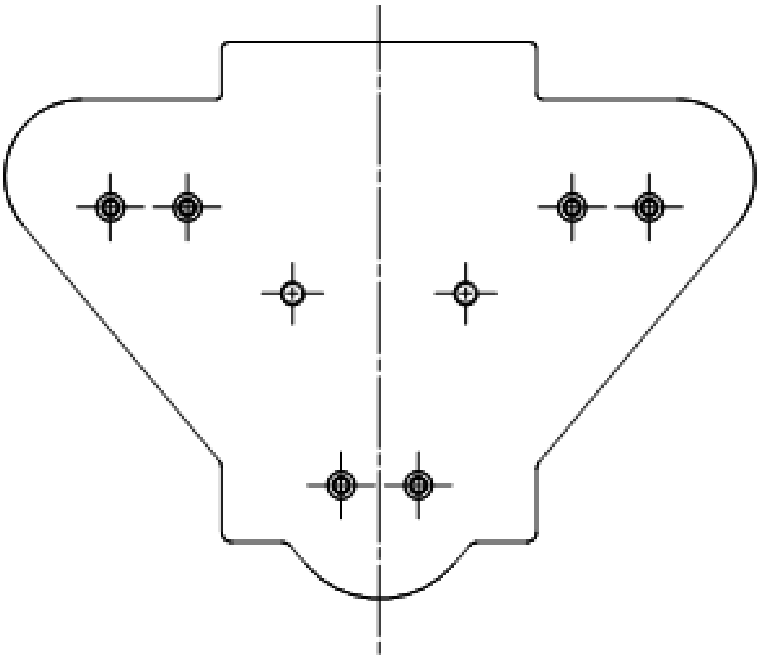


Figure C.3 mounting of three stick profiles on sledge

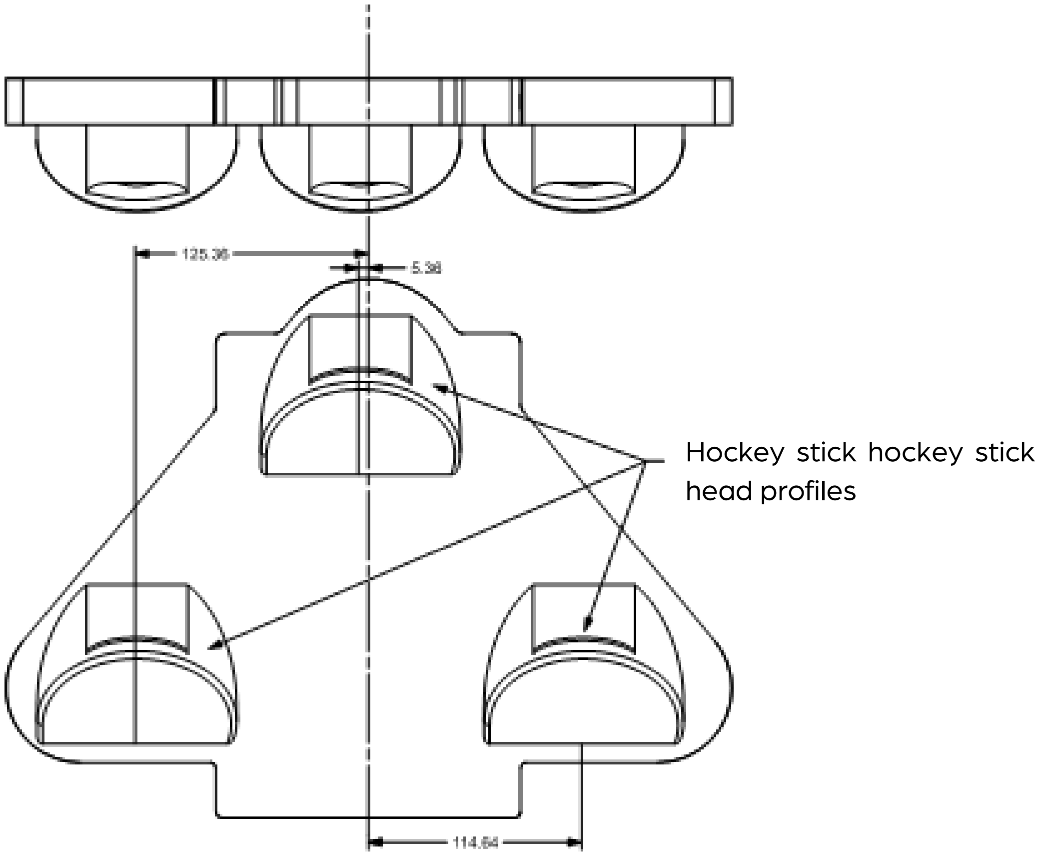


Figure C.4 mounting of three stick profiles on sledge (dimensions in mm)

Annex D – Determination of 3D surface stiffness

D.1 Scope

The test measures the dynamic stiffness of the hockey turf, an simulates a player popping the ball up off the surface to initial play the ball in vertical space (aka 3D skills).

D.2 Apparatus

An Advanced Artificial Athlete (AAA) as described in CEN Technical Specification CEN/TS 16717:2015[2], modified as follows:

1. The total mass of the impactor (foot, spring, accelerometer, carriage) is reduced to (10,000 ± 100) grams. The dimensions of the impactor, and spring rate specifications remain unchanged.
2. The drop height is reduced to (20 ± 0.25) mm (on concrete floor) and the target impact velocity is reduced to 0.6 m/s (on concrete floor).
3. The start (T1) and end of contact (T2) periods are defined as:

Start of impact

Find the last point before peak force where the force versus time curve crosses the 30 N line. If the force gradient at this point exceeds 10 kN/s then this is defined as T1. If the force gradient at this point does not exceed 10 kN/s, then move forward in time until this condition is first met and this is defined as T1.

End of impact

Find the first point after peak force where the force versus time curve crosses the 30 N line. If the absolute force gradient at this point exceeds 10 kN/s then this is defined as T2. If the absolute force gradient at this point does not exceed 10 kN/s then move backward in time until this condition is first met and this is defined as T2.

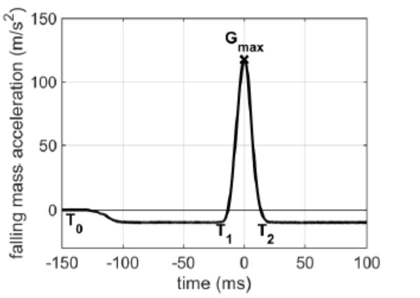


Figure D.1 Example curve showing the falling mass acceleration versus time

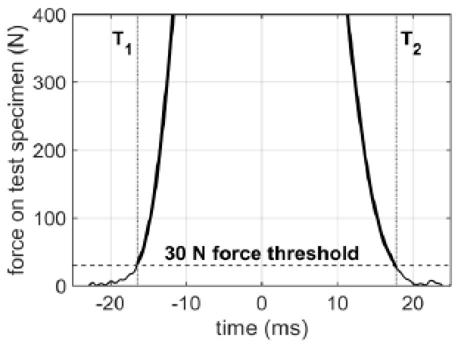


Figure D.2 Example of 30 N force threshold

D.3 Test specimen

A sample of the hockey turf and underlying shockpad measuring at least 1.0 m x 1.0 m.

[2] Surface for sports areas – Method of test for the determination of shock absorption, vertical deformation and energy restitution using the advanced artificial athlete

If the hockey turf is intended to be loose laid over the shockpad and clamped when laid on a field, the hockey turf carpet shall be anchored on all four sides to prevent movement during the test.

If the hockey turf is intended to be bonded to the shockpad when laid on a field, the test specimen should be constructed in a similar way, and in accordance with the turf manufacturer's instructions.

D.4 Procedure

Set up the apparatus so it is positioned vertically on the test specimen.

Adjust the height of the lower face of the steel test foot so it is (20.00 ± 0.25) mm above the test specimen. Drop the mass and record the acceleration signal.

Repeat to make a total of five measurements, moving the test apparatus between impacts so it is positioned over a different part of the test specimen, ensuing no measurement is made within 200 mm of the edge of the test specimen.

D.5 Calculation of results

For each test determine the Peak Force (N) and Peak Deformation (mm).

D.6.1 Calculation of peak force

Peak force correspond to the maximum force, expressed in Newtons and is calculated as:

$$F_{max} = m \times (A_{max} + g)$$

Where:

- A_{max} = is the peak acceleration during the impact (ms^{-2})
- m is the mass of the falling weight (kg)
- g is the acceleration due to gravity (ms^{-2}).

D.6.2 Calculation of peak deformation

Peak deformation (mm) (is defined as the maximum value of $D_{specimen}(t)$ on the interval [T_1, T_2]

$$D_{specimen}(t) = -D_{test\ foot}(t) = -(D_{mass}(t) + D_{spring}(t))$$

The velocity ($V_{mass}(t)$) and displacement (D_{mass} (t)) of the falling mass are calculated by single and double integration respectively of the falling mass acceleration over the full signal

For the velocity integration, Vmass(t) is 0 m/s at the start of the signal (before the drop commences). For the displacement integration, the D_{mass} (t) is 0 mm at the time of initial contact between the test foot and test specimen.

Compression of the spring D_{spring} (t) throughout the contact phase between the test foot and test specimen, [T1, T2], is calculated as:

$$D_{spring}(t) = \frac{F(t)}{C_{(spring)}}$$

Where:

- D spring (t) is the compression of the spring (mm)

- F(t) is the force applied by the falling mass on the test specimen (N)
- C spring is the spring rate, as detailed in (N/mm)

D.6.3 Calculation of 3D surface stiffness

Calculate the 3D surface stiffness using:

$$\text{3D surface stiffness (N/mm)} = \frac{\text{Peak force}}{\text{Peak deformation}}$$

Calculate and report the mean value of Dynamic Stiffness of the five tests.

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