International Hockey Federation

Handbook of Performance, Durability and Construction Requirements for Synthetic Turf Hockey Pitches

February 2014

Foreword

Synthetic turf is increasingly used for hockey pitches around the world. It is over 30 years since the surface was first used for international hockey. In that time, the structure and composition of pitches has developed tremendously. New materials and new construction and installation methods have been introduced. Synthetic turf pitches are now used widely at many levels of hockey play.

To support these developments while maintaining the quality of synthetic turf pitches, it is necessary to update this Handbook of performance requirements from time to time. This version therefore reflects the latest synthetic turf technology, together with the latest update of FIH requirements.

However, FIH hopes to see further development in synthetic turf in the near future primarily in relation to the use of water. At present, all global level turf and pitches and some at national level require the application of water to achieve the performance requirements. This is not sustainable in a world where water is an increasingly scarce and valuable natural resource. FIH is therefore undertaking research and consulting with the synthetic turf industry to develop a specification for a global level turf which does not require the application of water. In doing so, the playing characteristics of the game and the safe actions of players will be taken into account.

A test has been identified which appears to differentiate irrigated unfilled global turf from other types of turf but more data is needed before the test can be included as a requirement for turf approval. The test (loss of ball velocity on interaction with a turf) is therefore included in this Handbook and all new product approval requests must include it. However, this is solely for FIH data collection and not a criterion for turf approval. In due course, the test will be evaluated and if considered appropriate included in a revised Pitch Handbook.

The test above may, in due course, lead to the development of global turfs which do not, de facto, require watering. However, and in the interim in relation to top level hockey, water-based pitches will continue to be specified. For some time after the new turfs are available, FIH will continue to allow top events to be played on existing water-based pitches that meet the performance requirements. Organisations considering the installation of new pitches or refurbishment of existing pitches can therefore use current approved turf products with confidence. Pitches installed in the near future using these turfs will continue to provide good facilities for hockey. Newly installed pitches using current turfs are not compromised by and do not contradict the aims of the FIH described above.

International Hockey Federation

Any questions about this Pitch Handbook or related subjects should be addressed to:

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HANDBOOK OF PERFORMANCE REQUIREMENTS AND TEST PROCEDURES FOR SYNTHETIC TURF HOCKEY PITCHES

Contents

1 Introduction

1.1 Authority

This Handbook is published by the International Hockey Federation (FIH) as a comprehensive statement of its requirements for approved synthetic hockey turf products and for certification of pitches constructed using those products.

To be approved by the FIH, a synthetic turf product supplied by an FIH licensee must meet the performance requirements in this Handbook.

To be certified by the FIH, an installed hockey pitch must meet the performance and composition requirements of this Handbook.

This Handbook therefore establishes the technical basis for the supply of approved turf products and also acts as a reference for organisations contemplating the installation of synthetic pitches.

In the latter context, pitch owners are recommended to specify the desired performance requirements by reference to this Handbook in any contract agreement for the construction of a hockey pitch.

This edition of the FIH Handbook becomes effective from 1st May 2013. It shall be implemented as follows:

Existing approved products	Products currently approved by the FIH do not need to be upgraded to the requirements of this edition of the FIH Handbook unless the manufacturer wishes. When the current product approval expires the Licensed Manufacturer shall have the product fully tested in accordance with this edition of the FIH Handbook.
New products seeking approval	For period of three months from the date of publication a Licensed Manufacturer may have products tested in accordance with either this edition or the 2011 edition of the FIH Handbook Once this transition period has expired, all new products shall be tested in accordance with this edition of the FIH Handbook.
New field tests	From the date of publication of this manual all pitches requiring initial (first) field-tests shall be tested in accordance with this edition of the Handbook. When a pitch has been surfaced using an Approved Turf Product tested in accordance with the 2008 or 2011 editions of the Handbook full product identification tests shall be carried out on

	samples from site of the installed synthetic turf surfacing system and the results obtained compared to manufacturer's product declarations where-ever possible.
Pitch – re-tests	Pitches requiring re-certification may be tested in accordance with this edition of the handbook or the edition applicable when the field was initially tested. For fields re-tested in accordance with older editions of the handbook, the field test report template applicable at the time of the initial field test shall be used.

Only synthetic turf systems and fields incorporating synthetic turf systems manufactured by FIH Licensed Manufacturers may be reported on FIH Report forms. Tests undertaken for manufacturers that are not FIH Licensed Manufacturers or by laboratories that are not FIH Accredited Test Laboratories are unofficial tests and are not recognized by the FIH.

1.2 Objective

The primary objective of FIH in codifying the relevant performance requirements is to ensure that hockey competitions and matches are conducted so as:

- to reflect relative team merit;
- to provide an opportunity for players to display and develop their hockey skills;
- to offer comfortable playing conditions and to limit danger to players;
- to extend pitch playability in adverse weather conditions.

The system of product approvals helps to ensure uniformity and quality pitch performance to the benefit of the game. This is extended by the scheme for certifying that installed pitches meet specified requirements.

Three approval levels are laid down for **synthetic turf products**:

- for FIH world-level competitions including specified qualifying tournaments - hereafter called '**global**' level turf;
- for other international matches and higher level national competitions - hereafter called '**national**' level turf;
- for other levels of play, subject to national association regulations, surfaces designed to cater for a number of sports, with hockey not being the principal activity - hereafter called '**multi-sport**' level turf.

Before giving approval to particular competitions, FIH will specify the category of the pitch or pitches to be used by reference to this Handbook. The FIH website (www.fih.ch) or FIH Office

should be contacted to verify up to date requirements but an indicative list of competitions requiring certified 'global' pitches is:

- Olympic Games
- Youth Olympic Games
- World Cups
- Junior World Cups
- Champions' Trophies
- Champions' Challenges
- FIH World League

Other competition organisers also often specify similar requirements.

Pitch owners contemplating hosting an international or other top-level competition should therefore consider carefully the choice of an approved turf product when planning the facility. In addition to consulting this Handbook, they should seek advice on requirements from FIH or other competition organisers.

1.3 Performance Requirements

Several concepts underpin the performance requirements set out in this Handbook:

- the requirements have been laid down after consultation with players, turf manufacturers and FIH accredited laboratories. They embrace products upon which hockey can be played safely and comfortably.

- product approvals will only be granted to products and/or combinations of products which have been tested by an FIH accredited laboratory and shown to comply with the requirements in this Handbook. Such approvals are valid for a duration specified in this Handbook and in licensing agreements with manufacturers.

- a current list of approved products from licensed manufacturers is published on the FIH website www.fih.ch.

- specific installed pitches will be granted a Certificate of Compliance after field testing by an FIH accredited laboratory showing that the pitch meets the requirements in this Handbook.

- a current list of certified pitches is published on the FIH website www.fih.ch.

The technology on which synthetic turf is based continues to develop rapidly. As a consequence, the requirements in this Handbook may change. In this case, a revised Handbook will be published. Users of the Handbook should therefore always check the pitches and equipment section of the FIH website to ensure they are using the latest version.

1.4 Durability

FIH is conscious of the need for durability characteristics for synthetic pitch products and installed pitches as a matter of prudence for pitch owners and to maintain a large number of

high quality pitches around the world. The principal considerations are: the ability of the synthetic turf carpet to withstand the effects of weathering and in particular ultra violet light degradation; the ability of surfaces to offer adequate resistance to wear; and the ability of shockpads to provide adequate performance (in conjunction with the synthetic turf carpet) for more than one carpet life.

However, it must be understood that quality of maintenance and intensity of usage as well as climatic and environmental conditions have a significant influence on durability. To ensure that a proposed turf meets expectations, it is prudent for pitch purchasers to investigate the durability of a product by inspection of similar installations which have been in use for some time. It is also wise to negotiate a quality guarantee for a reasonable pitch lifetime when agreeing supply contracts.

2 Definitions and Abbreviations

The following terms will be encountered in this Handbook.

Synthetic Turf System	A combination of synthetic turf carpet, infill (when applicable) and shockpad, together with any supporting layers designed to contribute to the performance of the surface.
Approved Turf System	A Synthetic Turf System that has been tested by an FIH accredited laboratory and verified as meeting the requirements in this Handbook and the conditions laid down in the licensing agreement.
Global Turf	An Approved Turf Product supplied by a licensed manufacturer which has been shown by independent laboratory testing by an FIH accredited laboratory to meet the (top) global level performance requirements in this Handbook. Global Turf products will also satisfy the National Turf and Multi-sports Turf categories of this Handbook.
National Turf	An Approved Turf Product supplied by a licensed manufacturer which has been shown by independent laboratory testing by an FIH accredited laboratory to meet the national level performance requirements in this Handbook. National Turf products will also satisfy the Multi-sports Turf category of this Handbook.
Multi-sport Turf	An Approved Turf Product supplied by a licensed manufacturer which has been shown by independent laboratory testing by an FIH accredited laboratory to meet the multi-sport level performance requirements in this Handbook.
Certified Pitch	A pitch which has been tested by an FIH accredited laboratory and verified as meeting the requirements in this Handbook and the conditions laid down in the licensing agreement.
Wet Surface	An Approved Turf Product that requires watering to satisfy the relevant requirements in this Handbook.
FIH Standard Watering	Watering of the synthetic turf surface/pitch using the procedure described in this Handbook.
Manufacturer's Reduced Watering Procedure	Watering of the synthetic turf surface/pitch using a reduced water application rate as specified by the surface manufacturer.
Dry Surface	An Approved Turf Product that satisfies the relevant requirements in this Handbook in dry conditions.

Licensing Agreement	The formal agreement entered into by a turf manufacturer and the FIH governing the conditions under which approval of turf products may be granted.
Licensed Manufacturer	A synthetic turf manufacturer who has entered a licensing agreement with FIH. In this Handbook and in the licensing agreement, “manufacturer” also includes a supplier who has entered a licensing agreement with FIH, but who is not necessarily itself a manufacturer.
Pitch Certificate	The certificate issued to a pitch that meets the set of field test and product identification requirements in this Handbook.
Certified Global Pitch	A pitch that meets the set of field test requirements in this Handbook and uses a global turf product.
Certified National Pitch	A pitch that meets the set of field test requirements in this Handbook and uses a National Turf product.
Certified Multi-sport Pitch	A pitch that meets the set of field test requirements in this Handbook and uses a Multi-sport Turf product.
Unfilled Turf/Pitch	A synthetic turf system or pitch using a carpet of woven, tufted or knitted synthetic yarn in which the density of pile is sufficient to maintain the pile upright without the use of infill stabilisation.
Filled Turf/Pitch	A synthetic turf system or pitch using a carpet of woven, tufted or knitted construction, whose pile yarn is maintained upright by the support of filling material (e.g. sand and therefore sometimes referred to as a sand-filled turf).
Dressed Turf/Pitch	A synthetic turf system or pitch using a carpet of woven, tufted or knitted synthetic yarn partly supported or stabilised by the addition of filling material (e.g. sand and therefore sometimes referred to as a sand-dressed turf/pitch). Sometimes referred to as ‘Obscured Turf/Pitch’.
Sub-base	The engineered base or support structure for a synthetic turf surfacing system.
Shockpad	Resilient material under the synthetic turf carpet designed to absorb kinetic energy. Sometimes referred to as ‘Shock Absorbing Layer’, ‘Elastic Layer’ or ‘E-Layer’.
Carpet	The upper playing surface manufactured from woven, tufted or knitted materials.
Pile	The full depth of tufts of yarn which form the carpet.

Yarn	Extruded plastic ribbons or strands used to form the pile of the carpet.
Ball	An FIH approved hockey ball.
EN	European Standard published by the European Standards Organisation.
ISO	International Standard published by the International Standards Organisation.

3 Accredited Test Laboratories

The tests referred to in this Handbook are required to be undertaken by an FIH accredited laboratory.

In establishing a network of accredited laboratories for testing synthetic turf products and pitches to the requirements of this Handbook, FIH has regard to a number of factors including:

- the integrity and independence of the organisation;
- the competence of the staff of the organisation;
- the possession of, or willingness by the organisation to acquire, the necessary test and calibration equipment;
- the willingness to work with FIH to verify test consistency.

Laboratories which have obtained FIH accreditation are authorised to carry out tests on both turf products and pitches to the specifications laid down in this Handbook.

Independent of the result of testing, laboratory charges are the responsibility of the turf product manufacturer, pitch installer, pitch owner or other test applicant. It is the responsibility of the test applicant to contract an accredited laboratory to undertake tests.

Although the convenience of manufacturers, installers and owners has been a factor in establishing the laboratory network, there is no obligation to use a particular laboratory.

Official test reports must be in a format specified by FIH. Laboratory test reports are confidential to the laboratory, the test applicant and FIH but the applicant may supply copies to other parties.

A current list of FIH accredited laboratories is published on the FIH website www.fih.ch.

4 Turf Products: Licensing and Approval Procedures

4.1 Introduction

Manufacturers of synthetic turf systems for hockey pitches may apply to the FIH to have their products registered as FIH approved products. These products are tested by an FIH accredited laboratory and verified to meet the requirements set out in this Handbook.

A current list of approved products from licensed manufacturers is published on the FIH website www.fih.ch.

A separate section of this Handbook deals with the equivalent procedures for certifying installed pitches.

4.2 Manufacturer Licensing

Synthetic turf manufacturers are invited to enter a licensing agreement with FIH. Full information about the licensing agreement including a draft copy is available from the FIH office.

Only licensed manufacturers, their subsidiaries or licensees may seek FIH approval of their products. Any breach of the licensing agreement by a manufacturer, a subsidiary or a licensee may lead to cancellation of the licence and withdrawal of approval of the relevant products.

4.3 Pre-Approval Testing

Some manufacturers have their own product test facilities and use these facilities to check that their products meet FIH requirements.

Applicants that do not have these facilities are advised to seek an initial informal test by an FIH accredited laboratory. If the laboratory results indicate full compliance with the FIH requirements, the laboratory can then convert the informal result into a formal FIH report. If there are any short-comings in the results, the manufacturer can adjust the product design until the short-coming is resolved.

In all cases, approval of a product must be on the basis of a full set of tests by an FIH accredited laboratory.

4.4 Test Procedure

Synthetic turf system manufacturers must arrange for tests to be conducted by one of the FIH accredited laboratories.

4.5 Product Approval

Upon satisfactory completion of the tests and demonstration of compliance with the requirements set out in this Handbook, a manufacturer may apply for a product approval.

Each application must identify clearly a discrete marketing name or code for the product. Each application must relate to a specific combination of turf carpet, infill (when applicable) and shockpad. Any approval will be related only to that combination of turf carpet, infill and shockpad. Separate applications are necessary for other combinations.

To enable verification that a supplied synthetic turf is an FIH approved product, detailed information will be required about the composition of the turf.

A manufacturer may produce an approved turf in more than one factory under their control. In this case, the product approval will be based on turf samples from one factory. However, the manufacturer must specify to the satisfaction of FIH that its quality assurance processes ensure that production at each factory is identical. To verify this, FIH may at any time require a manufacturer at the manufacturer's cost to have samples from any of its factories tested by an FIH accredited laboratory against the composition information from the original approved product.

The locations of factories used by manufacturers will be specified in the list of approved products published by FIH.

A product approval issued by FIH entitles the manufacturer to advertise, as specified in the licensing agreement, the particular turf product as having complied with FIH requirements. Where a manufacturer is supplying the same turf product through an FIH accepted subsidiary or agent, the subsidiary or agent will be entitled to advertise the FIH approval in a similar fashion. The licensing agreement between FIH and a manufacturer contains provisions relating to use of the FIH registered mark.

When a licensed manufacturer no longer wishes to be licensed, or if a manufacturer's licence lapses or is cancelled, the manufacturer must withdraw all materials which indicate that any of the subject manufacturer's pitch products carry an FIH approval.

From time to time, FIH will publish and keep updated a list of licensed manufacturers and of turf products which have been approved. This list will be published on the FIH website www.fih.ch.

Turf product approvals last 5 years from the date of testing.

When a synthetic turf system is first submitted for approval, the manufacturer must supply a full product declaration for each of the components used in the system and the test laboratory must verify the declaration as specified in this Handbook. A test sample must also be retained by the laboratory for subsequent verification if necessary.

To enable an Approved Turf Product to be approved for a further period of time, a new sample of the Approved Turf Product should be sent to an FIH accredited laboratory to allow the product identification data as detailed on the original test report to re-validated. If the product composition is unchanged, the FIH accredited laboratory will issue a Product Approval Retest report to the FIH to enable a new period of approval to be granted. If there are discrepancies between the new and original product identification, the FIH will be notified and make a decision as to whether a full re-test must be undertaken or whether the discrepancies are relatively insignificant so that a new period of approval can be granted.

If necessary, the original test sample may be retrieved to enable the new and original sample to be compared.

Approval of a turf product will be withdrawn if it fails a re-test.

In accordance with the licensing agreement, a manufacturer is required to notify FIH of any material or production variation in a turf product for which approval has already been issued.

5 Turf Products: Performance Requirements and Test Procedures

5.1 Introduction

This section describes the requirements to be achieved and the test procedures to be followed in the conduct of laboratory tests on samples of synthetic turf systems submitted by FIH licensed manufacturers in order to gain FIH product approvals.

A subsequent section of this Handbook describes the requirements and test procedures for a field test.

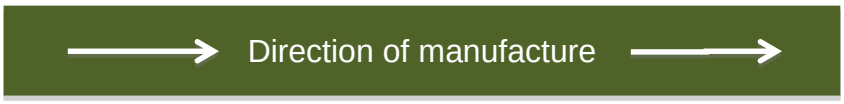
This Handbook incorporates by dated or undated reference provisions from other publications. For dated references, subsequent amendments to or revisions of any of these publications will apply to this Handbook only when incorporated into it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

5.2 Preparation for Test Procedures

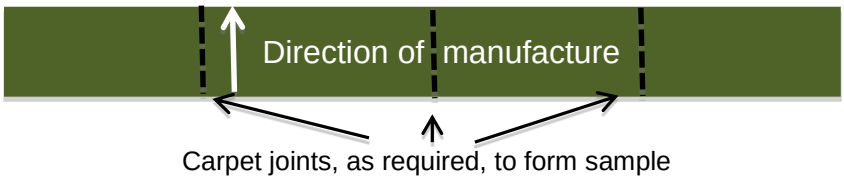
Product samples

Samples required for testing are two 1.0 m x 1.0 m specimens of both the synthetic turf carpet (plus infill if applicable) and shockpad. Two further specimens of carpet at least 16.0 m by 1.0 m are required for ball roll and ball roll deviation tests.

The long dimension of one of these samples must be in the direction of the manufacturing run.



The long dimension of the other sample must be across the manufacturing run. As necessary, this second sample must be joined by the manufacturer according to its pitch installation technique.



Sample preparation

Test pieces must be prepared in accordance with EN 12229 and the instructions provided by the manufacturer. The carpet and shockpad must be laid on a solid (e.g. concrete), horizontal and smooth surface unless specified otherwise in this Handbook or unless the carpet and shockpad is laid on a base that is designed to contribute to the dynamic performance of the surface. In such cases the measurements of ball rebound, shock absorption and pile/pad deformation shall be made on a test specimen comprising the carpet, shockpad and the base, laid to the depth specified by the manufacturer or supplier.

Filled surface	Depth and consolidation of materials must simulate the conditions applying to installed products. If specified by the manufacturer, infill materials must be consolidated using a consolidating roller or other means. All tests pieces must be consolidated in the same way.

5.3 Laboratory Test Conditions

5.3.1 Laboratory test conditions

Laboratory tests shall be made at an ambient laboratory temperature of 23 ± 2ºC.

Test specimens shall be conditioned for a minimum of 3 hours at the laboratory temperature prior to test.

5.3.2 Wet tests

5.3.2.1 FIH Standard Wetting Procedure

To ensure acceptable performance after rain or watering, all products shall be tested following wetting in accordance with the following procedure.

The test piece shall be immersed in tap water at 23°C (± 2°C) for 30 minutes (± 2 minutes) and the test commenced immediately upon removal from the water. Where tests are conducted on specimens too large for wetting in the way described above, the specimens shall be wetted by evenly applying a volume of water that thoroughly soaks the specimen (if in doubt this is should be equal to the volume of the test specimen). Tests shall commence immediately following application of the water.

All tests shall be completed within 15 minutes of the test specimen being wetted. If required, the wetting procedure shall be repeated to allow further testing.

5.3.2.2 Manufacturer's Reduced Wetting Procedure

Where a manufacturer specifies an alternative wetting procedure to the FIH Standard Wetting Procedure for their product, the surface shall also be tested using this procedure. The quantity of water to be applied to the test specimens shall be specified in terms of millimeters depth (using the same principal as that used to assess the performance of an irrigation system on a field test). The water shall be uniformly applied to the test specimen using a hose fitted with a spray nozzle. A minimum of three collector dishes shall be positioned on 1m x 1m test specimens and a minimum of one collector dish per metre length on ball roll test specimens. Water shall be applied until the required depth is measured in the collector dishes. Tests shall commence immediately following the application of water.

All tests shall be completed within 15 minutes of the test specimen being wetted. If required, the wetting procedure shall be repeated to allow further testing.

The minimum depth of water that can be specified by a manufacturer to satisfy the FIH's designation of a 'wet surface' is 1mm.

5.3.3 Dry tests

National and Multi-sport category products that are designed to be played on under wet and/or dry conditions should also be laboratory tested under dry conditions.

Note: Manufacturers may also arrange for Global turf category products to be tested under dry conditions to assist in the development of a "water-free" turf to meet future FIH global level requirements.

5.4 Turf Product Composition

When applying for an initial product approval, the applicant must submit a detailed product declaration/specification for the synthetic turf product. As part of the initial product approval test programme, the test laboratory will verify the product declaration using the test methods specified in the table below. The test specimen should conform to the product declaration (within the tolerances stated) for each property. Any discrepancies between the manufacturer's declaration and the laboratory's results shall be resolved by the two parties prior to an FIH laboratory test report being issued.

Synthetic turf

Property	Test Method	Permitted Tolerance
Mass per unit area	ISO 8543	≤ ± 10%
Tufts per unit area	ISO 1763	≤ ± 10%
Stitch gauge	Measurement	Same gauge
Pile length above backing	ISO 2549	≤ ± 10%
Total pile weight	ISO 8543	≤ ± 10%
Pile yarn(s) characterisation	ISO 11357-3	Peak temperature ± 3°C
Pile dtex(s)	-	≤ ± 10%
Pile yarn profile and dimensions	FIH test method C7	Same shape
Pile type (e.g. straight, curled, fibrillated)	Photographic record and description	Same profile
Pile construction (e.g. tufted, woven, needle punched)	Photographic record and description	Same construction
Pile colour(s)	RAL Classic Colour Charts	Same RAL number

Note 1: If it is not possible to extract tufts from the carpet backing (e.g. when there is an integral shockpad or the carpet is of a knitted construction, etc.) the pile mass per unit area above the substrate shall be determined in accordance with ISO 8543. This shall be noted in the test report.

Note 2: The number of filaments per square metre shall be calculated by multiplying the number of tufts per square metre by the number of filaments per tuft; this figure being the mean value of 20 tufts extracted at random from a 200mm x 200mm sample.

Note 3: The test method to determine pile yarn profile and dimensions is described in Annex C7 of this Handbook.

Shockpad

Property	Test Method	Permitted Tolerance
Thickness	EN 1969	≥ 90% of manufacturer's declaration
Mass per unit area	ISO 8543	≤ ± 10%
Shock absorption	EN 14808	≤ ± 5% Force Reduction
Tensile strength	EN 12230	≥ 0.15MPa
Composition	Photographic record and description	Same composition

Infill (when applicable)

Property	Test Method	Permitted Tolerance
Particle size	EN 933 - Part 1	≥ 80% to be within declared range
Particle shape	EN 14955	Similar shape
Bulk density	EN 1097-3	≤ ± 15%
Composition	Photographic record and description	Same composition
Polymeric composition (polymeric infills only)	Thermal Gravimetric Analysis	Organic/inorganic content ≤ ± 15%

5.5 Turf Carpet

5.5.1 Requirements

The materials used in a synthetic turf carpet are not prescribed but:

global: the turf carpet must be of an unfilled type which requires watering;

national: the turf carpet may be of an unfilled or filled type which does not necessarily require watering;

multi-sport: the turf carpet may be of an unfilled or filled type which does not necessarily require watering.

5.6 Durability

5.6.1 Tensile properties of synthetic turf carpet

When tested in accordance with EN ISO 13934-1, the mean maximum tensile strength of the synthetic turf carpet shall be greater than 15 N/mm and the difference between the results obtained on samples taken in the direction of manufacture and across the direction of manufacture shall be no more than 30% of the higher value.

5.6.2 Tensile strength of synthetic turf pile yarn(s)

When tested in accordance with EN 13864, the minimum tensile strength of the yarn(s) used to form the pile of the synthetic turf carpet shall be greater than 30N for fibrillated yarns and 5N for monofilament yarns. Monofilament yarns shall be tested as individual ribbons or strands.

5.6.3 Resistance to artificial weathering of synthetic turf pile yarns

The requirements of Clause 5.6.3 shall apply to each colour version of a synthetic turf pile yarn used in an Approved Turf System, including any alternative colours used to form the perimeter surrounds to a pitch.

5.6.3.1 Tensile strength

When tested in accordance with EN 13864, following artificial weathering in accordance with EN 14836, the tensile strength of the pile yarn(s) used to form the synthetic turf pile shall be shall be greater than 30N for fibrillated yarns and 5N for monofilament yarns. In addition the percentage change between the unaged yarn result and aged yarn result shall be calculated and reported.

Note 1: The requirements detailed in clauses 5.6.3 and 5.6.3.1 are based on existing products considered to offer acceptable durability and resistance to UV degradation. The FIH will review these requirements as they gain further knowledge on how pile yarns perform in the laboratory and on actual installations.

Note 2: The lower tensile strength requirements for mono-filament yarns takes into account the fact that these yarns are normally plied together to form a tuft bundle of six or eight single strands. Fibrillated yarns are used in the manufactured form and are not normally plied together.

5.6.3.2 Colour fastness

When tested in accordance with EN 20105-A02, following artificial weathering in accordance with EN 14836, colour fastness of the weathered synthetic turf compared with an unaged test specimen of the synthetic turf shall be Grey Scale 3 or greater.

5.6.4 **Synthetic turf carpet joint strength**

5.6.4.1 Stitched and bonded joints

When tested in accordance with Method 1 of EN 12228, the unaged strength of stitched and bonded joints shall be equal to or greater than 1000 N/100 mm.

Following immersion in hot water, in accordance with EN 13744, the aged strength of stitched and bonded joints shall be at least 75% of the unaged value and equal to or greater than 1000 N/100 mm.

5.6.4.2 Bonded joints

When tested in accordance with Method 2 of EN 12228 the unaged strength of bonded joints shall be equal to or greater than 50 N/100.

Following immersion in hot water in accordance with EN 13744, the strength of bonded joints shall be at least 75% of the unaged value and equal to or greater than the minimum requirements for unaged joints.

5.6.5 **Tufted carpet tuft bind**

When tested in accordance with ISO 4919, the tuft withdrawal force of the carpet pile of tufted carpets shall be equal to or greater than 25 N.

Following immersion in hot water in accordance with EN 13744, the tuft withdrawal force shall be at least 75% of the tuft withdrawal force of the unaged test specimen and equal to or greater than 25 N.

Note: this property is not applicable for woven or knitted carpets.

5.6.6 **Tensile strength of shockpads**

When tested in accordance with EN 12230, the tensile strength of shockpad used in the synthetic turf surfacing system shall be greater than 0.15 MPa.

Following air ageing in accordance with EN 13817, the tensile strength of any shockpad shall be at least 75% of the unaged value and equal to or greater than 0.15 MPa.

Note: Some forms of prefabricated shockpad have channels and slots incorporated into their structure to provide drainage or to aid dimensional stability. The design of such shockpads might mean it is not possible to obtain fully homogenous tests specimens. In such cases this should be reported along with the mean value of the maximum Force at Rupture. In such cases the mean value should be within 10% of the manufacturer's declared value.

5.6.7 Abrasion resistance of unfilled global and dressed national synthetic turf surfaces

When tested in accordance with EN 13672, the pile loss after 2000 cycles shall be equal to or less than 350mg.

5.7 Ball Rebound

5.7.1 Test Procedure

Ball rebound shall be measured using the test procedure specified in EN 12235. In this test the ball is released without imparting any impulse or spin from a height of 2.0 m and the rebound from the bottom of the ball to the surface measured.

The preferred procedure is the acoustic method, which measures the time interval between the first and second contacts with the surface from which the rebound height is calculated. The method used must be specified in the test report and must have a resolution better than 10 mm.

The test is conducted in five different locations at least 50 mm apart and at least 100 mm from the edge of the test piece. The mean rebound height from the five tests is calculated.

5.7.2 Requirements

Category	Ball rebound	Ball rebound consistency (individual tests)
Global	100 mm to 400 mm	< ± 10% of overall mean
National	100 mm to 400 mm	< ± 20% of overall mean
Multi-sport	75 mm to 400 mm	< ± 20% of overall mean

5.8 Ball Roll

5.8.1 Test Procedure

Ball roll shall be measured using the test procedure specified in EN 12334 and summarised in Annex C1. The test equipment consists of a standard inclined ramp comprising two smooth parallel rails with inside facing edges 45 mm (± 5 mm) apart. At their lower end, the bars curve to become parallel with the ground.

Laboratory tests are carried out with the test specimen positioned on a smooth level surface. The surface levels should be surveyed to ensure the maximum slope is < 0.2%. A ball is released down the ramp from a height of 1 m (± 5 mm) measured from the underside of the ball to the test surface. The ball is allowed to come to rest on the test surface. The ball roll distance is measured from the point where the ball first touched the surface to the centre of the ball when at rest. If the ball does not come to rest before reaching the end of the test piece this should be noted on the test report. The ball roll distance is the mean of five rolls. The position of the ramp must be changed slightly between each roll to avoid tracking on the surface.

Tests are undertaken on the two test samples, one representing the direction of manufacture and one across the direction of manufacture. On each sample tests are made in opposing directions. The mean of the tests in the four directions (20 tests) is calculated.

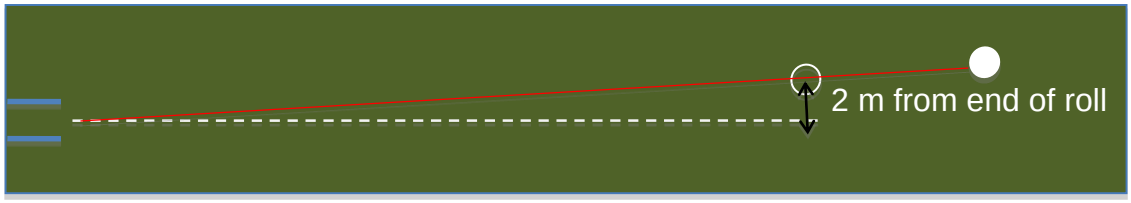
5.8.2 Requirements

Category	Ball roll	Ball roll consistency (individual directions)
Global	≥ 10.0m	< ± 10% of overall mean
National	≥ 8.0m	< ± 20% of overall mean
Multi-sport	≥ 5.0m	< ± 20% of overall mean

5.9 Ball Roll Deviation

5.9.1 Test Procedure

Ball roll deviation is measured using the apparatus and principals described above for ball roll. Having established the mean ball roll length for a particular test sample/direction, a further five tests are made where the deviation from a straight running parallel from the initial point the ball contacts the surface at the bottom of the ball roll ramp to a position 2.0 ± 0.01 metres from the end of the mean ball roll distance or at 14.0 m, whichever is shorter.



Two sets of five tests are carried out in each direction on each of the ball roll samples.

5.9.2 Requirements

Category	Ball roll deviation
Global	≤ 3°
National	≤ 3°
Multi-sport	≤ 3°

5.10 Underfoot Friction

Two methods of test are specified for underfoot friction; either may be used. Method 1 is based on the Leroux pendulum. Method 2 is based on a measure of Rotational Resistance as described in EN 15301-1 using a 'dimpled rubber test sole'.

Note: Two alternative methods of tests are allowed as the Leroux Pendulum, which has been specified by the FIH for many years, is no longer available commercially. It is envisaged that with time the Rotational Resistance test will become the definitive test for hockey surfaces.

5.10.1 **Test procedures**

5.10.1.1 Leroux Pendulum method

Tests are made using the apparatus and procedure detailed in Annex C2. Tests shall be made in the direction of manufacture and at 90° to the direction of manufacture.

5.10.1.2 Rotational Resistance method

Rotational Resistance is measured in accordance with EN 15301-1 using a dimpled rubber test sole described in the test method. The torque required to rotate the loaded test foot in contact with the surface is measured and the rotational resistance calculated.

5.10.2 **Requirements**

5.10.2.1 Leroux Pendulum method

Category	Requirement	Consistency
Global	0.6 to 1.0	< ± 0.1 of overall mean
National	0.6 to 1.0	<± 0.2 of overall mean
Multi-sport	0.6 to 1.0	< ± 0.2 of overall mean

5.10.2.2 Rotational Resistance method

Category	Requirement	Consistency
Global	25 Nm to 45 Nm	< ± 3 of overall mean
National	25 Nm to 45 Nm	< ± 3 of overall mean
Multi-sport	25 Nm to 50 Nm	< ± 5 of overall mean

5.11 Impact Response (shock absorption)

Two alternative methods of test are specified for Impact Response. Method 1 uses the Berlin Artificial Athlete and Method 2 uses the Advanced Artificial Athlete.

Note: Two alternative methods of tests are allowed to harmonise the testing of multi-sports surfaces where the Advanced Artificial Athlete has been specified by other sports federations and to benefit from the reduced air transportation costs of the more portable Advanced Artificial Athlete.

When the Advanced Artificial Athlete is used, Test Laboratories are requested to also record and report the values of Vertical Deformation and Energy Restitution to enable the FIH to gain more information on these properties. No requirements for these properties exist at this time.

5.11.1 Test Procedure

The apparatus is set up on the test specimen. Three impacts take place in the same location on the test piece. The peak force for the second and third impacts is recorded and the mean value calculated. The test is repeated in three locations and the mean value of the three series of tests is calculated.

5.11.1.1 Berlin Artificial Athlete

The impact response is measured in accordance with EN 14808 and as summarised in in Annex C3 of this Handbook using a Berlin Artificial Athlete.

5.11.1.2 Advanced Artificial Athlete

The impact response is tested using the procedure described in Annex C4 of this Handbook using an Advanced Artificial Athlete.

5.112 Requirements

Category	Requirement	Consistency
Global	40% to 60%	< ± 5 % absolute from mean
National	40% to 65%	< ± 5 % absolute from mean
Multi-sport	40% to 65%	< ± 5 % absolute from mean

5.12 Pile/pad compression of unfilled surfaces

5.12.1 Test Procedure

The test procedure assesses the surface's ability to withstand the effects of repeated impacts as may occur in high use areas of a pitch. The test procedure is an extension of that described for *Impact Response* above. Following determination of the first impact response (three impacts), a further ten unrecorded drops from the standard height are made in quick succession without repositioning the test piece between drops. The peak force is then measured for two

more drops (impacts 14 and 15) on the same location. The mean value of Force Reduction for these final two drops is then calculated.

The test is repeated at two additional different locations making three results in total from which the mean value is calculated.

5.12.2 Requirements

Category	Pile/pad compaction	Pile/pad compaction (individual tests)
Global, National, Multi-sport	≥ 40%	< ± 2% from overall mean

5.13 Surface Colour

5.13.1 Test Procedure

The colour of the synthetic turf product shall be classified using the RAL Classic Colour Charts.

5.13.2 Requirements

The colour of the surface pile shall be a single uniform green, single uniform blue (either RAL 5002 or RAL 5005) or any other FIH approved colour.

Note: If the turf sample is not green or RAL 5002 or RAL 5005, approval should be obtained from FIH for any other proposed colour quoting the RAL reference. Eventually, other approved colours will be listed on the FIH website.

Approval of alternative colours

If an Approved Turf Product is produced in more than one colour, alternative colours can be approved if a sample of the synthetic turf is submitted to an FIH Accredited Test Laboratory to allow the product identification tests detailed in clause 5.4 to be undertaken. Providing the sample is found to comply with the Manufacturer's Product Declaration and the pile yarn complies with the Tensile Strength (clause 5.6.2), Resistance to Artificial Weathering (clause 5.6.3) and Surface Gloss (clause 5.14) requirements of this Handbook, the alternative coloured version of the Approved Turf Product will also be approved. Results of tests on alternative coloured versions of the Synthetic Turf should be issued as an addendum to the original product test report by the Accredited Test Laboratory.

5.14 Surface Gloss

5.14.1 Test Procedure

Gloss measurements shall be made using an 85 degree gloss-meter meeting the characteristics and calibration requirements of a stated National Standard.

5.14.2 **Requirements**

The surface must be sufficiently matt to avoid glare or specular reflections. When wet, the degree of gloss shall be:

Category	Surface Gloss
Global, National, Multi-sport	≤ 15%

5.15 Turf Permeability

5.15.1 **Test Procedure**

The water permeability of the synthetic turf system shall be measured in accordance with EN 12616 and as described in Annex C5 of this Handbook.

5.15.2 **Requirements**

Category	Water permeability
Global, National, Multi-sport	≥ 150 mm/h

5.16 Loss of Velocity

This test is included in this version of the Pitch Handbook to enable data to be collected which may lead to differentiation between current unfilled water-based turfs and other turfs. A**ll surfaces shall be tested under Standard Wet and Dry Conditions.**

Laboratories are required to include it with all product approval test programmes. It shall be reported to FIH and the manufacturers as an annex to the main test report. Manufacturers and laboratories must not publish or use the data other than for this FIH trial.

5.16.1 **Test Procedure**

The test measures the loss of ball velocity on interaction with a turf. An FIH approved hockey ball is projected horizontally across the test turf and its velocity measured at two locations. The velocity reduction is calculated. The mean of five such tests is determined.

Further information about the required apparatus, procedure and determination of results is included in Annex C6 of this Handbook.

5.16.2 **Draft requirements (for information only)**

Category	Loss of velocity
Global	< 9 %
National	≥ 9 %
Multi-sport	≥ 9 %

6 Certified Pitches: Compliance and Certification Procedures

6.1 Compliance

Certification of compliance of an installed pitch with the requirements in this Handbook is usually undertaken for one of the following reasons:

- to demonstrate compliance with the contractual requirements to construct a pitch suitable for the game of hockey; which is often linked to warranty or funding conditions;
- to demonstrate the pitch operator has satisfied their legal and insurance obligations to provide a facility fit for the playing of the game of hockey;
- to approve a pitch for a hockey match or tournament.

In the latter context, FIH and other match or competition organisers may specify that a pitch meets requirements set out in this Handbook, as described in more detail in the first section of this Handbook.

National Associations and their affiliated bodies are also strongly recommended to include pitch certification in their national regulations as a means of promoting the construction and on-going maintenance of high quality hockey facilities to assist the global development of the game.

As part of the contractual requirements to certify a new pitch, tests are often performed immediately following the installation of a pitch. This is encouraged to check that a new pitch has been appropriately installed for example before final payments are released. However, it should be noted that a pitch achieves true playability characteristics after between 100 and 200 hours of use for hockey play.

6.2 Pitch Testing

A valid pitch compliance certificate is required for all pitches hosting FIH world level events and related qualifying tournaments (i.e. Continental Championships). At their discretion, Continental Federations and other competition organisers may also require certificates for particular events or matches.

The initial certificate for a newly laid FIH approved pitch is valid for 3 years from the date of testing. After each FIH approved re-testing of the pitch, the certificate will be valid for 2 years. Pitch owners should check requirements with competition organisers.

6.3 Certification Process

Upon satisfactory completion of the tests demonstrating that a pitch meets the requirements set out in this Handbook, a pitch owner may apply for a certificate of compliance through the laboratory conducting the tests. **The FIH makes no charge for processing and awarding certificates.**

Each application must identify clearly the pitch and its location. If there is more than one pitch at the location, the pitch to which the certificate applies must be clearly identified if necessary by reference to a location plan.

To be eligible for certification, a pitch must be constructed using an Approved Turf System as specified in this Handbook.

A certificate of compliance issued by FIH will entitle the pitch owner to advertise, in a form approved by FIH, the particular pitch as having complied with FIH requirements.

From time to time, FIH will publish and keep updated a list of certified pitches. This list will be published on the FIH website www.fih.ch.

An FIH Certificate of Compliance indicates that a particular pitch has met the performance specifications in this Handbook.

6.4 Use of existing shockpads / elastic layers

If an existing synthetic turf pitch is to be resurfaced, any existing shockpad may be incorporated into the new surfacing system providing:

- the Impact Response of the shockpad is within ± 5% of the Impact Response value declared by the manufacturer when the synthetic turf system was initially laboratory tested (to ensure adequate player protection and ball response);

- the water permeability of the shockpad is greater than 150 mm/h when tested in accordance with EN 12616.

To allow turf manufacturers and contractors to determine if an existing shockpad has similar properties to a shockpad in one of their Approved Turf Products, these properties should be measured in advance of any tender or bidding process.

If a Licensed Manufacturer finds the existing shockpad does not match one of their Approved Turf Products, they may apply for a 'site specific product approval' for the hybrid system comprising a synthetic turf carpet used in an Approved Turf Product and the existing shockpad. In these situations the Ball Rebound, Impact Response, Pile/Pad Compaction (if applicable) and water permeability properties of the hybrid system should be measured. All other properties are carried forward from an existing product test report, other than shockpad tensile strength that may be ignored on the basis the shockpad has demonstrated acceptable durability to be considered suitable for resurfacing. **The product approval of the hybrid system should take place prior to any contract for the resurfacing of the pitch being awarded to ensure the hybrid system will have acceptable performance.**

Compliance with the above requirements does not override the need for the resurfaced pitch to fully satisfy the field test requirements of the relevant sections of this Handbook.

6.5 Test Procedures

Pitch installers or owners must arrange for field tests to be conducted by one of the FIH accredited laboratories. Reference to pitch owner in this Handbook also applies to any other party seeking a certificate of compliance for a particular pitch.

Test reports must be made in a format specified by FIH. Field test reports are confidential to the laboratory, the test applicant and FIH but the applicant may supply copies to other parties.

If a laboratory or associated company (e.g. via common directors, employees or premises) has been involved in the design or construction of the pitch (e.g. as a consultant or project manager), it is not permitted to undertake the tests for pitch certification; a different laboratory without any link to the other laboratory must be used.

7 Certified Pitches: Performance Requirements and Field Test Procedures

This section of the Handbook describes the requirements to be achieved and the test procedures to be followed in the conduct of field tests on installed pitches. The tests are conducted by an FIH accredited laboratory at the request of pitch owners or other interested parties in order to obtain a FIH Certificate of Compliance.

7.1 Field Test Preparation: Spot Tests

Spot tests are conducted for:

- ball rebound;
- ball roll;
- underfoot friction;
- impact response;
- pitch permeability.

7.1.1 Wetting of test areas

Before commencing spot tests, a pitch constructed using an Approved Turf Product that is required (or requires) to be wetted prior to play shall be watered using the procedures specified for match play. When an Approved Turf Product was laboratory tested using the FIH Standard Wetting Procedure the pitch shall be watered using the same watering procedure. When an Approved Turf Product was laboratory tested using a manufacturer's reduced watering procedure the pitch may be watered using either the FIH Standard or reduced wetting procedure as the prevailing conditions allow (i.e. a pitch with an Approved Turf Product designed to perform with reduced watering may still be tested when fully wet due to rain, etc.).

Unless tests are undertaken in the rain, a pitch that requires wetting should be irrigated at intervals of 45 minutes to maintain the required surface conditions.

Note: A drying pitch or strong winds cannot be used to justify acceptance of non-complying test results. Tests should be conducted during a period of commonly prevailing conditions. Wherever possible, tests should be made when wind speeds are less than 5m/s.

Pitches with Approved Turf Products designed to be used under dry or wet conditions should be tested under the prevailing conditions at the time of test.

7.1.2 Test positions

A minimum of five spot tests must be undertaken in the locations specified below. However, the testing laboratory is responsible for adequately describing the pitch condition. Therefore the testing personnel may increase the number of spot tests at their discretion and they may select other spots if they consider this will present a more complete picture of the pitch condition. The location of the spot tests must be identified in the test report and need not be the same for each test.

If the client authorising the tests is concerned about the performance of particular areas of the pitch, they should require the testing laboratory to conduct additional tests in those areas.

The diagram below illustrates 15 possible positions for the conduct of spot tests.

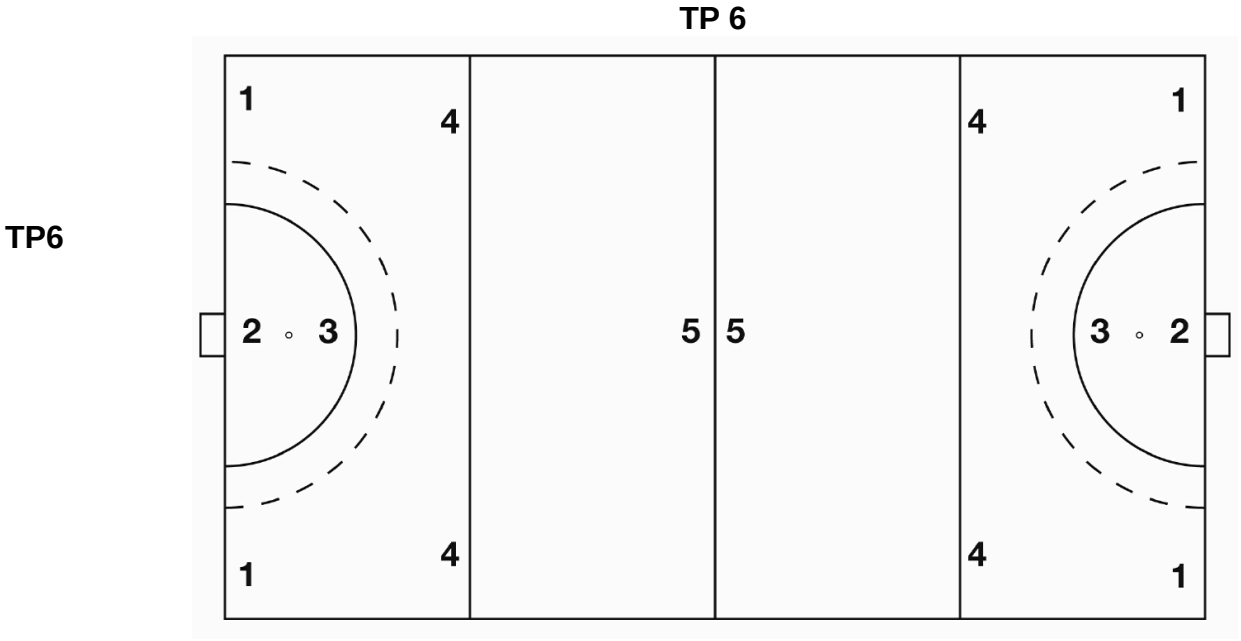


Figure: field of play

Test Position 1	This position is within the field of play and not more than 3 metres from the corner flag. Any one of the four marked positions may be chosen.
Test Position 2	This position is midway between the penalty stroke mark and the centre of the goal. Either of the two marked positions may be chosen.
Test Position 3	This position is a maximum of 1 metre inside the circle on the extended line from the centre of the goal-line through the penalty stroke mark. Test positions 2 and 3 must not be in the same circle.
Test Position 4	This position is within the field of play not more than 6 metres nor less than 4 metres from the side-line and on the 23 metre lines. Any one of the four marked positions may be chosen.
Test Position 5	This position is within 3 metres of the centre of the centre-line. Either of the two positions may be chosen
Test Position 6	At least one test position should be chosen in the field run-off areas. Ball roll is not required in this position
Additional Test Positions	Additional test positions are optional at the discretion of testing personnel. Any number of optional test positions may be used when the testing personnel are of the opinion that they are necessary to provide a true picture of the condition of the pitch or if required by the client.

7.2 Ball Rebound

7.2.1 Test procedures

The procedures are the same as for testing a synthetic turf product in the laboratory.

7.2.2 Requirements

Category	Ball rebound	Ball rebound consistency (individual tests)
Global	100 mm to 400 mm	< ± 10% of overall mean
National	100 mm to 400 mm	< ± 20% overall mean
Multi-sport	75 mm to 400 mm	< ± 20% overall mean

7.3 Ball Roll

7.3.1 Test procedure

The test procedure is the same as for testing a synthetic turf product in the laboratory.

At each test position two sets of measurements are taken in opposite directions along the length of the pitch and two sets of tests in opposite directions across the width of the pitch (four directions total).

7.3.2 Requirements

Category	Ball roll	Ball roll consistency (individual result at each test location)
Global	≥10m	< ± 10 % of overall mean
National	≥8m	< ± 20 % of overall mean
Multi-sport	≥ 5 m	< ± 20 % of overall mean

7.4 Ball roll deviation

7.4.1 Test procedure

The test procedure is the same as for testing a synthetic turf product in the laboratory.

At each test position two sets of measurements are taken in opposite directions along the length of the pitch and two sets of tests in opposite directions across the width of the pitch (four directions total).

7.4.2 Requirements

Category	Ball roll deviation (mean in each direction of test)
Global	≤3°
National	≤3°
Multi-sport	≤3°

7.5 Underfoot Friction

7.5.1 Test procedures

Either of the test procedures used for testing synthetic turf products in the laboratory may be used.

7.5.2 Requirements

7.5.2.1 Leroux pendulum method

Category	Requirement	Consistency (individual results)
Global	0.6 to 1.0	< ± 0.1 of overall mean
National	0.6 to 1.0	<± 0.2 of overall mean
Multi-sport	0.6 to 1.0	< ± 0.2 of overall mean

7.5.2.2 Rotational Resistance method

Category	Requirement	Consistency
Global	25 Nm to 45 Nm	< ± 3 of overall mean
National	25 Nm to 45 Nm	< ± 3 of overall mean
Multi-sport	25 Nm to 50 Nm	< ± 5 of overall mean

7.6 Impact Response

7.6.1 Procedures

Either of the test procedures used for testing synthetic turf products in the laboratory may be used.

7.6.2 Requirements

Category	Force Reduction	Force Reduction consistency (individual results)
Global	40 % to 60%	< ± 5% absolute of overall mean
National	40% to 65%	< ± 5% absolute of overall mean
Multi-sport	40% to 65%	< ± 5% absolute of overall mean

7.7 Material identification

In order to ensure the components of synthetic turf system installed on a pitch are the same as the Approved Turf Product, the initial field test shall include the material identification tests detailed in section 5.4 of this Handbook. The maximum variation between the installed materials and the manufacturer's declaration, as detailed on the Approved Turf Product Laboratory Report, shall be as specified for Permitted Tolerance in section 5.4.

Sampling shall be as follows:

Component	Sample size	Number of samples
Synthetic turf carpet	0.5m x 0.5m	1
Shockpad	0.5m x 0.5m	1
Infill	3 kg	1 per component

The samples supplied should be representative of materials installed on different areas of the pitch. The Licensed Manufacturer (or their agent) has responsibility for ensuring samples submitted to the FIH accredited laboratory conducting the tests comply with this requirement.

The samples of synthetic turf, shockpad and infill shall be supplied to the laboratory when they undertake the pitch test.

7.8 Pitch Dimensions, Run-offs and Markings

7.8.1 Test Procedure

Pitch dimensions shall be measured to an accuracy of ± 25 mm. The type of measuring device used must be reported. Dimensional discrepancies exceeding the tolerances must be reported.

7.8.2 **Requirements**

7.8.2.1 Pitch dimensions

The dimensions of the field of play shall comply with the latest edition of the Rules of Hockey.

7.8.2.2 Run-offs

Run-offs must comply with the latest edition of the Rules of Hockey.

The first part of the run-off area referred to in the Rules of Hockey must have the same qualities of synthetic turf, slope, smoothness and, for pitches requiring watering, pitch irrigation watering facilities, as the field of play. The run-off must then extend on the same plane for the further minimum distance specified in the Rules of Hockey before any obstruction is encountered. These outer run-offs may be surfaced with different materials (eg asphalt paving) to the synthetic turf playing surface and may accommodate flush mounted structures and/or fittings such as drain covers or covered channels.

Consideration must be given to the need to accommodate team officials, substitutes and match officials immediately adjacent to the field of play (but not within the minimum run-off areas).

Only the prescribed corner flags should obstruct the run-off areas and must be capable of bending to the horizontal without fracture and without injuring any person.

Water cannons or lighting masts must not intrude onto run-off areas. Pop-up sprinkler heads are acceptable providing a level seat is maintained when the sprinkler heads are in their lowered position.

7.8.2.2 Pitch markings

Pitch markings shall conform with the latest edition of the Rules of Hockey and must not depart from the dimensions stated therein by more than the following tolerances:

length of straight lines	± 50 mm
width of lines	± 10 mm
radius of circle arcs	± 30 mm
position of penalty spots	± 30 mm
300mm external field markings	± 30 mm

The difference between diagonals must be less than 300 mm.

Lines intended to be straight must show no sudden deviation or irregularity.

Where pitch markings have been tufted into a pitch and a change to the Rules of Hockey makes the markings redundant, the redundant markings must be painted out and any new markings painted on or inserted into the carpet.

An FIH Certificate of Compliance will not be withheld if markings other than those specified in the Rules of Hockey (e.g. for hockey practice or for use by other sports) are present. Such markings should be in a colour, which distinguishes them from the markings required in the Rules of Hockey. It should be noted, however, that competition organisers including FIH may require any such marks to be obliterated before agreeing to sanction particular matches including international matches on the pitch concerned.

7.9 Pitch Longitudinal Slope

7.9.1 Procedure

The longitudinal slope is determined by taking a series of measurements on the playing surface along the longitudinal axis through the centre of the centre-line. A surveyor's optical level and staff, or equivalent technique, must be used.

The means of measurement must be reported and a description or sketch of the slope pattern provided.

In the report, the pitch sketch may combine the longitudinal slope and lateral profile measurements (see below).

7.9.2 Requirement

Category	Maximum gradient
Global	< 0.2%
National	< 1.0%
Multi-sport	< 1.0%

Note: Longitudinal slope should normally be symmetrical on either side of the pitch centre-line. However, exceptions may be agreed provided approval is given by FIH before installation of the concerned pitch on the basis of a substantiated request by the pitch owner.

7.10 Lateral pitch profile

7.10.1 Procedure

The surface profile of the pitch is determined by taking a series of measurements on the playing surface on a regular 10 metre grid, using a surveyor's level and staff, or equivalent technique.

The means of measurement must be reported and a description or sketch of the profile pattern provided.

In the report, the pitch sketch may combine the longitudinal slope and lateral profile measurements.

7.10.2 Requirements

Category	Maximum gradient
Global	< 0.4%
National	< 1.0%
Multi-sport	< 1.0%

Limits to the lateral slope are intended to preserve unbiased ball roll characteristics. However, to accommodate extreme climatic conditions, a lateral slope up to 1.0% may be permitted exceptionally for global pitches, provided approval is given by FIH before installation of the concerned pitch on the basis of a substantiated request by the pitch owner.

A lateral slope up to 1.0% for global pitches may also be acceptable for pitch certification if the slope pre-exists and a turf carpet is being replaced. Again, approval should be sought from FIH before installation of the concerned turf carpet if possible.

Lateral slope should normally be symmetrical on either side of the longitudinal axis. However, exceptions may be agreed provided approval is given by FIH before installation of the concerned pitch on the basis of a substantiated request by the pitch owner.

7.11 Pitch Smoothness and surface regularity

7.11.1 Procedure

The surface regularity of the pitch is measured using a 3m straightedge and graduated wedge as described in EN 13036–7. The straightedge is pulled over the entire pitch longitudinally and transversally to the direction of play and any out of tolerance undulations recorded.

Any localised ridges or hollows identified during the 3m straightedge survey of the pitch should also be checked using a 300 mm straightedge.

7.11.2 Requirements

Category	Surface regularity - maximum undulation

	3 m straightedge	300 mm straightedge
Global	≤ 6 mm	≤ 2 mm
National	≤ 6 mm	≤ 3 mm
Multi-sport	≤ 6 mm	≤ 3 mm

Note: To ensure acceptable smoothness and consistency of performance of the final playing surface, it is recommended the smoothness of the sub-base and shockpad be measured at each stage of construction before the overlying layer of construction is installed**.**

7.11.3 Carpet joints

Carpet joints between carpet roles and inserted line markings should be examined. Joints should be tight so the maximum gap at the top of the pile is equal to or less than the carpet's stitch gauge plus 2 mm.

Bonded carpet joints should not have adhesive beads within the pile of the carpet that may cause a ball to lift or deviate as it passes over the joint.

Stitched joints should not cause a ball to lift or deviate as it passes over the joint.

The pile of the carpet immediately either side of the joint should be consistent with the remainder of the pitch. In particular, the carpet pile should not be trapped within the joint nor should adhesive layers and backing films beneath the carpet cause ridges outside the tolerances stated in clause 7.11.2 above.

7.12 Pitch Watering – pitches requiring watering

These requirements only apply to pitches using Approved Turf Products that require watering.

7.12.1 Test Procedures

A grid of dishes is laid out on the field of play and its run-offs on a grid at 10 m maximum intervals. A full watering cycle, preferably under commonly prevailing weather and wind conditions, is conducted. The watering cycle should require no more than 8 minutes to complete. The collected water is measured and uniformity calculated and reported as a contour or grid diagram and table. The water depth measured in a collecting dish must be adjusted if necessary to take account of the dish shape.

A pitch irrigation system must service the whole of the pitch in the most commonly prevalent conditions. The wind cannot be used as a factor to influence acceptance particularly if such winds are likely to occur during proposed playing times.

Note: It is important that the pitch surface must not become dry in some areas and remain wet in others during play. Accordingly, under some climatic conditions there may be a need to water the pitch during the half-time interval of a match. The capacity of the irrigation system should be sufficient to fully water the pitch within 8 minutes and allow a full reapplication 40 minutes after the first cycle.

Flexible irrigation systems can be used to operate partial or reduced watering if this is sufficient to ensure that a previously wetted pitch is returned to the manufacturer's specified watering requirements at half time.

7.12.2 Requirements

The whole pitch and run-offs surfaced with an Approved Turf Product shall satisfy the appropriate pitch watering requirements detailed below depending on whether the Approved Turf Product was laboratory tested using the FIH Standard Watering procedure or a Manufacturer's Reduced Watering procedure.

FIH Standard Watering:

Average 3 mm with no collection dish having less than 2 mm. In addition, the water depth at any one test spot may not be more than twice the depth at an adjacent test spot or less than half the depth at an adjacent test spot.

Manufacturer's Reduced Watering:

Average in accordance with the manufacturer's specified watering procedure with no collection dish having less than 1 mm. In addition, the water depth at any one test spot may not be more than twice the depth at an adjacent test spot or less than half the depth at an adjacent test spot

7.13 Pitch Permeability – for pitches requiring watering or designed to be used in wet conditions

7.13.1 Procedure

The procedure is the same as for testing an Approved Turf Product in the laboratory. Pitches tested under dry conditions shall be thoroughly saturated prior to pitch permeability being measured.

Note: Permeability sometimes changes over time and in particular may deteriorate. There can be various causes of this such as the sheer volume of rain, poor construction of or subsequent damage to a sub-base, poor carpet maintenance and so on. It is not therefore possible to set out a test for such conditions. If there is doubt about the permeability of a particular pitch, further investigation should take place looking at all possible causes and remedies.

In this context, it should be noted that a pitch compliance certificate verifies that a pitch at the time of testing met the FIH permeability requirements after application of the FIH or a manufacturers watering procedures. The certificate does not verify that a pitch will extreme necessarily meet drainage requirements after, for example, exposure to heavy rain or after time has elapsed and drainage characteristics have changed

7.13.2 **Requirements**

Category	Water permeability
Global	> 150 mm/h
National	> 150 mm/h
Multi-sport	> 150 mm/h

7.14 Surface Colour

Playing area

The colour of the playing area for all pitches (Global, National and Multi-sport) other than when a uniformly single tone green or Ultramarine Blue (5002) or Signal Blue (RAL 5005) shall be approved by FIH before installation in accordance with section 5.13.2 of this Handbook.

Line markings

Hockey line marking on Global pitches shall be white.

Note: The certification of Global pitches will not be withheld if, besides the official white lining, as defined by the rules of hockey, there are additional lines in a different and subdued colours to define smaller playing areas. However should such pitches have to be used for high level FIH or other hockey tournaments, then such additional linings may have to be obliterated.

For national and multisport pitches line markings should preferably be white. If other sports have to be accommodated on the same pitch the hockey line marking can be of a different colour, providing it is sufficiently visible and different from the marking line colours used for the other sports.

Run-offs

Providing the same specification of Approved Turf System is used, run-off areas may be of a different colour to the field of play. Alternative coloured run-offs for other sports shall not encroach onto the playing area of the hockey pitch.

Logos and advertising

The inclusion of advertising or logos on the field of play or the run-off areas is permitted so long as the playing performance of these areas is the same as that of the main part of the turf and therefore complies with the performance specification of the approved turf. Pitch owners should be aware that the inclusion of advertising or logos may be subject to conditions imposed by the users of pitches or by the organisers of particular competitions including the FIH. Competition organisers including FIH may require any such marks to be obliterated before agreeing to sanction particular matches including international matches on the pitch concerned.

Any permanent logos cut in to the synthetic turf carpet shall be manufactured from carpet of

the same specification as the main playing surface. Each yarn colour should satisfy the relevant requirements of clause 5.6 of this Handbook.

7.15 Artificial Lighting

7.15.1 Test Procedure

The laboratory undertaking the field test may assess the quality of the artificial lighting installed directly or employ professional assistance acting under the control of the laboratory personnel.

Measurement of the lighting levels is carried out using a lightmeter meeting the characteristics and calibration requirements of an applicable National standard. The procedures to be followed are those set down in the manufacturer's operating manual. The requirements to be met are specified in the relevant part of the latest version of the *FIH Guide to the Artificial Lighting of Hockey Pitches*.

7.15.2 Requirements

If no artificial lighting is installed, a pitch compliance certificate is issued stating that "floodlights are not installed so this approval applies only to matches conducted in daylight".

If artificial lighting is installed but a pitch owner does not wish it to be tested, a pitch compliance certificate is issued stating that "floodlights are installed but have not been tested so this approval applies only to matches conducted in daylight".

If artificial lighting is installed and a pitch owner wishes it to be tested, a pitch compliance certificate is issued stating that "floodlights have been tested and found to comply with the performance requirements for high level national club and international matches" (or other specified level of performance as appropriate). If artificial lighting is tested, the following applies.

These requirements apply if artificial lighting is installed and it is intended that the pitch is certified for matches played outside the hours of natural daylight.

Lighting requirements are contained in the latest version of the *FIH Guide to the Artificial Lighting of Hockey Pitches* which is available on the FIH website www.fih.ch.

Annex A Summary of Requirements: Turf Products

Performance Requirements	Global Turf Product	National Turf Product	Multi-sport Turf Product
Composition	In accordance with manufacturer's product declaration		
Unfilled / Filled	Unfilled	Unfilled / filled	Unfilled / filled
FIH Standard Wet Tests	Yes	Yes	Yes
Manufacturer's Reduced Watering Wet Tests	Optional	Optional	Optional
Dry tests	Optional	Yes, if designed to be used in dry conditions	Yes, if designed to be used in dry conditions

Performance Tests

Ball rebound		mean 100 mm to 400 mm individual tests < ± 10% from mean	mean 100 mm to 400 mm individual tests < ± 20% from mean	mean 75 mm to 400 mm individual tests < ± 20% from mean
Ball roll		mean ≥ 10 m individual tests for either roll or deviation < ± 10% from mean	mean ≥ 8 m individual tests for either roll or deviation < ± 20% from mean	mean ≥ 5 m individual tests for either roll or deviation < ± 20% from mean
Ball roll deviation		deviation ≤ 3°	deviation ≤ 3°	deviation ≤ 3°
Underfoot friction	Leroux Pendulum	coefficient of friction 0.6 to 1.0 individual tests < ± 0.1 from mean	coefficient of friction 0.6 to 1.0 individual tests < ± 0.2 from mean	coefficient of friction 0.6 to 1.0 individual tests < ± 0.2 from mean
	Rotational Resistance	25 – 45 Nm individual tests < ± 3 from mean	25 – 45 Nm individual tests < ± 3 from mean	25 – 50 Nm individual tests < ± 5 from mean
Impact response		40 to 60 % individual tests < ± 5 % from mean	40 to 65 % individual tests < ± 5 % from mean	40 to 65 % individual tests < ± 5 % from mean
Pile / pad deformation		≥ 40 % individual tests < ± 2 % from mean	≥ 40 % individual tests < ± 2 % from mean	≥ 40 % individual tests < ± 2 % from mean
Loss of velocity *(test for data collection only)*		< 9 %	≥ 9 %	≥ 9 %

Material Tests (all categories of surface)

<table>
<tr><td colspan="2">Colour</td><td colspan="2">‘green, royal blue’ or other FIH approved colour uniform</td></tr>
<tr><td colspan="2">Surface gloss</td><td colspan="2">≤ 15 % when wet</td></tr>
<tr><td colspan="2">Water permeability</td><td colspan="2">≥ 150 mm per hour</td></tr>
<tr><td colspan="2">Tensile strength of carpet</td><td colspan="2">> 15 N/mm</td></tr>
<tr><td rowspan="2">Tensile strength of pile yarn</td><td>Unaged yarn</td><td>Mono-filament yarn</td><td>≥ 5 N</td></tr>
<tr><td>After artificial weathering</td><td>Fibrillated yarn</td><td>≥ 30 N</td></tr>
<tr><td colspan="2" rowspan="2">Tuft bind</td><td>New</td><td rowspan="2">≥ 25 N</td></tr>
<tr><td>After water ageing</td></tr>
<tr><td colspan="2">Resistance to artificial weathering of pile yarn</td><td colspan="2">Colour change ≥ Grey Scale 3</td></tr>
<tr><td rowspan="4">Joint strength</td><td rowspan="2">Stitched and bonded joints</td><td>New</td><td rowspan="2">≥ 1000 N/100mm
Reduction after ageing ≤25%.</td></tr>
<tr><td>After water ageing</td></tr>
<tr><td rowspan="2">Bonded joints</td><td>New</td><td rowspan="2">≥ 50 N/100mm
Reduction after ageing ≤ 25%.</td></tr>
<tr><td>After water ageing</td></tr>
<tr><td colspan="2">Tensile strength of shockpad</td><td colspan="2">> 0.15 MPa</td></tr>
<tr><td colspan="2">Abrasion resistance of non-filled global and dressed surfaces</td><td colspan="2">< 350mg</td></tr>
</table>

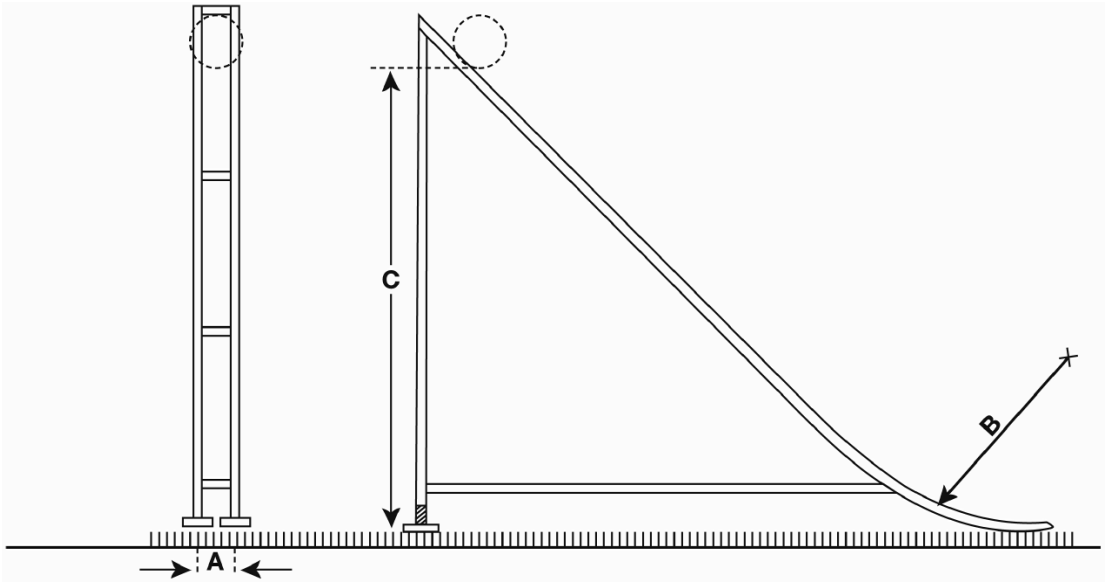
Annex B Summary of Requirements: Installed pitches

Performance Requirements		Global Pitch	National Pitch	Multi-sport Pitch
Product compliance with manufacturer's declaration		Yes	Yes	Yes
Ball rebound		mean 100 mm to 400 mm individual test positions < ± 10% from mean	mean 100 mm to 400 mm individual test positions < ± 20% from mean	mean 75 mm to 400 mm individual test positions < ± 20% from mean
Ball roll		mean ≥ 10 m individual tests < ± 10% from mean	mean ≥ 8 m individual tests < ± 20% from mean	mean ≥ 5 m individual tests < ± 20% from mean
Ball roll deviation		≤ 3°	≤ 3°	≤ 3°
Underfoot friction	Leroux Pendulum	coefficient of friction 0.6 to 1.0 individual tests < ± 0.1 from mean	coefficient of friction 0.6 to 1.0 individual tests < ± 0.2 from mean	coefficient of friction 0.6 to 1.0 individual tests < ± 0.2 from mean
	Rotational Resistance	25 – 45 Nm individual tests < ± 3 from mean	25 – 45 Nm individual tests < ± 3 from mean	25 – 50 Nm individual tests < ± 3 from mean
Impact response		40 to 60 % individual tests < ± 5 % from mean	40 to 65 % individual tests < ± 5 % from mean	40 to 65 % individual tests < ± 5 % from mean
Pitch dimensions and markings		line length ± 50 mm line width ± 10 mm circle radius ± 30 mm penalty spots position ± 30 mm length of 300 mm marks ± 30 mm diagonals < 300 mm difference		
Pitch run-offs (minima)		back-line 2 m same synthetic turf surface side-line 1 m same synthetic turf surface both plus 1 m synthetic turf or alternative surface		

Performance Requirements	Global Pitch	National Pitch	Multi-sport Pitch
Pitch slope	longitudinal fall < 0.2 %	longitudinal fall < 1.0 %	longitudinal fall < 1.0 %
Pitch profile	lateral fall < 0.4 % exceptions < 1.0 % permitted on FIH approval	lateral fall < 1.0 %	lateral fall < 1.0 %
Pitch smoothness	deviation ≤ 6 mm above or below 3 m straight edge		
	deviation above or below 300 mm straight edge		
	≤ 2 mm	≤ 3 mm	≤ 3 mm
Pitch watering	as specified by turf manufacturer	if specified by turf manufacturer	if specified by turf manufacturer
Pitch permeability	≥ 150 mm per hour	≥ 150 mm per hour	≥ 150 mm per hour
Colour	FIH approved	FIH approved	FIH approved
Artificial lighting	See *FIH Guide to the Artificial Lighting of Hockey Pitches*	See *FIH Guide to the Artificial Lighting of Hockey Pitches*	See *FIH Guide to the Artificial Lighting of Hockey Pitches*

Annex C Test Equipment Specifications

C1 Ramp (ball roll)



end view *side view*

A internal dimension 45 ± 5 mm

B radius 500 ± 50 mm

C release height 1,000 ± 5 mm measured from the underside of the ball to the test surface

Specification

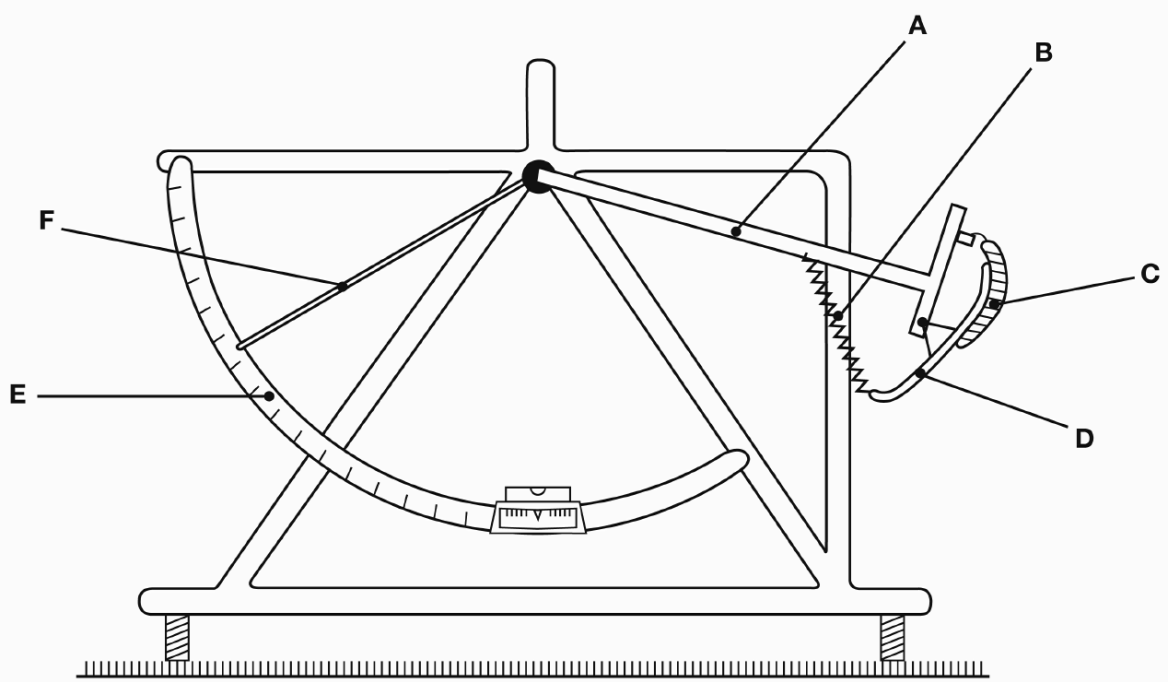
C1.1 The ramp consists of two smooth parallel bars secured at an angle in a rigid frame.

C1.2 The internal dimension between the bars is 45 ± 5 mm.

C1.3 The bars curve to become parallel to the ground at their lower end with a radius of 500 ± 50 mm.

C1.4 Adjustable feet enable the apparatus to be positioned securely.

C2 Underfoot friction – Leroux pendulum method



A pendulum arm
B spring
C shoe profile
D profile holder
E scale
F pointer

Specification

C2.1 A schematic drawing of the apparatus is shown in the diagram above. Its component parts are specified below.

C2.2 This apparatus is commonly known as the Leroux slip resistance tester.

C2.3 The pendulum has a length of 340 ± 3 mm to the shoe profile.

C2.4 The pendulum, profile holder and shoe profile have a mass of 1,600 ± 50 g.

C2.5 A spring adjusts the pressure of the shoe profile on the test turf; the spring has a K-value of 0.8 ± 0.05 N/mm.

C2.6 The frame incorporates a device for holding the pendulum horizontal to start the test and then to release it.

C2.7 A pointer on the scale records the maximum value in the test.

C2.8 A multi-studded rubber shoe profile is used. It has the following properties:

material:	neoprene rubber
width:	30 ± 2 mm
length:	120 ± 5 mm
studs:	13 ± 2 in number
stud height:	7 ± 1 mm
stud diameter (upper):	7 ± 1 mm
stud diameter (base):	11 ± 2 mm
stud hardness:	90° ± 5° (shore A scale)
stud stiffness:	95 ± 5 N/mm

The test is conducted five times on different parts of each of the two test pieces and the scale value recorded. The mean scale value is calculated for each test piece.

Calculation

In the calculation of underfoot friction:

$$S = (v - r) / 100$$

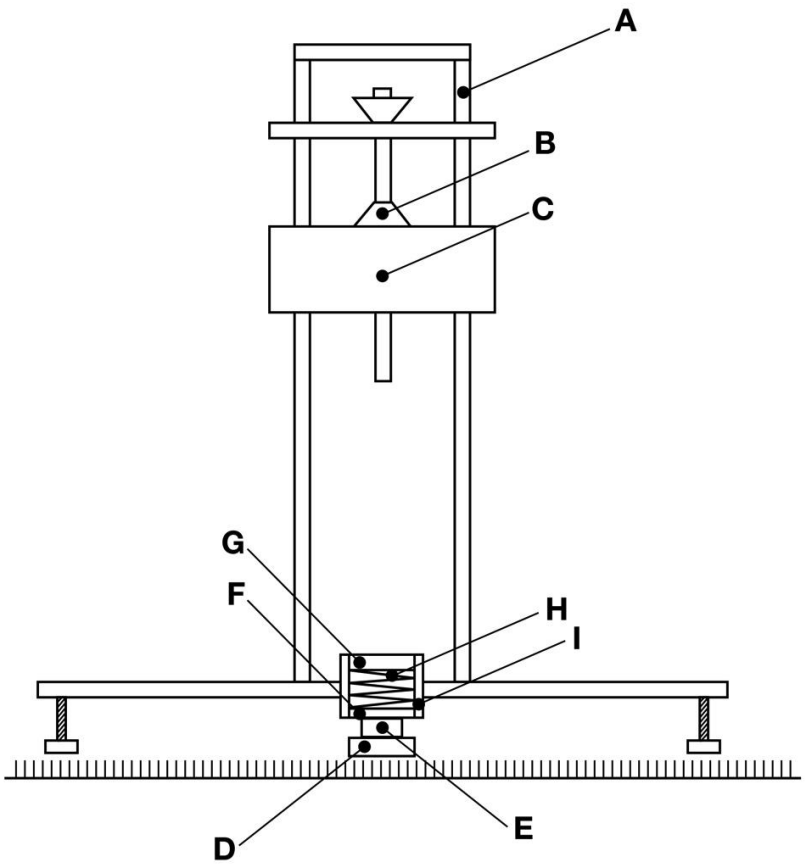
S is the coefficient of friction

v is the mean scale value

r is the reduction value from the table below.

mean scale value	reduction value
0 to 99.0	20
99.1 to 99.2	16
99.3 to 99.4	12
99.5 to 99.6	8
99.7 to 99.8	4
≥ 99.9	0

C3 Berlin Artificial Athlete (Method A - impact response and pile/pad compression)



A	guide frame for the falling weight
B	electromagnet release
C	falling weight
D	test foot
E	force sensor (load cell)
F	base plate
G	upper plate
H	spring
I	guide tube

Specification

C3.1 A schematic drawing of the apparatus is shown in the diagram above. Its component parts are specified below.

C3.2 The falling weight has a mass of 20 ± 0.1 kg. It must fall vertically and smoothly with minimum friction.

C3.3 An electromagnetic device retains the weight in its upper position ± 0.25 mm from the specified drop height.

C3.4 Adjustable supporting feet are located at least 250 mm from the point of application of the deforming force.

C3.5 The metal guide tube has an internal diameter of 71 ± 0.1 mm.

C3.6 The spring has a diameter of 69 ± 1 mm. Over the range 0.1 kN to 7.5 kN it behaves linearly with a spring rate of 2,000 ± 60 N/mm.

C3.7 The spring is fixed to a hardened upper plate which has a minimum thickness of 20 mm.

C3.8 The test foot consists of a round steel plate with a diameter of 70 ± 0.1 mm and a minimum thickness of 10mm. It has a rounded base of nominal radius 500mm and edge radius of 1mm.

C3.9 The force sensor, spring and upper plate are attached to the upper side of the steel plate.

C3.10 The total mass of the test foot excluding the guide tube is 3.5 ± 0.35 kg.

The apparatus is set up on the test specimen. Three impacts take place in the same location on the test piece. Within 5 seconds of each impact, the falling weight is lifted and re-attached to its support mechanism. The peak force for the second and third impacts is recorded and the mean value calculated as follows:

$$FR = (1 – (F/f)) \times 100$$

where

FR is the force reduction (impact response) expressed as a percentage

F is the reference force in Newtons

f is the peak force from the turf test.

The test is repeated in three locations and the mean value of the three series of test calculated.

C4 Advanced Artificial Athlete (Method B - impact response and pile/pad compression)

C4.1 Test Apparatus

The principle of the apparatus is shown in Figure 1 and consists of the following essential components specified below:

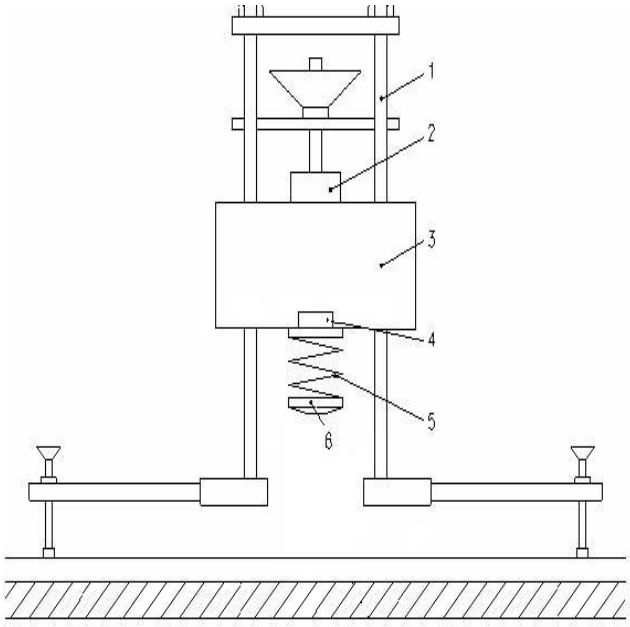


Figure 1 – test apparatus

1 guide for the falling mass

2 electric magnet

3 falling mass

4 accelerometer

5 spring

6 test foot

C4.1.1 Falling mass (3), incorporating a spiral metal spring and steel test foot, having a total mass of 20,0 kg ±0.1 kg.

C4.1.2 Spiral steel spring (5), whose characteristic is linear (measured with maximum increments of 1000N) with a spring rate of 2000 ± 100 N/mm over the range 0.1 to 7.5 kN. The spring shall be positioned centrally below the point of gravity of the falling mass. The spring shall have three coaxial coils that shall be rigidly fixed together at their ends. The mass of the spring shall be 0.80 ± 0.05 kg.

C4.1.3 Test foot (6) having a lower side rounded to a radius of 500 mm ± 50 mm; an edge radius of 1 mm; a diameter 70 ± 1 mm; and a minimum thickness of 10 mm. The mass of the test foot shall be 400g ± 50g.

C4.1.4 Test frame with three adjustable supporting feet, no less than 250 mm from the point of application of the load designed to ensure the weight of the apparatus must be equally distributed on its feet. The pressure (with the mass) on each foot must be less than 0.020 N/mm² and the pressure (without the mass) on each foot must be greater than 0.003 N/mm².

C4.1.5 A piezo-resistive accelerometer (4) having a 50g full scale capacity with the following characteristics:

- frequency range: bandwidth until 1000 Hz (-3dB)
- linearity: 2% operating range.

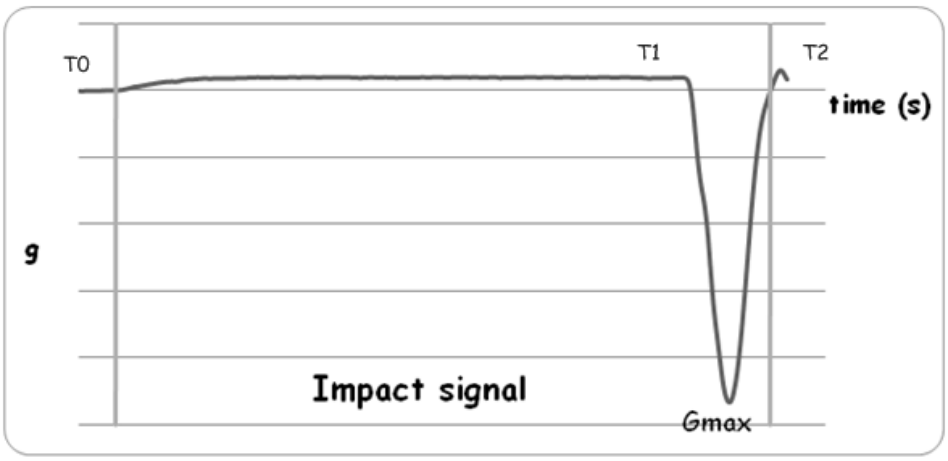
The g-sensor should be positioned on the vertical line of gravity of the falling weight (see figure 1), as much as possible on the lower side of the weight. The g-sensor should be firmly attached to avoid natural filtering.

C4.1.6 A means of supporting the mass (2) that allows the falling height to be set to an accuracy of ± 0.25 mm.

C4.1.7 A means of conditioning and recording the signal from the acceleration sensing device and a means of displaying the recorded signal (see the figure below):

- sampling rate minimum: 9600 Hz.
- electronic A/D converter must have a minimum resolution of 16 bits.
- signal from the acceleration-sensing device must be filtered with a 2nd order low-pass.
- Butterworth filter with a cut-off frequency of 600 Hz.

C4.1.8 Means of calculating the speed and displacement of the falling weight during the course of impact by integration and double integration of the acceleration signal. To be verified in accordance with the procedure described below.



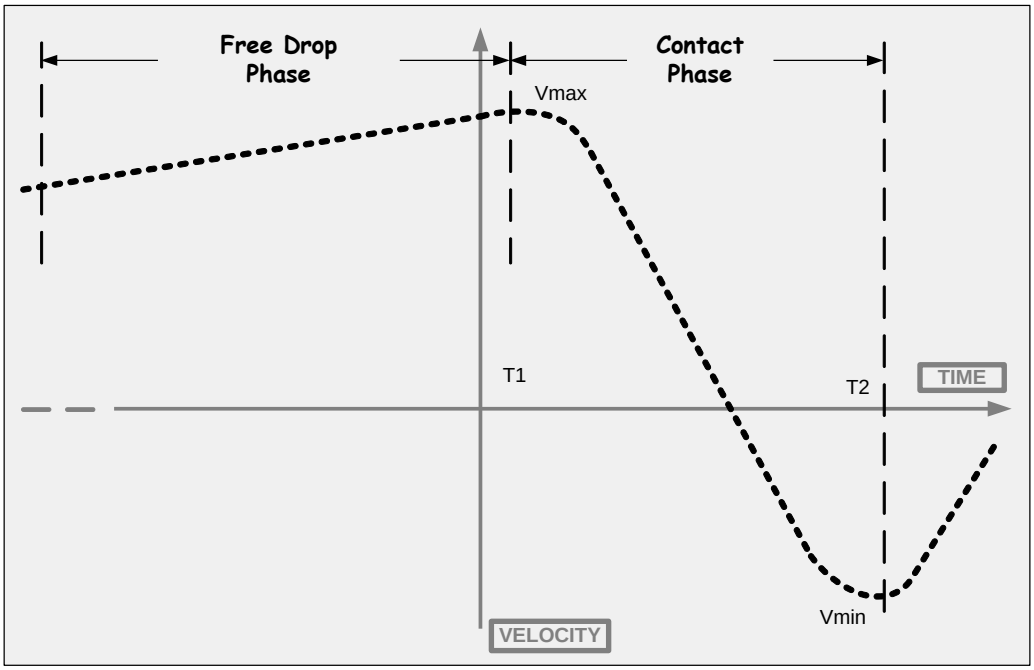
Example of falling mass acceleration/time curve

T0 time when the mass starts to fall

T1 time when the test foot makes initial contact with the surface (determined on the Velocity / time curve – Vmax*)

T2 time (determined on the Velocity / time curve – Vmin*) corresponding to the maximum velocity when the mass rebounds after the impact.

** T2 can be a minimum or maximum depending on the sensor direction*



Example of velocity / time curve

C4.2. Checking of impact speed

Note: The verification should be carried out to ensure the correct impact speed (or energy, because the mass is fixed) and the correct functioning of the apparatus.

The checking procedure consists of three steps and must be carried out on a stable and rigid floor (no significant deflexion under a 5 kg/cm² pressure).

This checking must be done as follows.

C4.2.1 In the laboratory at a frequency determined by the laboratory taking into account frequency of use, removal to site, etc.

C4.2.2 On site before a field test.

C4.2.3 Set up the apparatus to assure a perfect vertical free drop. Verticality tolerance: max 1°. Adjust Set the height of the lower face of the steel test foot so it is 55.00 ± 0.25 mm above the rigid floor. Drop the weight on the concrete floor and record the acceleration of the falling weight until the end of impact.

C4.2.4 Repeat two more times, giving a total of three impacts.

C4.2.5 For each impact calculate, by integration from T0 to T1 of the acceleration signal, the initial impact velocity. Calculate the mean impact velocity. The mean impact velocity shall be in the range of 1.02 m/s to 1.04 m/s. If the initial impact velocity is outside this range, any subsequent results obtained shall be considered invalid.

C4.2.6 After verifying the initial impact velocity, place the falling weight on the rigid floor. Measure the height between a static reference point on the apparatus (for example the magnet) and the falling weight. The measured height shall be used for all measurements and is designated the "lift height".

Note: the "lift height" will be slightly greater than 55.0 mm. due to the deflection of the apparatus.

C4.3 Test procedure

C4.3.1 Set up the apparatus so it is positioned vertically (90 degrees to the surface ± 1°) on the test sample.

C4.3.2 Lower the test foot smoothly onto the surface of the test piece.

C4.3.3 Immediately after (within 10 seconds) set the "lift height" and re-attach the mass on the magnet.

C4.3.4 After 30 (± 5) seconds (to allow the test specimen to relax after removal of the test mass) drop the mass and record the acceleration signal.

C4.3.5 Re-validate the lift height after the impact so that within 30 ± 5 seconds the mass is lifted from the surface of the test piece and re-attached to the magnet.

C4.4 Force reduction calculation:

Calculate the maximum force (F_{max}) at the impact with the following formula,

$$F_{max} = m \times g \times G_{max} + m \times g$$

Where:

F_{max} corresponds to the peak force, expressed in Newtons [N];

G_{max} is the peak acceleration during the impact, expressed in g [1 g = 9.81 m/s²];

m is the falling weight including spring, base plate, acceleration sensing device expressed in [kg], 20 kg ± 01 kg (given by the mass calibration);

g is the acceleration due to gravity (9.81 m/s²).

Calculate the Force reduction (F_{red}) with the following formula,

$$F_{Red} = \left[1 - \frac{F_{max}}{F_{ref}}\right] \times 100$$

Where:

F_{Red} is the force reduction, in %;

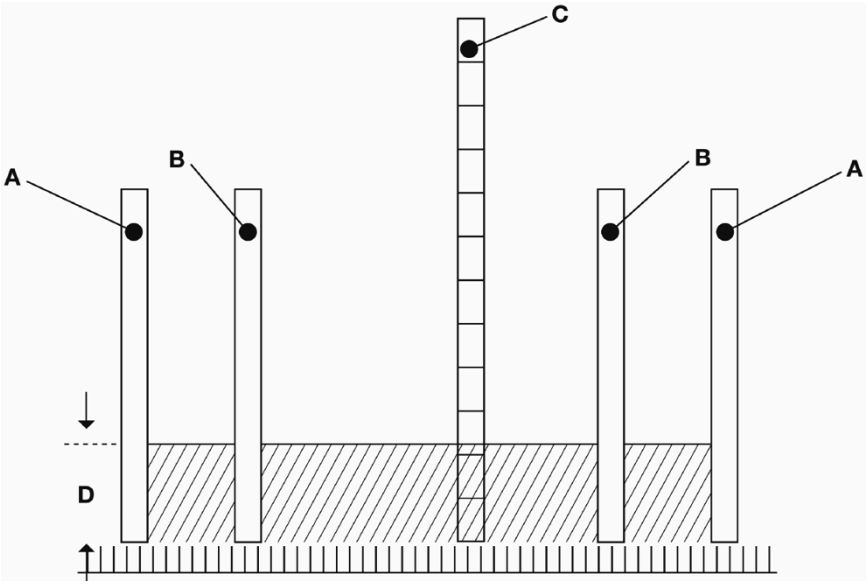
F_{max} is the Force max measured on the sport surface, in [N];

F_{ref} is the reference force fixed to 6760 N corresponding to the theoretical value calculated for a concrete surface.

Expression of the results

Report the Force Reduction value to the nearest 0.1% eg 56.9%.

C5 Double-ring Infiltrometer (permeability)



A outer cylinder

B inner cylinder

C scale

D water level

Specification

C5.1 A sectional drawing of the apparatus is shown in the diagram above. Its component parts are specified below.

C5.2 The outer cylinder has an inner diameter 500 ± 25 mm.

C5.3 The inner cylinder has an inner diameter 300 ± 25 mm.

C5.4 A graduated scale is used to measure water depth.

C5.5 If sealing material is necessary, silicone rubber or closed-cell foam may be used.

C5.6 Heavy weights may be used to improve the seal.

After setting up on the test surface, the time taken for the water to fall by 20 mm from an initial ponding depth of 30 (±1) mm is measured. If a fall of 20mm has not been recorded after 30 minutes, the fall in water level is recorded at that time. The test is undertaken at five different locations on the surface.

The infiltration rate is calculated as follows:

IR = (F x C) / t

Where:

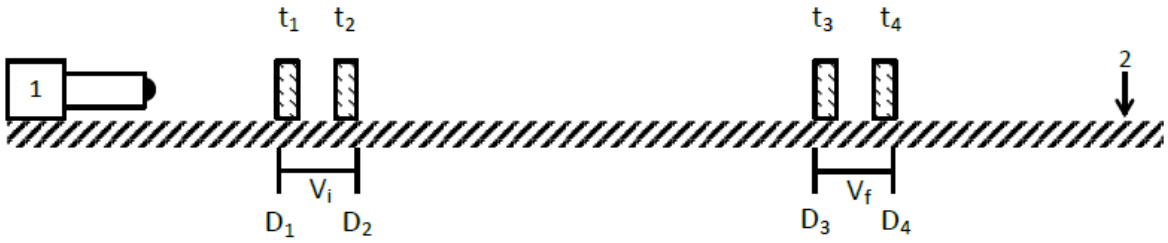
IR is the infiltration rate;

F is the fall of water level (mm);

C is any required temperature correction factor;

t is the measurement period in minutes.

C6 Loss of Velocity Test



Key

1 = ball projector	D_1 = distance 1 (1.5 m ± 0.01 m) ball projector – t_1
2 = test specimen	D_2 = distance 2 (2.5 m ± 0.01 m)
t_1 = timing gate 1	D_3 = distance 3 (7.5 m ± 0.01 m)
t_2 = timing gate 2	D_4 = distance 4 (8.5 m ± 0.01 m)
t_3= timing gate 3	V_i = initial velocity
t_4 = timing gate 4	V_f = final velocity

Specification

Ball projector: providing a means of projecting an FIH approved hockey ball at a specified velocity onto a turf surface without imparting spin > 3 rev/s.

Note: Suitable ball projection machines are commercially available. The release characteristics from the machine should be checked specifically (eg by stroboscope photography) to ensure that spin in excess of 3 rev/s does not occur.

Timing gates: providing a means of recording the time to an accuracy of ± 0.001 seconds when a ball passes through them at a velocity up to 25 m/s ± 2 m/s.

Balls: FIH approved hockey balls

Measurement device: providing a means of measuring distance to an accuracy of ± 1 mm.

Timing gate housing (optional): providing a means of fixing the timing gates at a distance of 1,000 mm ± 1 mm apart.

Test specimen

A 16 m x 1 m turf specimen is used. The test specimen is placed on the laboratory floor and prepared according to the test conditions.

Procedure

C6.1 The ball projector is adjusted to deliver a ball onto the test piece at an angle of incidence $0^{o} \pm 2^{o}$ at a mean velocity of 18 m/s ± 2 m/s (recorded between the first two timing gates). The ball projector should be positioned so the bottom of the ball is 30 mm ± 10 mm above the turf surface.

C6.2 The four timing gates are placed at 1.5 m ± 0.01 m, 2.5 m ± 0.01m, 7.5 m ± 0.1 m and 8.5 m ± 0.1 m from the end of the ball projector.

Note: The use of optional frames to set the timing gates in position is advisable to ensure the correct position of each gate.

C6.3 The ball is projected across the test specimen. Time is recorded at each of the four timing gates.

C6.4 The procedure is repeated until 5 tests have been completed.

Calculation

Calculate V_i and V_f using the following equations:

$$V_i = \frac{(D_2 - D_1)}{(t_2 - t_1)}$$

$$V_f = \frac{(D_4 - D_3)}{(t_4 - t_3)}$$

Calculate the velocity reduction (%), V_r, using the following equation:

$$V_r = (1 - \frac{V_f}{V_i}) \times 100$$

Calculate the mean velocity reduction (%) from the five tests.

C7 Measurement of pile profile

C7.1 Apparatus

Microscope

The microscope to be used shall be able to have a 230X magnification. In cases where the yarn exceeds the monitoring area of the microscope a lower magnification may be used. In any case the maximum magnification possible shall be used to reduce calculation errors.

The microscope used shall have the possibility to measure the sample in real time and to record the measurement as a digital file.

The microscope shall be calibrated with an appropriate reference gauge before each measurement session or each month if the microscope has the possibility to save the calibration in a file.

The reference gauge shall be calibrated by an external laboratory.

'Freezing' system

The yarn shall be 'frozen' before the cutting to reduce the effect of de-burring and increase the precision of measurement. A normal canister of compressed air held upside down can be used to cool the yarn before cutting.

Reference square: a reference metal square shall be used to ensure the cutting of the yarn is as perpendicular as possible referred to the cross section of the synthetic yarn.

Cutting blade: a surgical cutting blade shall be used to cut the yarn before being observed with the microscope. Cutting shall be operated immediately after the cooling and shall be as perpendicular as possible to the cross section of the yarn. Cutting shall be undertaken on a wood surface.

Small clamp for the positioning of the sample under the microscope: a small vice should be used to position perpendicularly the yarn sample under the optical lens of the microscope.

C7.2 Samples

Samples shall be cut out from a synthetic turf carpet.

If the sample is cut out from a synthetic turf carpet a minimum of three measurements shall be made and the results shall be reported as the mean of the three measurements.

If the sample is cut out from a yarn spool a single measurement is considered as representative of the production.

C7.3 Procedure

Cut with scissors a yarn from the synthetic turf carpet at the bottom side without applying a tensile force. Repeat the procedure in other two points that shall not be in the same tufting line.

Cool (‘freeze’) the yarn until frost s formed on the surface of the yarn.

Cut immediately the yarn as perpendicular as possible to the cross section using the reference square.

Position the yarn perpendicularly by the mean of a small vice under the optic of the microscope.

Select the 230X magnification or the most appropriate in cases where the yarn exceeds the monitor area of the microscope. Focus the cross section of the yarn. Using the measuring tool determine the maximum thickness detected of the synthetic yarn and save the image including all measurements.

Annex D FIH Reference Documents

The International Hockey Federation publishes various reference and advisory documents on its website: www.fih.ch. The documents of particular relevance to this Pitch Handbook are:

List of FIH Accredited Laboratories

Guide to the Artificial Lighting of Hockey Pitches

List of Approved Synthetic Turfs

List of FIH Certified Installed Pitches

List of FIH Approved Balls

Address any questions about this Handbook to: info@fih.ch.