Australian Football League and Cricket Australia Handbook of Testing for Synthetic Turf

March 2018

The User acknowledges that the specifications outlined in this manual are effective from 1st March 2018 and that AFL and CA reserve the right to amend, update or delete sections of this manual at any time as they deem necessary.

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1 GENERAL INFORMATION ON TESTING PROCEDURES

The Australian Football League (AFL) and Cricket Australia (CA) will only approve synthetic turf fields that have passed the series of laboratory and field based tests outlined in this manual. The steps outlined in Figure 1 below must be followed to ensure a suitable and safe synthetic turf field is installed.

Step 1
- Synthetic turf manufacturer submits sample(s) and product declaration form to accredited laboratory.

Step 2
- Product is tested and results returned to the AFL/CA.

Must pass to continue

Step 3
- Field is installed with approved product, samples are taken for identification and construction quality reports must be provided to field test agent.

Step 4
- Onsite testing is undertaken after 1 month of play or 160 hours of play.

Step 5
- Field test results returned to AFL/CA.

If pass, AFL/CA issues field certification

Step 6
- Re-testing will take place approximately every two years after installation.

Figure 1: Steps for field approval.

For product approval, samples must be submitted to an accredited AFL/CA test laboratory, where a series of tests to identify the product and to determine its dynamic playing characteristics will be carried out.

2 LABORATORY TESTING SAMPLES

2.1 Sample Requirements

Laboratory testing will determine the following:

- Identification and quality of the product;
- Durability of the product;
- Surface properties of the product;
- Performance characteristics.

All companies will be required to submit the following samples to the laboratories responsible for testing the specific characteristics (Table 1).

Table 1: Summary of samples required.

SAMPLE SIZE	TESTS PERFORMED	CONDITIONS
One 5 m of each pile yarn	Tensile Strength, Linear Density Yarn Thickness	Dry
One 0.5 x 0.5m split down the middle and re-joined using the proposed joining/seaming method	Joint Strength	Dry
One 1.0m x 1.0m	Ball Rebound Clegg Hardness AAA Traction Infill Splash	Dry & Wet* (Infill splash dry only)
One 11m x 1.8m	Ball Roll Friction/Abrasion Angled Ball Rebound HIC	Dry & Wet (Friction/Abrasion dry only)
Two 1.0m x 0.4m Plus one 1.0 mx 0.4 m for coloured fibres	Ball Rebound Clegg Hardness AAA Traction HIC	Dry, Lisport (80,200 cycles)
Two 0.5 m x 0.5 m	Ball Rebound Clegg AAA Traction	-5°C and 40°C Dry

*Wetting procedure is explained in detail on page 10

If the synthetic turf is due to be laid on a base that will contribute to the performance characteristics of the surface, then the test sample must include the base as part of the system. In such cases, the base must be fully described (aggregate type, grading, depth and compaction) in the test report. If the base is not designed to contribute to the performance, the tests should be made on a concrete test floor.

The synthetic turf surface should be prepared in accordance with EN 12229 and as stipulated by the manufacturer prior to testing.

In the event of a significant difference found within/between the samples, the company will be notified and additional samples will be requested and will incur further cost.

2.2 Test Laboratory

Laboratory and field tests shall only be undertaken by laboratories operating a quality system accredited to ISO 17025 for the principal sports performance tests. A list of suitable laboratories may be obtained from the AFL. The laboratory appointed to undertake a field test shall not have been involved in the design, specification or procurement of the field.

2.3 Laboratory Test Conditions

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

Dry test specimens shall be conditioned for a minimum of 24 hours at the laboratory temperature prior to the test.

Wet test specimens shall be prepared by immersing the test sample in tap water for 30 minutes prior to testing. If this is not possible, it must be thoroughly soaked by a volume of water equal to the volume of the test sample. Once removed from the water, the sample shall be left 5 minutes to drain any excess water and then the specific test must be carried out and be completed within 15 minutes.

3 IDENTIFICATION AND QUALITY TESTING

Testing of the physical, chemical and performance properties of the turf and its component materials allows positive identification of the whole turf system to ensure verification of consistency in the supplied materials. The properties and construction of the sampled turf and components must be maintained in the installed systems. The turf and pile properties must be determined from a sample of turf conditioned to a standard laboratory atmosphere, particularly in the case of mass measurements, and testing must be carried out to repeatable standard methods. The test methods are briefly described and summarised in Table 2.

3.1 Linear Density

The linear density of the yarn used in the turf pile, expressed in Tex, is determined from the weight of a 5m length of yarn, conditioned in a standard atmosphere according to AS 2001.2.23. Results obtained must be within 10% of the manufacturer's declaration as outlined in Table 2.

3.2 Yarn Thickness

Yarn thickness is measured from the supplied pile yarn according to the microscopic test detailed in Appendix 1. For yarns with a tapering cross-section, the maximum thickness measurement is to be used. The average of three samples is calculated and visual images saved and included in the test report. Results obtained must be >90% of the manufacturer's declaration as outlined in Table 2.

3.3 Mass Per Unit Area

The total area density of the turf product, including pile and adhered backing, is determined from a sample of at least 0.5 m^2 taken from the supplied material after conditioning according to ISO 8543. Results obtained, including those from subsequent identification tests, must be within 10% of the manufacturer's declaration (Table 2).

3.4 Tufts Per Unit Area

The pile tuft density is determined from the total tuft count over 100 mm, or a length containing 41 tufts or more, in the directions parallel to, and perpendicular to, the selvedge according to ISO 1763. Results obtained, including those from subsequent identification tests, must be within 10% of the manufacturer's declaration (Table 2).

3.5 Pile Length Above Backing

Pile length is determined from ten samples of pile tuft filaments straightened underweight in a tuft length block and the length accurately measured according to ISO 2549. For pile length above the backing, tufts are sheared off from the turf backing. For total tuft length, tufts are withdrawn from the backing. Results obtained, including those from subsequent identification tests, must be within 5% of the manufacturer's declaration (Table 2).

3.6 Total Pile Weight

The total pile mass per unit area can be determined from the measured values of the total pile length, pile yarn tex, and pile tufts per unit area. A sample of tufts is withdrawn from the backing and the total tuft length is measured according to the method in section 3.5. The total weight of the pile is calculated in accordance with ISO 8543. Results obtained, including those from subsequent identification tests, must be within 10% of the manufacturer's declaration (Table 2).

3.7 Tuft Withdrawal Force

The force required to remove pile tufts from the turf backing is measured as a product identification tool and as a turf performance criterion. The backing is secured beneath a plate with a circular cut-out to allow the tuft to be gripped. The tuft is pulled from the backing at constant speed in a Constant Rate of Extension (CRE) testing machine and the maximum force in Newtons is measured, according to ISO 4919. The pile yarns must be able to withstand a minimum of 40 N before pulling out from the backing and must not fall below 10% of the initial tested value in subsequent identification tests as outlined in Table 2. The tuft withdrawal value is to be achieved before and after simulated ageing in hot water (70° for 14 days in accordance with EN 13744).

3.8 Water Permeability

The ability to allow water to pass through the synthetic turf sample is critical to avoid flooding and associated damage. The test is carried out on the carpet alone and the whole system in accordance with EN 12616 using a single-ring infiltrometer. The water permeability of the carpet is tested by gluing the infiltration ring to the back of the grass sample and the whole system is tested in a sealed box with clamps. The infiltration rate is determined by the amount of time it takes the water to fall by 25 mm from the initial ponding of 35 mm. The rate achieved must be ≥ 300mm/h and > 75% of laboratory result supplied.

3.9 Pile Yarn Characterisation – Thermal Fingerprint

Differential scanning calorimetry (DSC) is a method that allows the identification of the characteristic thermal transition temperatures of a polymer when heated. The temperature of melting, glass transition, and crystallisation will be different depending on the composition of the polymer and any additives present. A DSC plot is obtained for a material (Figure 2) and provides a thermal fingerprint of the polymer for comparison to subsequently tested samples. The main points of references used when comparing samples will be peak temperature, peak area and overall curve shape. The pile characteristic must fall between 3° of the initial value in subsequent identification tests as outlined in Table 2. The test must be in accordance with AFL/CA Test Method 1 in Appendix 2.

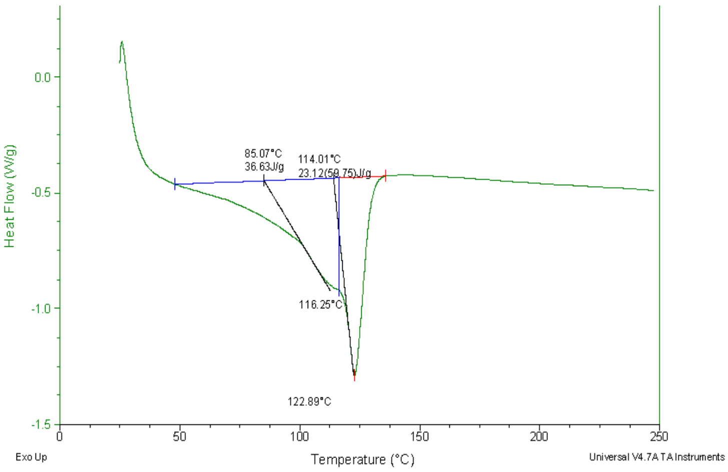

Figure 2: Typical DSC curve for a polymer. ***(Reproduced with permission from Tapex)***

3.10 Pile Yarn Characterisation – Chemical Fingerprint

Fourier Transform Infrared Spectroscopy (FTIR) is an analytical technique that can be used to obtain a characteristic spectral fingerprint of a material based on the amount of infrared light absorbed by the chemical bonds present. A chemical fingerprint of the pile yarn is obtained through the use of FTIR (Figure 3) and can be used in combination with DSC results to confirm whether any subsequently tested pile yarns have been produced from an identical polymer using the same additives.

Test results will be used to verify installed turf systems against the previously sampled turf product with the main points of reference being the peak locations and peak heights.

Yarn sample is to be prepared into a constant thickness film measuring 450 um. Measurement is undertaken using a vernier or micrometer with 4 N pressure. Sample is then to be placed into the FTIR with an average of 20 scans to be taken as the sample. FTIR signal is then measured in absorbance. When a field sample is compared to the lab sample a direct overlay will be expected on all peaks <2000 wavenumbers, any deviation from an exact overlay will need to be explained by the manufacturer.

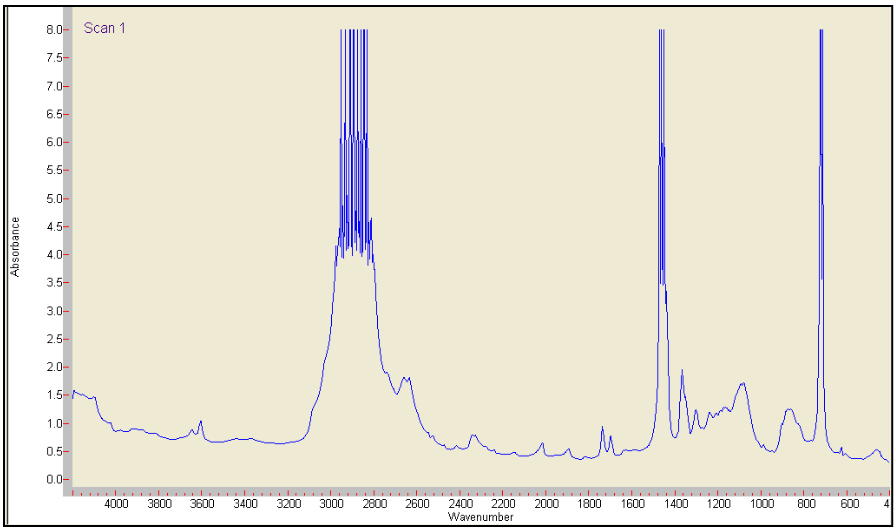

Figure 3: Typical FTIR spectrum for a polymer fibre. ***(Reproduced with permission from Tapex)***

3.11 Joint Strength

A sample of the turf backing of 100 mm width is taken across the bonded or stitched joint. The sample is loaded using a CRE testing machine to open up the joint, according to EN 12228. Stitched and overlapped joints are tested in tension, while adhesive-backed butt joints are tested for peel strength of the backing layer. The peak load is measured and the type of failure is reported, such as failure of stitching or adhesive bond, or failure of the backing material. Stitched joints must have a minimum strength of 1200 N per 100 mm, and bonded joints must have a minimum strength of 75 N per 100 mm. The joint strength value is to be achieved before and after simulated ageing in hot water (70° for 14 days in accordance with EN 13744).

3.12 Infill Depth

The depth of the infill layer is measured by means of a spiked depth gauge, according to AS 4693.2. The spike penetrates the infill layer down to the backing, while the base of the vernier rests on the infill surface, allowing measurement of the depth. Results obtained, including those from subsequent identification tests, must be within 20% of the manufacturer's declaration (Table 2).

3.13 Free pile height

The measurement of free pile height is undertaken using a steel and glass transparent prism, with a mirrored base angled at 45 ± 0.2 degrees. The prism is placed flat on the surface and the length of the ten highest fibres are recorded. The measurements shall be carried out at 90 degree orientation to each other, at least 100 mm apart and a minimum of 100 mm from the edge of an unworn sample. Testing must be in accordance with AFL/CA Test Method 2 in Appendix 3 and be within must be within 10% of the manufacturer's product declaration (Table 2).

3.14 Infill - Particle Size

A representative sample of infill material (both stabilising and performance) is taken and tested according to EN 933 - Part 1. The infill is graded into size ranges by passing through a series of increasingly fine graduated mesh sieves. The total mass of each particle size range is reported as a percentage of the total infill. Test results will be used to verify installed turf systems against the previously sampled turf product while the proportions retained on each sieve must be within 20% of the initially tested value (Table 2).

3.15 Infill - Particle Shape

The shape profile of infill materials can affect the frictional properties of sports surfaces. This will be assessed by a classification chart based on its sphericity, shape, structure and texture according to EN 14955. Test results will be used to verify installed turf systems against the previously sampled turf product. The proportion of each shape type must be similar shape (Table 2).

3.16 Infill - Bulk Density

A representative sample of infill material (both stabilising and performance) is taken and tested according to EN 1097-3. The sample is dried to remove moisture, which can influence the mass, and is lightly tamped into a container of known volume and weighed to determine bulk density. Test results will be used to verify installed turf systems against the previously sampled turf product and must be within 15% of the initially tested value (Table 2).

3.17 Thermo Gravimetric Analysis (TGA)

Polymeric infill materials are analysed to determine the ratio of organic to inorganic material present. This test in divided into two procedures depending on the infill used; SBR recycled tyre, or EPDM, TPV, TPE. Testing must be in accordance with AFL/CA Test Method 3 in Appendix 4 and be within 15% of the manufacturer's declaration.

3.18 Shockpad Strength

A sample of sub-base layer material is taken and tested in tension in a CRE testing machine until it ruptures or tears according to EN 12230. The shockpad must have a minimum tensile strength of 0.15 MPa and be within 15% of the previously sampled product as outlined in Table 2. If the shockpad cannot be tested in tension due to its construction, it is to be tested in compression using the method of ISO 604 to obtain the stress required to compress by 20% of its thickness or to a fraction of the shockpad thickness as deemed applicable to the material. The result obtained will be used to verify installed systems against the initially tested value.

3.19 Shockpad Thickness

The thickness of the sub-base pads or layers is measured by means of a lightly weighted plate coupled to a micrometer, according to EN 1969. The mean of a minimum of five readings is calculated. Test results will be used to verify installed turf systems against the previously sampled turf product. Results obtained must be within 10% of the manufacturer's declaration (Table 2).

3.20 Shockpad Absorption

The AAA apparatus is used to measure shockpad absorption. The device is positioned vertically on the shockpad sample and the falling weight is lifted to a drop height of 55 mm ± 0.5 mm. After 30 (± 5) seconds of waiting for the relaxation of the material, the mass is dropped a second time. After the impact and within 30 seconds, the lift height is adjusted and the weight lifted. This procedure is repeated a third time and the force reduction is calculated from the recorded acceleration of the weight from the moment of release until after the impact. A force reduction of ≤ 5% must be achieved.

Table 2: Summary of quality and identification requirements.

COMPONENT	CHARACTERISTIC	TEST METHOD	VARIATION REQUIREMENT
SYNTHETIC GRASS	Linear Density	Weight expressed in Tex	Within 10% of manufacturer's declaration
	Yarn Thickness	Microscopic test	> 90% of manufacturer's declaration
	Mass Per Unit Area	ISO 8543	Within 10% of manufacturer's declaration
	Tufts Per Unit Area	ISO 1763	Within 10% of manufacturer's declaration
	Pile Length	ISO 2549	Within 5% of manufacturer's declaration
	Pile Weight	ISO 8543	Within 10% of manufacturer's declaration
	Tuft Withdrawal Force	ISO 4919	Initial test minimum of 40 N > 90% of initial test in ageing tests
	Water Permeability[a]	EN12616	≥ 300mm/h and >75% of the lab result
	Pile characteristic	AFL/CA Test Method 1	Within ± 3°C of previously declared value (polymer peaks, commonly LDPE, MDPE + LDPE, HDPE) if applicable with a similar signature. If there is any doubt on signatures seek advice from AFL.
	Yarn profile	Measurement by microscopy pictures of yarn/profile must be provided in report	To be identical to declared shape
	Pile Colour	RAL Number	To be identical to the declared colour
	Joint Strength	EN 12228	≥ 1200 N per 100 mm - stitched ≥ 75 N per 100 mm - bonded
PERFORMANCE INFILL	Infill Depth	AS 4693.2	Within 20% of manufacturer's declaration
	Free Pile Height	AFL/CA Test Method 2	Within 10% of manufacturer's declaration

	Particle Size	EN 933 - Part 1	≤± 20% of initial tests
	Particle Shape	EN 14955	Similar shape
	Particle Density	EN 1097-3	≤± 15% of initial tests
	TGA	AFL/CA Test Method 3	≤± 15% of the manufacturer’s declaration
STABILISING INFILL	Particle Size	EN 933 - Part 1	≤± 20% of initial tests
	Particle Shape	EN 14955	Similar shape
	Particle Density	EN 1097-3	≤± 15% of initial tests
SHOCKPAD	Strength	EN12230	0.15MPa minimum and ≤± 15% of initial tests
	Thickness	EN1969	≥ 90% of the manufacturer’s declaration.
	Shockpad absorption	Advanced Artificial Athlete	≤ 5%

[a] All individual elements of the football turf should satisfy this requirement and any value above 2000mm/h shall be recorded as “>2000mm/h”. In addition, this requirement is not applicable to surfaces designed specifically for indoor use.

4 DURABILITY TESTING

4.1 Resistance to Weathering

As previously described in section 3.7, the tensile strength of a sample of the supplied yarn is measured using a CRE testing machine (Figure 4), according to European standard EN 13864. A larger sample of the yarn is wrapped around a metal holding plate and exposed to UV radiation in a QUV weatherometer (Figure 5) for 5,000 hours to simulate UV exposure in use. After exposure, a tensile test is carried out again on the exposed yarn. The unaged tensile strength of the yarn must be ≥ 30 N for a fibrillated yarn and ≥8 N for a monofilament yarn and the aged yarn must not undergo more than 50% reduction in tensile strength (Table 3).

Testing of yarns in advance by an approved laboratory, in accordance with this testing manual, is acceptable.

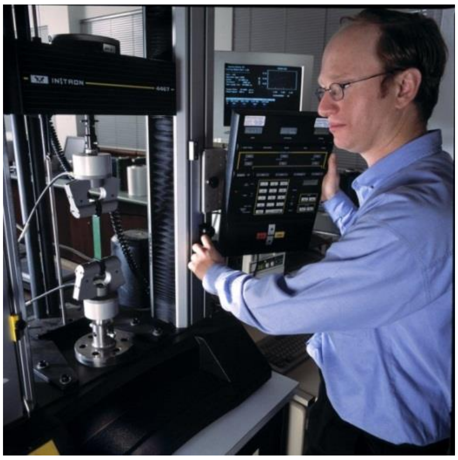

Figure 4: Tensile test of pile yarn. *(Reproduced with permission from Tapex).*

Figure 5: QUV weatherometer sample. *(Reproduced with permission from Tapex).*

4.2 Colourfastness to Weathering

After 5,000 hours UV exposure as above, the colour change in the yarn is rated against a grayscale according to EN ISO 20105-A02. The colour change must not fall below a grayscale rating of 3 (Table 3).This testing is applicable to all colour fibres.

4.3 Resistance to Simulated Use - Lisport

The Lisport wear tester (Figure 6) employs studded rollers which are rotated and dragged back and forth over the surface of synthetic turf to produce a combined rolling and sliding wear stress on the material to simulate usage according to the method of EN 15306. This test is carried out for 80,200 cycles, with visual inspection at the first 5,000 cycles, and at intervals of 5,000 cycles thereafter. The test causes pile and backing damage and removal of pile tufts and infill material. The removed material is gathered after 80,000 cycles and weighed to determine the total material lost. The sample must have less than 10% fibre loss based on the initial calculated pile weight of the test area and minimal visual fibre degradation after 80,000 cycles (Table 3). A further 200 cycles are performed with dispersed infill reintroduced and allowed to consolidate before the surface and performance tests are undertaken. All surface and performance tests described in section 5 & 6 will be repeated after the simulated wear test, with the exception of the critical fall height test. After wear, three single impacts are measured from 1.3 m and the mean of the three is reported. The mean result should be a HIC value < 1000. Proof of previously tested yarns by an approved laboratory, in accordance with the testing described in this section, or equivalent testing to 6,200 cycles on the Lisport XL is acceptable.

Figure 6: Lisport wear tester. ***(Reproduced with permission from Tapex)***

Table 3: Summary of durability requirements.

TEST	TEST METHOD	REQUIREMENT
Resistance to Weathering	QUV weatherometer EN 13864	<50% reduction in tensile strength
Colourfastness to Weathering	Standard grayscale after 5,000 hours of UV exposure EN ISO 20105-A02	Grayscale rating ≥3
Resistance to Simulated Use	Lisport Wear Test- 80,200 cycles EN 15306	< 10% fibre loss Visual assessment of fibres

5 SURFACE PROPERTIES

The test procedures for all surface properties are outlined in this section. The conditions under which the tests are carried out are outlined in Table 3 and regardless of condition the same procedure is used and the same criteria required. The only exception is the critical fall height test after wear and this is detailed in section 5.1.

5.1 Critical Fall Height

5.1.1 Principle

The most serious of all injuries are those associated with the head, including head impacts. Australian football involves players jumping to considerable heights to catch a ball and returning to ground sometimes falling with head contact. The universally accepted method uses the concept of Critical Fall Height, the characteristic of a surface which measures its propensity for head injury.

5.1.2 Test Procedure

Critical fall height is assessed according to either AS/NZS 4422 (2016) or BS EN 1177. For the test after simulated wear, three single drops are performed from 1.3 m, depending on equipment and the mean value of the three drops is reported.

5.1.3 Expression of Test Results

The results of the Drop Tests (G-max and HIC) are plotted and the Critical Fall Height determined at the HIC = 1000 criterion as per AS/NZS 4422 or BS EN 1177. Three tests are repeated, each on a new position on the sample, and the mean of the three is determined as the final result.

5.1.4 Criterion

The recommended criterion for Critical Fall Height is ≥ 1.3 m.

For the test after simulated wear, three single drops are performed from 1.3 m, depending on equipment, and the mean value of the three drops reported with a HIC <1000.

5.2 Clegg Hammer Hardness Measurement

5.2.1 Principle

Ground hardness is the effect that the surface has on absorbing impact energy. Harder grounds have been associated with increased injury risk, such as bruising and in extreme circumstances fractures, when landed on from falls. It has also been suggested that harder grounds lead to faster game speed and consequently higher collision impacts.

5.2.2 Test Procedure

The equipment used to assess ground hardness is the Clegg hammer (Figure 7). A 2.25 kg weight (hammer) encasing an accelerometer is dropped from a height of 45 cm through a vertical guide tube, in accordance with AS 1289.6.9.1. The deceleration on impact is measured in gravities (g). The first Clegg hammer drop on the surface is recorded. The procedure is repeated at an adjacent position for a total of five readings.

5.2.3 Expression of Test Results

The mean of the five single Clegg Hammer drops on three distinct positions on the surface is calculated. The result is expressed as the deceleration on impact in gravities. Where the variance between the readings is greater than 10% a further two tests will be undertaken.

5.2.4 Criterion

The hardness reading must be ≤ 120 g to pass this test.

Figure 7: Clegg hammer for measuring ground hardness by impact force.

5.3 Force Reduction, Vertical Deformation and Energy Restitution

5.3.1 Principle

The shock absorbing capacity of a surface and the amount it deforms under impact with either the foot or any body part can contribute to injury risk. Furthermore, it can affect the way an Australian football or cricket ball bounces. It is also commonly known as force reduction. Linked to this is the notion of energy restitution which is the energy that is returned to the player from the surface. Optimising these three surface properties decreases injury risk and creates a suitable surface for optimum performance. A new device called the Advanced Artificial Athlete (AAA) records all three surface characteristics in a single drop. This Handbook has, with the permission of FIFA and IRB, reproduced in part the test procedure from the FIFA Turf Manual and IRB Regulation 22 Performance Specification.

5.3.2 Test Procedure

The apparatus is positioned vertically on the synthetic turf sample and the falling weight is lifted to a drop height of 55 mm ± 0.5 mm. After 30 (± 5) seconds waiting for the relaxation of the material, the mass is dropped a second time. After the impact within 30 seconds the lift height is adjusted and the weight lifted. This procedure is repeated a third time and the force reduction, vertical deformation and energy restitution are calculated from the recorded acceleration of the weight from the moment of release until after the impact.

5.3.3 Expression of Test Results

5.3.3.1 Force Reduction

Firstly, the maximum force at impact (denoted as F_{max}) is calculated using the following formula:

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

Where:

F_{max} is the calculated peak force for the test piece, expressed in Newtons (N);

G_{max} is the peak acceleration during the impact, expressed in g's (1g = 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 by gravity (=9.81 m/s²).

Then the force reduction is calculated using the following formula:

$$FR = [1- (F_{max}/F_{reference})] \times 100\%$$

Where:

FR is the force reduction, expressed as a percentage (%);

F_{max} is the calculated peak force for the test piece, expressed in Newtons(N);

$F_{reference}$ is the reference impact force of 6760 N corresponding to the theoretical value on a concrete surface.

The force reduction (FR) of a single test location is reported as the average of the force reduction results of the second and third impact and is expressed to the nearest whole percentage number.

5.3.3.2 Vertical Deformation

The vertical deformation is defined as:

$$\text{Vertical Deformation} = D_{weight} - D_{spring}$$

Where:

D_{weight} = travel of weight after moment of impact

D_{spring} = compression of spring

The compression of the spring can be calculated as follows:

$$D_{spring} = (m \times g \times G_{max}) / C_{spring}$$

Where:

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 by gravity (=9.81 m/s²);

G_{max} is the peak acceleration during the impact, expressed in g's (1g = 9.81 m/s²);

C_{spring} is spring constant (given the certificate of calibration, in the adapted range).

The vertical deformation (VD) of a single testing location is calculated as the average of the vertical deformation results of the second and third impact and is expressed to the nearest 0.1 mm.

5.3.3.3 Energy Restitution

Energy restitution is calculated using the following formula;

$$ER1 = [E_2 / E_1] \times 100\%$$

E_1 is the energy before impact = ½m $(V1)^2$

E_2 is the energy after impact = ½m $(V2)^2$

V2 is the take-off velocity [m/s]

V1 is the initial impact velocity [m/s]

m is the mass [kg]

$$ER = \frac{(V2)^2}{(V1)^2} \cdot 100\%$$

The energy restitution (ER) of a single testing location is calculated as the average of the energy restitution results of the second and third impact and is expressed to the nearest whole percentage number.

5.3.4 Criterion

The acceptable range for force reduction is 55 - 70%, energy restitution is 20 - 50% and the vertical deformation reading must be 4 - 11 mm.

Figure 8: The Advanced Artificial Athlete.

5.4 Abrasion/Friction

5.4.1 Principle

A common perception is that synthetic turf has a highly abrasive property and results in skin abrasions and friction burns when the players slide/land on it. Since contact with the ground is customary in the game of Australian football and cricket, it is essential to assess the interaction of the surface with skin. This Handbook has, with the permission of FIFA and IRB, reproduced in part the test procedure from the FIFA Turf Manual and IRB Regulation 22 Performance Specification.

5.4.2 Test Procedure

The Securisport ® Sports Surface Tester comprising a test foot, a polished test plate, water level and silicon skin, is used to determine skin friction and abrasion. The test procedure is made up of three parts; determination of the new skin sliding force, the skin friction and skin abrasion. It is imperative that the surface of the silicon skin is not touched before or during any tests and that the ambient temperature is 23 ± 2 °C.

5.4.2.1 New Skin Sliding Force

Three pieces of silicon skin (15 cm x 8 cm) need to be prepared by washing in water and left to dry for 24 hours. Just prior to the test the polished test plate is cleaned with acetone and let to evaporate for 5 minutes. One piece of silicon skin is attached, smooth side facing out, to the test foot (Figure 9) and with a total mass of 1,700 ± 50g, the force required to pull the silicon skin along the test plate over a sliding distance of 100 mm at a speed of 500 ± 10mm/min is measured ten times. The force over a sliding distance of 40mm and 80mm is recorded. The average of the ten force measurements is calculated and referred to as $F_{new\ skin}$. (Ensure the standard deviation is less than 0.3 and the average force is 6 ± 1.5N). This procedure is then repeated on the other two skin samples and the overall mean is calculated and recorded.

Figure 9: Securisport test foot with skin attached. ***(Reproduced with permission from FIFA and IRB)***

5.4.2.2 Determination of skin friction

The skin friction is measured by mounting the test foot with the silicon skin onto the Securisport Sports Surface Tester apparatus and positioning it above the synthetic turf sample, which has been secured to the laboratory floor. The level of the test foot is adjusted according to the sample height and a vertical force of 100N ±10 N is applied and rotations of the test foot are started. The test foot must complete five full revolutions at a speed of 40 ± 1 rev/min; sampling at a frequency of 40 Hz. The mean coefficient of friction (μ) for test is displayed on the Securisport device. This procedure is repeated on the three skin samples with any displaced infill replaced before each test.

5.4.2.3 Determination of skin abrasion

To determine the skin abrasion value of the synthetic turf sample, the test foot is removed from the Securisport apparatus and any detritus material removed using compressed air. The test foot is placed on the clean polished test plate and the force required to pull the silicon skin along the metal plate over a sliding distance of 100mm at a speed of 500 ± 10mm/min is measured. Similar to the New Skin Sliding Force, ten measurements are taken and the mean value of the ten calculated. This procedure is repeated with the other two test skins and the overall mean from the three skin samples is calculated and reported.

5.4.3 Expression of Test Results

Skin friction is expressed as the mean coefficient of friction of the three tests.

Skin abrasion is calculated using the following formula:

$$100 \times [F_{\text{new skin}} - F_{\text{abraded skin}}] / F_{\text{new skin}})$$

where:

$F(_{\text{new skin}})$ = the mean average force of the second to fourth tests prior to the skin friction test;

$F(_{\text{abraded skin}})$ = the mean average force of the second to fourth tests after the skin friction test.

5.4.4 Criterion

The skin friction value must be ≤ 0.7 μ and the skin abrasion ±30 %.

(*Note*: Values of uncertainty for this test are yet to be established.).

5.5 Rotational Traction

5.5.1 Principle

The ability to change direction is an integral skill of the game of Australian football and to a lesser extent in cricket. Rotational traction refers to the traction that resists rotation of the shoe during turning movements. For the athlete, high rotational traction equates to a greater tendency for the foot to grip during changes of direction and low rotational traction means the shoe tends to release from the surface more easily.

5.5.2 Test Procedure

Rotational traction is measured using a Studded Boot Apparatus (Figure 10), in accordance with BS EN 15301-1. Australian football studs must be screw-in plastic tipped studs of 16 mm ± 2 mm in length. The apparatus is lifted vertically and released from a drop height of 60 mm and turned smoothly at a nominal speed of rotation of 12 rev/min until movement of the test foot occurs and it has rotated through at least 45 degrees. Rotational traction is measured in Newton metres using a torque wrench. After every 20 tests the stud length must be checked and all replaced where relevant. In the event of a construction with a synthetic outfield and a natural turf wicket, cricket spikes of 10 mm length and plastic cricket cleats of 5 mm ± 1 mm in length will also be tested.

5.5.3 Expression of test results

The mean traction of five tests on the sample will be calculated in Newton metres. Where the variance between the readings is greater than 10% a further two tests will be undertaken.

5.5.4 Criterion

Rotational traction for the football studs must fall between 25 – 50 Nm, between 7 – 15 Nm for cricket cleats and for cricket spikes 15 – 25 Nm.

Figure 10: Studded Boot Apparatus for measuring rotational traction.

6 PERFORMANCE CHARACTERISTICS

The cricket ball used for all these tests must be a two seam ball of weight 160 ± 10 g and the calibrated round ball must be a round ball of weight 430 ± 20 g and inflated to 800 ± 50 kPa.

Tests shall be made with a calibrated round football. Immediately prior to any test the pressure of the ball shall be adjusted within the range 0.6 -1.0 bar so the ball gives a rebound on concrete to the bottom of the ball of 1.35± 0.03 m from a drop height of 2.0 ± 0.01m . This must be undertaken at the same temperature as the test. The ball is to be conditioned at room temperature for 48 hours prior to testing.

A different but identical calibrated ball must be used for the ball roll and ball rebound tests.

6.1 Ball Roll

6.1.1 Principle

The predictability and consistency of a ball rolling across the playing surface is of utmost importance in the game of cricket. As the batter hits the ball along the ground he/she needs to be able to anticipate how far it will roll to determine the number of runs he/she can attempt to score. Although it is not so crucial to the game of Australian football, if a ball was to roll exceptionally fast or slow down significantly when rolling on the surface, it may result in players altering their habits and hence cause changes to the nature of the game.

6.1.2 Test Procedure

This property is measured by rolling a ball, both a calibrated ball and cricket ball, down a ramp with a 45 degree inclination (Figure 11). The ball is released from a height of 1.00 ± 0.05 m on a 45 degree ramp, and allowed to roll along the test surface. The ball is released by the operator removing the fingertips from the ball; it must not be pushed down the ramp. The cricket ball must be positioned with the seam of the ball across the ramp.

6.1.3 Expression of test results

The ball roll distance is measured from the point where the ball first comes into contact with the surface to the middle of the ball at rest. Five tests are undertaken from each end of the sample and the mean of the five from each end are calculated. Then the mean of the two directions determines the overall result. The ramp must be moved slightly between tests to ensure the ball is rolling in a new track in each tests. Where the variance between the readings is greater than 10% a further two tests must be undertaken.

6.1.4 Criterion

The recommended criterion for the calibrated round ball is 4.0 – 12.0 m and 3.5 – 15.0 m for the cricket ball.

Figure 11 : Ball roll test set-up for calibrated round ball

6.2 Vertical Ball Rebound

6.2.1 Principle

The resilience of the surface can be measured by how high the ball bounces after it is dropped vertically from a specific height. In both Australian football and cricket, the height to which the ball bounces is important to the player for catching, kicking or punching the ball away. If the ball bounces higher or lower than expected it may cause injury or result in the player's inability to perform the desired task.

6.2.2 Test Procedure

The Vertical Ball Rebound Test is conducted by dropping the calibrated round ball and cricket ball from 2 m and measuring its rebound height (Figure 12). The testing is to be in accordance with EN12235.

6.2.3 Expression of test results

The rebound height is measured using 2-dimensional video software or a microphone timing device that measures the time interval between the first and second bounce is used to determine the height of rebound. The microphone timer must first be calibrated against bounces on concrete and a typical synthetic turf surface. The ball is dropped using a remotely controlled release device from 2.00 m onto the test surface and the time interval between first and second bounce measured. Five tests are undertaken and the mean of the five calculated. Where the variance between the readings is greater than 10% a further two tests must be undertaken.

6.2.4 Criterion

The acceptable rebound height range for the calibrated round ball is 0.6 – 1.0 m and 0.1 – 0.4 m for the cricket ball.

Figure 12: Vertical ball rebound test equipment.

6.3 Angled Ball Rebound

6.3.1 Principle

In addition to vertical ball rebound, the ball in both football and cricket will hit the surface at an angle and rebound accordingly. If the ball rebounds off the surface at an unanticipated speed or trajectory, the risk of sustaining an injury or of the player's inability to perform the required task may increase.

6.3.2 Test Procedure

The balls used in the Angled Ball Behaviour test must meet the requirements as specified in the introduction for Section 6. The Angled Ball Behaviour Test is performed by releasing the ball through an electronic ball machine or pneumatic ball cannon and measuring the change in horizontal velocity before and after the ball hits the surface. The calibrated ball is released onto the surface at 50 ± 5 km/hr and at an angle of 15 ± 2 degrees from the horizontal. The cricket ball is released at 75 ± 5 km/hr also at an angle of 15 ± 2 degrees. Five repeated measurements are recorded with each ball type, ensuring a different point of impact for every test.

6.3.3 Expression of test results

The difference in velocity before(Vi) and after(Vf) the ball connects with the surface is measured in km/hr using a radar gun. This difference is then converted from an absolute to a percentage change using the following formula;

Angled ball rebound = ((Vf/Vi) x100)

Five tests are undertaken and the mean of the five calculated as the overall result. However, where the variance between the readings is greater than 10% a further two tests must be undertaken. In this instance, the final result is the mean of the seven tests.

6.3.4 Criterion

The acceptable angled ball rebound is 45 – 70% for the calibrated round ball and 35 – 60% for the cricket ball.

6.4 Infill Splash

6.4.1 Principle

Given the nature of both cricket and Australian football, it is important that infill splash is limited when the ball interacts with the ground. A large vertical dispersion of infill can disrupt the subsequent bounce of the ball. Furthermore, it could have unpleasant consequences for players diving to catch or block the ball. This test procedure and images have been reproduced in part from the GAA Performance and Construction Standards for Synthetic Turf Pitches and Performance and Construction Standards for Synthetic Turf Rugby League Competition and Training Pitches with permission from Labosport.

6.4.2 Test Procedure

The test is carried out by releasing the calibrated round ball and cricket ball from 2 m, similar to the vertical ball rebound test (section 6.2). The test is video recorded and the degree of infill dispersion at the point of impact is assessed.

6.4.3 Expression of test results

The degree of infill splash is reported according to the photograph scale in Figure 13.

6.4.4 Criterion

The infill splash must be ≤ Category 3.

Category 1 - No Infill Splash 	Category 2 - Low Infill Splash 
Category 3- Medium Infill Splash 	Category 4 – High Infill Splash 

Figure 13: Infill splash grading scale. (*Reproduced with permission from Labosport*)

Table 4: Summary of laboratory surface and performance tests.

TEST	TEST METHOD	CONDITIONS	REQUIREMENT
Critical Fall Height	Uniaxe Impact Tester (AS/NZS 4422) or (BS EN 1177)	Dry, Wet and Aged	≥ 1.3 m
Hardness	Clegg Impact Tester	Dry, Wet and Aged	≤ 120 G
Force Reduction	Advanced Artificial Athlete	Dry, Wet and Aged	55 – 70%
Energy Restitution	Advanced Artificial Athlete	Dry, Wet and Aged	20 – 50%
Vertical Deformation	Advanced Artificial Athlete	Dry, Wet and Aged	4 – 11 mm
Abrasion - Change in Friction Force	Securisport Test Apparatus	Dry	± 30%
Friction - Coefficient of Friction	Securisport Test Apparatus	Dry	≤ 0.70
Traction Football Studs	Studded Boot Apparatus (EN 15301-1)	Dry, Wet and Aged	25 Nm – 50 Nm
Traction Cricket Spikes	Studded Boot Apparatus (EN 15301-1)	Dry, Wet and Aged	15 Nm – 25 Nm[a]
Traction Cricket Cleats	Studded Boot Apparatus (EN 15301-1)	Dry, Wet and Aged	7 Nm – 15 Nm[a]
Ball Roll Calibrated Ball	Inclined Ramp (EN12234)	Dry and Wet	4 m – 12 m

Ball Roll Cricket	Inclined Ramp (EN12234)	Dry and Wet	3.5 m – 15.0 m
Vertical Ball Rebound Calibrated Ball	Vertical Rebound Frame (EN12235)	Dry, Wet and Aged	0.6 m – 1.0 m
Vertical Ball Rebound Cricket	Vertical Rebound Frame (EN12235)	Dry, Wet and Aged	0.1 m – 0.4 m
Angled Ball Rebound Calibrated Ball	Angled Ball Shooter	Dry Wet	45% – 70% 45% – 80%
Angled Ball Rebound Cricket	Angled Ball Shooter	Dry and Wet	35% – 60%
Infill Splash	Vertical Rebound Frame	Dry	≤ Category 3

Footnote [a]: The rotational traction with cricket spikes and cricket cleats will only be undertaken where there is a synthetic field with a natural wicket.

7 CONSTRUCTION AND PERFORMANCE FIELD TESTS

7.1 General Information

Field tests are designed to ensure that the quality of the installation meets the requirements imposed by AFL/CA on synthetic playing surfaces.

Before installation of the playing surface, tests will be done on the earthworks surface to ensure appropriate base construction.

After the carpet has been laid and filled to produce the playing surface, it should be allowed to age and be played on for a period of one month or 160 hours of play to allow consolidation before testing.

7.2 Construction Requirements

To ensure that the finished synthetic turf installation is optimal for playing Australian football and cricket, it is essential that the surface be laid on a prepared base. This base must be smooth (even), of sufficient slope that heavy rainfall will drain quickly leaving no ponding and that it has sufficient permeability that it remains stable following extended periods of wet weather.

These properties will be determined by measurements on the prepared base of slope, evenness and water infiltration rate prior to surface installation to ensure appropriate base construction.

In addition to this testing the proprietor shall provide:

- a copy of the last geodesic survey of the field;
- details of the base composition;
- depth and composition of fill, and information on the geology of the sub-base.

The following sections will provide details of the specific field tests that must be undertaken.

7.3 Visual Inspection

As part of the field tests, a visual inspection will be undertaken by the Test Institute to ensure that there are no visible defects in the playing area that are hazardous to the users. If any defects are found, they will be recorded and reported to the manufacturing company. A report on how the defects were rectified must be returned to the Test Institute prior to the finalisation of the Field Test report for the AFL/CA.

In particular, there shall be no:

- failed or excessively open joints (greater than 3mm);
- no looped piles;
- excessively uneven distribution of infill: difference in infill height between lowest and highest spot should not exceed 10mm;
- exposed irrigation sprinkler heads within the playing area;
- exposed goal post sockets;
- hazards within 3 metres of the perimeters of the field of play;
- significant deviations in line markings.

If unacceptable joints, looped piles, non-straight lines or any other defect considered hazardous to play are found they shall be reported to the manufacturing/installation company who shall rectify the defects to the satisfaction of the Field Test Institute prior to the Field Test Institute issuing the Field Test Report.

The visual inspection undertaken by the Test Institute is not a formal site audit and neither the AFL, Cricket Australia, nor the Test Institute will accept any liability for any defects or other issues that subsequently result in an injury to a player or other users.

7.4 Maintenance Equipment

For a field to be certified by the AFL/CA, the facility operator must ensure that all the maintenance equipment specified by the surface manufacturer is available for inspection during the site visit.

7.5 Determination of Evenness

7.5.1 Principle

The finished surface should have a degree of evenness that players can run on it without fear of injury or effects on their stride patterns. This evenness will ultimately depend on the base or earthworks. Depressions in the base can be smoothed over by the shock pad and carpet but then there will be inconsistency at these points in other properties (e.g. hardness). The surface of the prepared base shall not show high spots or depressions at a localised level beneath a 3 m straight edge.

7.5.2 Test Procedure

The straight edge (Figure 14) shall be placed on the surface at right angles to the direction of travel and dragged along to cover the field comprehensively. Continuous inspection of the surface beneath the straight edge as it is dragged along will reveal local depressions or humps, which shall be measured using a calibrated wedge.

7.5.3 Expression of test results

Observations of local depressions or humps exceeding the recommended criterion should be noted and marked on a plan of the field. Deviations from evenness greater than 15 mm under the 3 m straight edge shall also be recorded and annotated on a plan of the field.

7.5.4 Criterion

The recommended criterion for Evenness of the base is 15 mm under a 3 m straight edge. Variations around the cricket pitch will be subject to particular focus.

Figure 14: Photo of a Straight Edge used to measure surface evenness.

7.6 Determination of Slope and Dimensions

7.6.1 Principle

The slope of the field should be sufficient for adequate drainage, but also not excessive to the extent that players find it noticeable. Spectators at ground level may also find excessive slope aesthetically unpleasing. The field should also be of sufficient dimensions to satisfy the grade of Australian football or cricket for which it is required.

7.6.2 Test Procedure

The slope of the earthworks will generally have been extensively surveyed during construction, so these procedures are merely a check.

Levels shall be measured (Figure 15) at 5 positions at approximately 20 m intervals across the field and at 7 positions along it. The length and breadth of the field (from fence to fence) shall be measured.

7.6.3 Expression of test results

Observations of slope or variations greater than 1% should be noted and marked on a plan of the field.

7.6.4 Criterion

The recommended criterion for Slope and Dimensions of the base are:

Slope – falling from the center spot in all directions (turtle-back preferred)

Maximum 1.0% in longitudinal and latitudinal direction.

Dimensions* (Refer to 3.2 (a) (ii) & (iii) Laws of Australian Football):

Length: 135 – 185 m from Goal to Goal

Width: 110 – 155 m from boundary to boundary

Recommended run-off: 4 m for regional level and 3 m for local level.

Ground markings should be made as per Figure 16 below. Should the dimensions or ground markings not meet these dimensions the field may be accredited for junior football or training only.

Figure 15: Photo of levels used to measure surface slope.

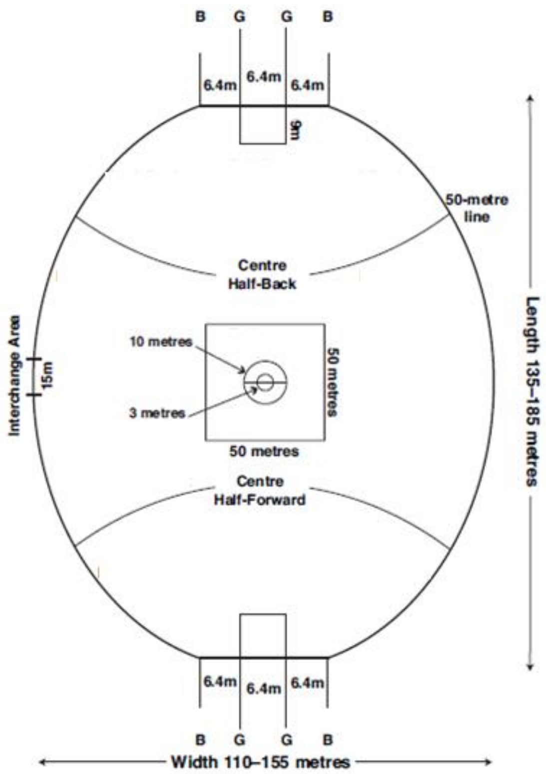

Figure 16: Required ground markings.

7.7 Determination of Water Infiltration Rate (Base)

7.7.1 Principle

Water needs to drain freely from the pitch. Excess rain water needs to be removed quickly so the surface can be playable in a short period of time.

7.7.2 Test Procedure

The required equipment is specified in the Standard EN 12616:2003 (E). The two cylinders are affixed to the base surface and filled with water. Measurement is made of the time taken for the level of the inner cylinder water to fall 25 mm from an initial ponding depth of 35 mm, maintaining (from a reservoir) a corresponding level in the outer cylinder. The temperature of the water is also measured.

These tests shall be made on the earthworks under the meteorological conditions prevailing. These conditions should be reported as well the general wetness of the surface due to previous weather. The tests shall be done at 6 representative positions as shown in the field test section (Figure 17). Extra positions may be selected if the tester deems necessary. The mean and uncertainty (at 95 % confidence) are estimated for each measurement position.

7.7.3 Expression of Test Results

The infiltration rate (IA) is given by the formula

IA = 600 FWA C / tA

where:

FWA is the fall in water level (mm);

C is the viscosity correction factor to correct to a standard temperature of 10 degrees (tabulated values given in EN 12616);

tA is the time taken (s).

7.7.4 Criterion

The recommended criterion for Infiltration Rate is > 300 mm/h.

Note: Where necessary due to site location, this test can be carried out by a local surveyor organised through the approved test laboratory/agent.

7.8 Performance Field Tests

Prior to testing the proprietor should provide a current Product Test Report to enable the required identity checks on the product installed. For these identity checks, a sample of carpet (500 X 500 mm), shock pad if it is preformed, sand and rubber infill must be provided on site to the test laboratory.

During field testing of the surface a general inspection will be carried out looking in particular at the evenness and uniformity of the installation, especially seams and joins in the carpet, dangerous obstructions in the play area or over-runs and boundary fences. Dimensions will be checked for compliance according to dimensions outlined in 7.4.4.

The following surface characteristic tests are undertaken and are identical procedures to those previously described in the laboratory tests with the exception of the horizontal ball roll. It is described in detail in section 7.9.

- Critical fall height;
- Hardness;
- Force reduction, vertical deformation and energy restitution;
- Traction;
- Vertical ball rebound;
- Horizontal ball roll.

The tests shall be made under the meteorological conditions prevailing and the temperature and moisture content of the sample. These conditions should be reported as well as the temperature of the surface. The general wetness of the surface due to previous weather shall also be reported.

The tests shall be done at 6 representative positions on the field (as shown in Figure 17). Extra positions may be selected if the tester deems necessary at the time of testing. The mean and its uncertainty (at 95 % confidence) of the results at each position shall be determined and reported. In relation to force reduction, vertical deformation and energy restitution using the AAA, 15 tests must be performed on the field as outlined in Figure 17.

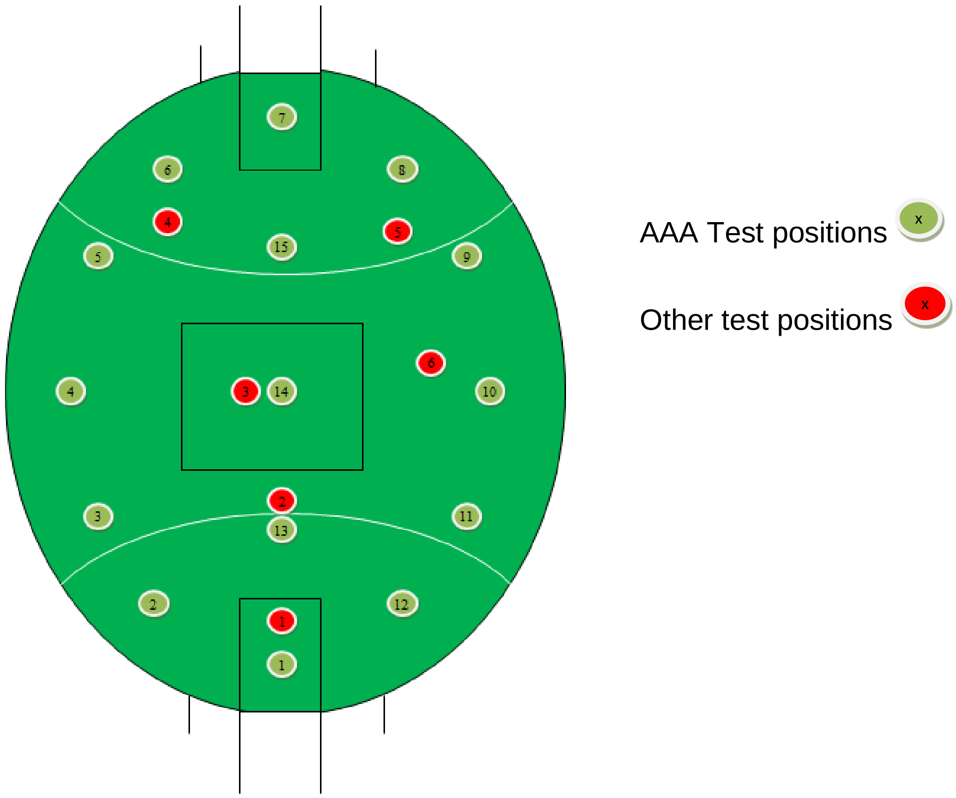

Figure 17: Diagram of the field test positions.

7.9 Field Test - Ball Roll Measurement

7.9.1 Principle

The roll of the ball on the surface is important in general Australian football play and more specifically cricket, but is also a critical indicator of the general state of the surface – a badly worn or compacted surface exhibits longer roll than is desirable. In this test, a ball is rolled at a specified speed along the surface and the distance to stopping is measured.

7.9.2 Test Procedure

This test is sensitive to wind and levelness of the surface. Wind speed should be measured using a wind gauge and if greater than 1.0 m/s, the test should be deferred. The effect of slope is adjusted in the results.

The ball is released from a height of 1.00 ± 0.05 m on a 45 degree ramp, and allowed to roll along the test surface. The distance of roll-out from the bottom of the ramp is measured. Ball roll positions are selected as per the field test positions indicated in Figure 17. At each position, five rolls in opposite directions should be performed.

7.9.3 Expression of test results

To correct for any effect of slope, the mean and uncertainty of forward and reverse rolls is determined.

7.9.4 Criterion

The recommended criterion for the calibrated round ball is 4.0 – 12.0 m and 3.5 – 15.0 m for the cricket ball.

Table 5: Summary of requirements for field testing.

TEST	TEST METHOD	REQUIREMENT
Critical Fall Height	Uniaxe Impact Tester (AS/NZS 4422) or (BS EN 1177)	≥ 1.3 m
Hardness	Clegg Impact Tester	≤ 120 G
Force Reduction	Advanced Artificial Athlete	55 – 70%
Energy Restitution	Advanced Artificial Athlete	20 – 50%
Vertical Deformation	Advanced Artificial Athlete	4 – 11 mm
Traction Football Studs	Studded Boot Apparatus (EN 15301-1)	25 Nm – 50 Nm
Traction Cricket Spikes	Studded Boot Apparatus (EN 15301-1)	15 Nm – 25 Nm[a]
Traction Cricket Cleats	Studded Boot Apparatus (EN 15301-1)	7 Nm – 15 Nm[a]
Ball Roll Calibrated ball	Inclined Ramp (EN12234)	4 m – 12 m
Ball Roll Cricket	Inclined Ramp (EN12234)	3.5 m – 15.0 m
Vertical Ball Rebound Calibrated ball	Vertical Rebound Frame (EN12235)	0.6 m – 1.0 m
Vertical Ball Rebound Cricket	Vertical Rebound Frame (EN12235)	0.1 m – 0.4 m

Footnote: [a] The rotational traction with cricket spikes and cricket cleats will only be undertaken where there is a synthetic field with a natural wicket.

8 FUTURE DEVELOPMENTS

The equipment and testing procedures outlined in this manual are currently recognised international test methods. It is acknowledged, however, that developments in technology may occur in the coming years and changes to this guide will be made accordingly.

9 APPENDICES

Appendix 1: Microscopic Measurement of Yarn Thickness

This handbook has, with the permission of FIH, reproduced in part the test procedure from the FIH Handbook of Performance, Durability and Construction Requirements for Synthetic Turf Hockey Pitches.

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 but maximum magnification must be used to reduce calculation errors. The microscope must have the possibility to measure the sample in real time and to record the measurement as a digital file.

The microscope shall be calibrated against a 1um reference gauge and the optical graticule before each measurement session or each month if the microscope has the possibility to save the calibration in a file. The reference gauge must be calibrated by an external laboratory.

'Freezing' system

The yarn shall be 'frozen' before 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 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 must be operated immediately after the cooling and be as perpendicular as possible to the cross section of the yarn. Cutting must be undertaken on a wooden surface.

Small clamp

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

2. Samples

Samples are cut out from a synthetic turf carpet and a minimum of three measurements made. The results shall be reported as the mean of the three measurements.

3. Procedure

- Cut 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 forms on the surface of the yarn.
- Immediately cut the yarn as perpendicular as possible to the cross section using the reference square.
- Using a small vice, position the yarn perpendicularly 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 of the yarn and the width of the fibre.

4. Results

The average yarn thickness of the three samples must be recorded and visual images reported. Results obtained must be >90% of the manufacturer's declaration.

Appendix 2: AFL/CA Test Method 1

Determination of melting point of Polymers (DSC)

1. Principle

The method determines the melting temperature and heat flow of polymers.

2. Apparatus

- Differential Scanning Calorimeter (DSC) which has the following features:
  - capability to generate constant heating and cooling rates between 0.5 and 20°C/min;
  - capability to maintain test temperature constant to ± 0.5°C for 60 min;
  - nitrogen purge gas with a flow rate in the range 10 ml/min to 50 ml/min;
  - temperature signal with 0.1°C resolution and noise below 0.5°C.
- The pans for test, reference and calibration specimen must be made of the same material and have an equal mass;
- Analytical balance with accuracy of ± 0.01 mg;
- Gas supply;
- Cooling to achieve at least 5°C/min controlled cooling.

3. Calibration of the apparatus

- The apparatus must be calibrated at least every 100 tests or when the cell is dirty, using indium and tin. The guidelines of your machine supplier should be used to make a new baseline with these two materials.

4. Procedure

4.1. Setting up apparatus:

- Switch on apparatus and allow to equilibrate for at least 30 min;
- Use the same purge gas flow rate that was used to calibrate the instrument.

4.2. Loading test specimen into the pan:

- Use 2 pans, equal to these used for the calibration;
- Weigh the pans and the lid to the nearest 0.01mg;
- Put 1 to 5 mg filaments in the pan and close the lid;

- Take care that the bottom of the pan is still flat after closing the lid;
- If not, make another pan.

4.3 Insertion of the pans in the instrument:

- Use tweezers to place the pans in the specimen holder;
- Ensure there is a good contact between pan and holder;
- Close cover(s) of specimen holder.

4.4 Temperature scan

Using Nitrogen at 20 ml/min, Program the instrument to carry out the following thermal cycle:

Step.	Temperature regime
1	Heat from 30°C to 300°C at 50°C/min
2	Cool from 300°C to 30°C at 40°C/min
3	Hold for 8 min at 30°C
4	Heat from 30°C to 350°C at 10°C/min

5. Calculation and expression of results

- Determine the peak melting temperature of the second heating.
  (The first heating is only used to erase the material previous thermal history)
- For field test: determine the difference in melting temperature between the field sample and the value from the lab report. This can be a maximum of 3°C.

6. References

ISO 11357-1:1997 Plastics – Differential scanning calorimetry (DSC) – Part 1: General Principles

ISO 11357-3:1999 Plastics – Differential scanning calorimetry (DSC) – Part 3: Determination of temperature and enthalpy of melting and crystallization

7. Uncertainty

Note: Values of uncertainty for this test have are yet to be established.

Appendix 3: AFL/CA Test Method 2

Assessment of Free pile height

1. Principle

As a means of validation for laboratory and onsite testing to ensure that the free pile height is the same with the product declaration. If the free pile height is correct, this infers that the sum of the two infills is also correct (not necessarily the ratio). It also helps during retests to establish whether the infill levels are consistent with previous tests.

2. Apparatus

A steel and glass prism with a minimum dimension of 150 mm length; 125 mm width; and 70 mm height. The frame should contain a transparent prism or a mirrored bottom surface of reflective material which should be angled at 45 ± 0.2 degrees. A scale in 'mm' to a height of 40 ± 1 mm with a measuring resolution of 1 mm.

3. Procedure.

The prism is placed flat on the surface and the length of the ten highest fibres are recorded. The measurement shall be carried out at all test locations as set out for field tests and at 90 degree orientation to each other, at least 100 mm apart and a minimum of 100 mm from the edge of an unworn sample.

4. Calculation

The measurement shall be calculated from all test locations. Calculate the median of the highest pile fibres in mm from the 10 highest yarn fibres.

5. Assessment of Results

The exposed fibre shall not be longer than 30 mm (The excessive length of fibre has shown that the traction results can be high as the fibres grab onto the studs)
The manufacturer's product declaration should have an infill depth requirement of 15-20 mm (Table 2).

6. Uncertainty

No Uncertainty available. The errors in this test method are largely due to the parallax error and averaging of the fibers.

Appendix 4: AFL/CA Test Method 3

Assessment of Synthetic Infill Thermo Gravimetric Analysis (TGA)

1. Principle

Polymeric infill materials are analysed to determine the ratio of organic to inorganic material present. This test in divided into two procedures depending on the infill used.

2. Apparatus

2.1 Thermo Gravimetric Analysis (TGA) which has the following features:

- heating rate of 40°C/min;
- nitrogen purge gas with a flow rate in the range 10 ml/min to 50 ml/min;
- the analyzer should be maintained and calibrated in accordance with the manufacturer instructions;
- analytical balance with accuracy of ±0.01 mg.

3. Procedure.

3.1 Setting up apparatus.

- Switch on apparatus and allow to equilibrate for at least 30 minutes;
- Use the same purge gas flow rate that was used to calibrate the instrument;
- Sample Weight should be between ≥40 mg and ≤100 mg;

3.2 Heating Rate for SBR (recycled tyres coated or uncoated)

- Heat from 50°C - 300°C with a heating rate of 15°C/min;
- Maintain the sample at 300°C for 8 minutes;
- Heat from 300°C - 650°C at a heating rate of 15°C/min;
- Maintain the sample at 650°C for 1 minute;
- Heat from 650°C - 850°C at a heating rate of 25°C/min.

3.3 Heating Rate for Polymeric EPDM, TPV,TPE

- Heat from 50°C - 850°C with a heating rate of 10°C/min.

4. Calculation and expression of results

Organic content (%) = weight loss at 620°C * 100 .
Total weight of sample

Inorganic (%) = 100 – organic content (%)

The average is taken of the two scans.

4.1 Measurements SBR Infill

- Organic: mass loss up to 650°C
- Inorganic: mass loss from 650°C to 850°C

- Elastomers: mass loss between 300°C and 650 °C

4.2 Measurements EPDM, TPV, TPE ,Infill

- Organic: mass loss up to 650°C
- Inorganic: mass loss from 650°C to 850°C
- Elastomers (EPDM only): mass loss between the beginning of second peak usually 400°C and 650°C.
- Determine the Elastomer content.

(If this is less than 20% do QUV testing on the EPDM sample)

5. Assessment of Results

Field test samples must be within ±15% of the manufacturer's declaration.

6. Uncertainty

Note: Values of uncertainty for this test have are yet to be established