FIFA®

FIFA QUALITY PROGRAMME FOR FOOTBALL TURF

TEST MANUAL I: TEST METHODS

APRIL 2024 EDITION

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OVERVIEW

1. INTRODUCTION

This Test Manual describes the procedures for assessing artificial-turf football surfaces – designated as "football turf" by FIFA – under the FIFA Quality Programme for Football Turf. Although this Test Manual has been written to specify how football turf surfaces should be tested, the ball and surface, and the player and surface tests can also be used to assess the qualities of natural turf pitches (in this Test Manual, football pitches are also referred to as "fields"). This edition of the Test Manual supersedes all previous editions with effect from 15 April 2024.

2. NORMATIVE REFERENCES

This Test Manual 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 Test Manual only when incorporated into it by amendment or revision. For undated references, the latest edition of the publication referred to applies.

3. LABORATORY TEST SPECIMENS

3.1 Definitions

Football turf is defined as the synthetic surface, infill, any shockpad and all supporting layers that influence the sports performance or biomechanical response of a surface that meets the requirements of the FIFA Quality Programme for Football Turf.

Tests must be conducted on all elements of the construction that influence the surface's sports performance or biomechanical response. Unless football turf is laid on a base that is designed to contribute to the surface's dynamic performance, laboratory tests must be carried out on test specimens laid on a rigid, flat concrete floor.

If football turf is laid on a base that is designed to contribute to the dynamic performance of the surface, the measurements of vertical ball rebound, angle ball rebound, shock absorption, peak deformation and energy return must be conducted on a test specimen comprising the football turf and the base, laid to the depth specified by the manufacturer or supplier. Laboratory tests for ball roll, peak torque, rotational shear stiffness, and skin and surface friction must be conducted on all elements that influence the response, which does not normally include the supporting layers.

3.2 Size of test specimen

Test specimens must be equal to or greater than the sizes stated below in Table 1: minimum size of test specimens.

TABLE 1 – MINIMUM SIZE OF TEST SPECIMENS

Unless specified in the test method, laboratory test specimens must not include joints or inlaid lines.

Test	Min. length of test specimen (m)	Min. width of test specimen (m)
Vertical ball rebound	1.0	1.0
Angle ball rebound and splash testing	1.0	1.0
Reduced ball roll	4.0	1.0
Shock absorption	1.0	1.0
Peak deformation	1.0	1.0
Energy return	1.0	1.0
Peak torque and rotational shear stiffness	1.0	1.0
Surface friction	1.0	1.0
Subambient and elevated temperature tests	0.4	0.4
Simulated wear	4.0	1.0
Heat testing	0.4	0.4
Artificial weathering: carpet pile yarn(s)	Minimum length: 10.0m	
UV stabiliser assessment	Minimum length: 1.0m	

3.3 Preparation of test specimens

Following filling, filled test specimens must be conditioned prior to test by passing a hand-pulled roller over the test specimen for 50 cycles (one cycle comprises one outward and one return pass of one roller) in two different directions (split into 25 passes lengthwise and 25 passes in the transverse direction) or five cycles of the Lisport XL. The barrel of the roller must weigh 28.5±0.5kg, be 118±5mm in diameter and have plastic studs mounted as shown below in Figure 1: pattern of studs table and as detailed above in Table 1: minimum size of test specimens. The studs must be as shown below in Table 2: coordinates of stud positions (centre of stud), be manufactured from plastic and have a Shore A hardness of 96±2.

NB: A manufacturing tolerance of ±1mm for the stud positions has been found to be satisfactory.

Figure 1: pattern of studs table

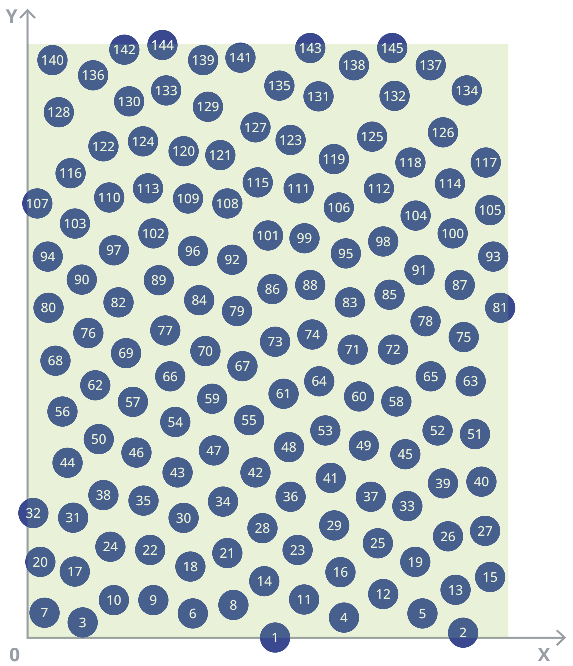


TABLE 2 – COORDINATES OF STUD POSITIONS (CENTRE OF STUD)

STUD	X-AXIS mm	Y-AXIS mm	STUD	X-AXIS mm	Y-AXIS mm	STUD	X-AXIS mm	Y-AXIS mm	STUD	X-AXIS mm	Y-AXIS mm
1	154.5	0.0	38	48.5	89.5	75	272.5	189.0	112	219.0	280.5
2	271.5	4.5	39	259.5	96.0	76	38.5	190.5	113	76.0	282.0
3	35.0	8.5	40	283.0	97.5	77	85.0	192.5	114	263.5	284.0
4	198.5	10.5	41	189.0	100.0	78	249.0	196.5	115	145.5	285.0
5	246.0	13.5	42	142.0	103.0	79	131.5	204.5	116	28.0	291.5
6	105.0	14.0	43	94.5	104.0	80	14.5	207.0	117	286.0	297.0
7	11.5	16.0	44	25.5	109.0	81	294.5	208.0	118	239.0	298.5
8	128.5	19.0	45	235.0	114.5	82	58.5	210.5	119	192.0	300.0
9	79,.0	23.0	46	69.5	116.0	83	201.0	210.5	120	98.0	304.0
10	55.0	23.0	47	118.5	117.5	84	108.5	212.5	121	121.0	304.0
11	173.0	24.0	48	162.5	119.5	85	226.0	215.0	122	48.5	308.0
12	222.0	25.0	49	211.5	119.5	86	153.0	218.0	123	166.0	312.0
13	267.0	30.0	50	46.0	123.5	87	270.0	220.0	124	72.0	312.5
14	149.0	33.5	51	279.5	127.5	88	176.5	220.5	125	215.0	313.5
15	289.5	37.0	52	255.5	128.5	89	82.0	222.5	126	260.0	316.0
16	196.0	40.0	53	185.5	129.5	90	34.5	224.5	127	142.0	319.5
17	31.0	41.0	54	92.5	134.5	91	246.0	231.0	128	21.0	329.0
18	102.0	43.5	55	139.0	136.5	92	128.5	237.5	129	113.0	333.0
19	242.0	46.0	56	22.0	141.0	93	292.0	237.5	130	64.5	336.0
20	8.5	47.0	57	65.5	146.5	94	12.0	238.5	131	180.0	340.0
21	125.0	52.5	58	231.5	149.0	95	199.0	241.0	132	231.0	340.0
22	76.0	54.0	59	114.5	149.5	96	104.0	242.0	133	87.0	342.5
23	169.0	55.0	60	208.0	151.0	97	55.0	243.0	134	275.0	343.5
24	52.0	56.0	61	159.5	152.5	98	222.0	248.0	135	157.5	345.5
25	218.5	57.5	62	42.0	157.5	99	172.5	250.0	136	40.0	352.0
26	263.0	63.0	63	276.0	158.5	100	266.5	252.5	137	251.0	357.5
27	286.0	67.0	64	182.5	160.0	101	150.0	252.5	138	204.0	358.5
28	146.0	68.5	65	252.5	162.5	102	78.5	252.5	139	110.0	362.5
29	193.0	70.5	66	89.0	164.0	103	31.0	259.0	140	16.5	362.5
30	98.5	75.0	67	135.0	170.0	104	242.5	264.5	141	133.0	363.5
31	28.0	75.5	68	18.5	173.0	105	289.0	268.0	142	61.0	368.0
32	5.5	78.0	69	63.0	177.5	106	195.0	270.5	143	177.5	369.0
33	239.0	81.0	70	111.0	179.5	107	7.5	271.0	144	84.5	370.0
34	122.0	85.0	71	204.5	180.0	108	125.0	271.0	145	228.0	370.0
35	73.0	85.5	72	229.0	180.5	109	101.0	274.5			
36	166.0	88.0	73	155.5	184.5	110	51.5	275.5			
37	215.0	88.0	74	178.5	188.5	111	169.5	280.5			

4. TEST CONDITIONS

4.1 Laboratory tests

Laboratory tests must be conducted at an ambient laboratory temperature of 23±2°C.

Test specimens must be conditioned for a minimum of three hours at the laboratory temperature prior to testing.

Laboratory tests must be conducted on dry and wet test specimens as specified in the appropriate test procedure.

4.2 Preparation of wet test specimens

Wet specimens must be prepared by evenly applying to the test piece a volume of water that thoroughly soaks the specimen (if in doubt, this should be equal to the volume of the test specimen). Following wetting, the test specimen must be allowed to drain for 15 minutes and the test carried out immediately thereafter.

5. FIELD (SITE) TESTS

Field tests must be carried out by a FIFA-accredited technician. The FIFA-accredited technician can be supported by another person from the same test institute who does not require accreditation. Any additional people from third-party organisations (club, community, installer, etc.) should not be present on the pitch during testing.

On-site tests must be conducted under the prevailing meteorological conditions, but with the surface temperature in the range of -5°C to +50°C. The field may be tested at temperatures as low as -5°C provided that there is no ice on the field at time of testing.

If the weather conditions make it impossible to undertake tests within the specified temperature range, the deviation from the specified test conditions must be clearly noted in the test report. In cases of failure, a retest must be undertaken within the specified range.

The surface and ambient temperatures and the ambient relative humidity at the time of the test must also be reported.

Ball roll and ball rebound tests must be conducted when the maximum prevailing wind speed is less than 2m/s (unless the test area is screened from the wind). The wind speed at the time of the test must also be reported.

Depending on the type of infill materials in the system, the field may require a period of settling-in prior to the field testing.

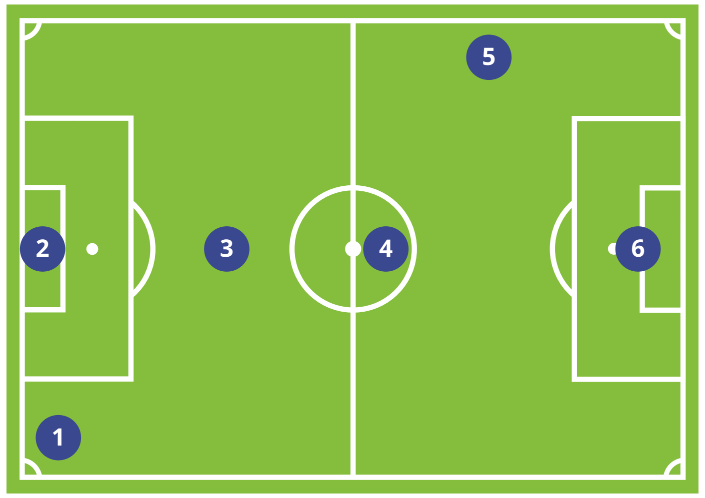
6. FIELD TEST POSITIONS

Unless otherwise specified, on-site tests must be conducted in the positions shown below in Figure 2: field test positions.

All field tests, when not otherwise specified, must be undertaken in positions 1 to 6. The orientation of the test positions must be determined by the FIFA-accredited test institute.

Field tests should not be conducted on joints or inlaid lines, other than ball roll that will traverse them.

Figure 2: field test positions



7. VIDEO FOOTAGE OF FIELD (SITE) TESTS

The following conditions must be met when recording time-lapse footage at the field:

- A full-colour HD-quality (1080) camera must be used.
- The camera must have an unobstructed view of all test locations, including all planarity testing.
- The camera must be secured at least 2.0m off the ground, and ideally 3.0m off the ground.
- Two images of the FIFA-accredited test technician(s) must be provided at the beginning and end of each test session.
- A frame rate of no less than one frame every 30 seconds must be used.

8. BALLS USED FOR TEST

Tests must be conducted with a FIFA Quality Pro ball. Immediately prior to any test, the pressure of the ball must be adjusted so that it gives a rebound on concrete to the underside of the ball, at the prevailing ambient temperature, of 1.45±0.03m, from a drop height of 2.0±0.01m. If the pressure adjustment is excessive and exceeds the ball pressure of its manufacturer's recommended range, the ball should be rejected.

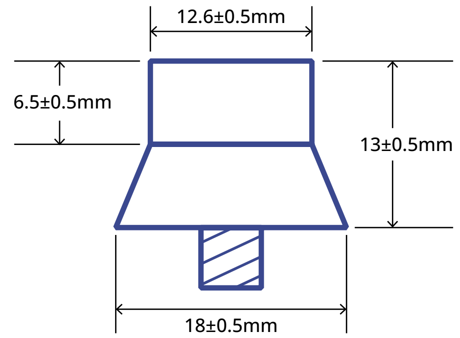
To prevent damage to the skin of the ball, the ball used to measure ball roll must not be used for any other tests.

NB: To minimise the effect on results due to the inherent variations found in balls, FIFA-accredited test institutes are supplied with specially selected test balls.

9. FOOTBALL STUDS USED FOR TEST

The football studs used to test peak torque and rotational shear stiffness (FIFA test methods 06 and 07) and the sample conditioning roller must be in accordance with Figure 3: profile of football stud (new) below. They must be manufactured from plastic and have a Shore A hardness of 96±2.

Figure 3: profile of football stud (new)



9.1 Stud replacement – peak torque and rotational shear stiffness

After a maximum of 50 tests, the length of the studs must be checked. If any stud is found to be less than 11.0mm long, all studs must be replaced.

02.

PLAYER-AND-SURFACE AND FOOTBALL-AND-SURFACE INTERACTION

10. DETERMINATION OF BALL REBOUND (FIFA TEST METHOD 2024-01)

10.1 Scope

The vertical ball rebound test is conducted to assess the bounce characteristics of a football turf surface when a ball is dropped onto it from a specified height. This test method aims to provide an objective measure of the surface's ability to rebound the ball vertically.

10.2 Test apparatus

The test apparatus comprises the following:

a. An electromagnetic or vacuum release mechanism that allows the ball to fall vertically from 2.00±0.01m (measured from the underside of the ball) without imparting any impulse or spin.

b. Vertical scale or laser distance-measuring devices to allow the drop height of the ball to be established.

c. A timing device, activated acoustically, capable of measuring to an accuracy of 1ms.

d. A football as specified in section 8: Balls used for test.

e. A means of measuring wind speed to an accuracy of 0.1m/s (field tests only).

f. A thermometer capable of recording from a minimum range of -10°C to +60°C, accurate to ±0.5°C, to record the surface temperature.

10.3 Test procedure

Validate the vertical rebound of the ball on concrete immediately before testing and adjust it accordingly until it meets the specified value on concrete.

Check the wind speed is in accordance with section 5: Field (site) tests.

Release the ball from 2.00±0.01m, measured from the underside of the ball to above the top of the infill (in filled systems) or the top of the pile (on unfilled systems) of the football turf surface, and record the time between the first and second impact in seconds.

NB: To limit the influence of the valve, it should preferentially be positioned at the top of the ball when the ball is attached.

10.4 Calculation and expression of results

For each test, calculate the rebound height using the following formula:

$$H = 1.23 \times (T-\Delta t)^2 \times 100$$

Where:

- H = rebound height in centimetres
- T = the time between the first and second impact in seconds
- Δt = 0.025s

Report the value of the ball rebound to the nearest 0.01m as an absolute value in metres, e.g. 0.80m.

10.5 Laboratory tests at 23±2°C

10.5.1 Procedure

Determine the ball rebound of the test specimen in five positions, each at least 100mm apart and at least 100mm from the edges of the test specimen. Recondition the sample to its original state as per the manufacturer's declaration prior to each individual ball rebound.

Undertake tests under dry and wet conditions, as appropriate.

10.5.2 Calculation of results

Calculate the mean value of the ball rebound from the five tests.

10.6 Laboratory tests after simulated use (Lisport XL)

10.6.1 Procedure

Condition the test specimen in accordance with Appendix I – Lisport XL: sample preparation procedure.

Leave the sample in place and perform the tests below with the sample in the Lisport XL machine. Record the temperature of the surface to the nearest whole degree.

Determine the ball rebound of the test specimen in a minimum of five positions. Each measurement must be made on the fully conditioned area of the test specimen at least 250mm from any edge and at least 150mm from any other test position. Remove any displaced infill from adjacent tests prior to conducting a test.

Undertake tests under dry conditions, except when moisture is an inherent constituent of the system.

10.6.2 Calculation of results

Calculate and report the mean value of the ball rebound from the five tests.

10.7 Field tests

10.7.1 Test conditions

Tests must be conducted under the meteorological conditions found at the time of the test, subject to the limits of section 5: Field (site) tests. The conditions must be reported.

10.7.2 Procedure

Record the maximum wind speed during the test.

At each test location, make five individual measurements, each at least 300mm apart.

10.7.3 Calculation of results

Calculate the mean value of the ball rebound from the five tests for each test location and report them.

11. DETERMINATION OF BALL ROLL (FIFA TEST METHOD 2024-02)

11.1 Scope

The ball roll test method entails rolling a ball down a ramp and allowing it to traverse the football turf surface until it stops. The distance covered by the ball across the surface is measured and recorded. This test is used to evaluate the rolling characteristics of the surface.

11.2 Test apparatus

The test apparatus comprises the following:

a. A ball roll ramp, as shown below in Figure 4: ball roll ramp, consisting of two smooth parallel rounded bars with a maximum diameter of the contact area with the ball of 40mm, whose inside edges are 100±10mm apart. The ball must transfer from the ramp to the surface without jumping or bouncing.

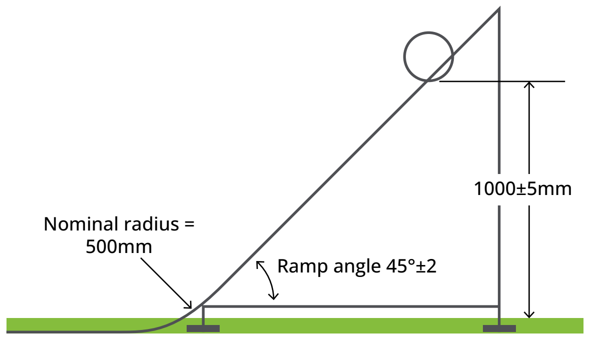
b. A method of measuring the distance the ball rolls to an accuracy of ±0.01m (e.g. using steel tape or a laser).

c. A football as specified in section 8: Balls used for test.

d. A means of measuring wind speed to an accuracy of 0.1m/s (field tests only).

e. A thermometer capable of recording from a minimum range of -10°C to +60°C, accurate to ±0.5°C, to record the surface temperature.

Figure 4: ball roll ramp



11.3 Test procedure

Validate the vertical rebound of the test ball on concrete immediately before the testing and adjust it accordingly until it meets the specified value on concrete.

Adjust the ramp so that it is perpendicular to the surface and so that the end of the guide rails are resting on the top of the infill (in filled systems) or on the top of the pile (on unfilled systems). In practice, the ramp is likely to be resting on the thatch of the non-filled system rather than on top of the pile so that the ball rolls smoothly from the ramp onto the surface without jumping or bouncing.

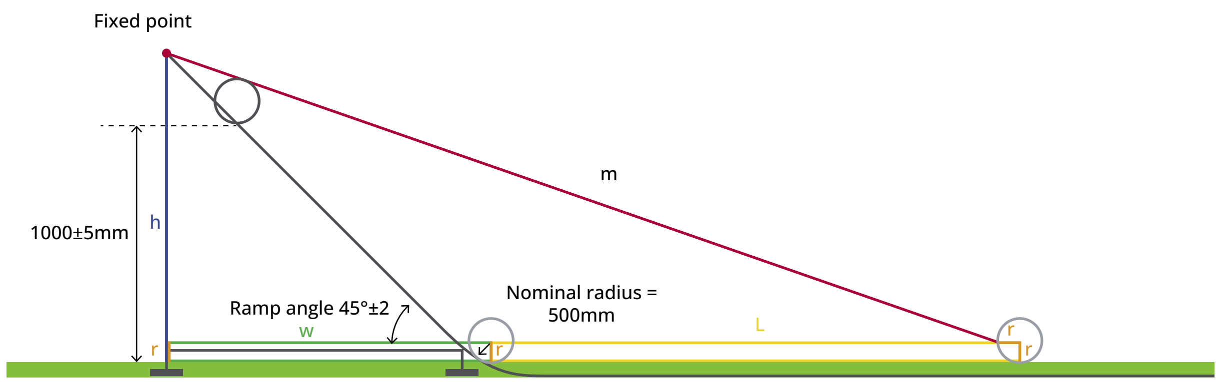
Place the ball on the ball roll ramp so that the point approximately below the centre of the ball sitting on the ramp is 1,000±5mm above the test specimen.

Check the wind speed is in accordance with section 5: Field (site) tests.

Release the ball and allow it to roll down the ramp and across the test specimen until it comes to a rest.

Measure the distance from the point at which the ball first comes into contact with the test specimen (top of carpet pile) to the point below the centre of the ball resting on the test specimen at the position the ball came to a rest.

Figure 4a: additional ball roll length measurement procedure



Ball roll length formula:

$$L=\sqrt{(m^2-{(h-r)}^2)}-w+r$$

11.4 Expression of results

Report the ball roll value to the nearest 0.1m, e.g. 6.9m.

11.5 Field tests

11.5.1 Test conditions

Tests must be conducted under the meteorological conditions found at the time of the test, subject to the limits of section 5: Field (site) tests. The conditions must be reported.

11.5.2 Procedure

Record the wind speed during the test.

At each test location, conduct three individual measurements, each at least 100mm apart.

Undertake the tests in at least four directions (0º, 90º, 180º and 270º) with three individual measurements in each direction to determine if the result is influenced by factors such as slope or turf direction.

If there is a slope, ensure that the ball roll is carried out up and down the slope, and if there is a crown(s), do not perform the test in a location resulting in the ball rolling over the crown in any direction.

11.5.3 Calculation of results

For each test position/direction, calculate the mean value of ball roll from the three tests in each direction.

Calculate the mean value of ball roll from all four directions at each test position.

12 DETERMINATION OF REDUCED BALL ROLL (FIFA TEST METHOD 2024-02A)

12.1 Scope

The ball roll test method using timing gates involves rolling a ball down a ramp onto the football turf surface, where it passes through two sets of timing gates to measure the ball speed over a predetermined distance. By releasing the ball from various heights, the interaction between the ball and surface is assessed throughout different phases of a reduced ball roll, enabling a comprehensive assessment. Using the measured speeds allows for the calculation of the ball's deceleration and the determination of the distance at which it comes to rest.

12.2 Test apparatus

The test apparatus comprises the following:

a. A ball roll ramp as described in section 11.2: Test apparatus.

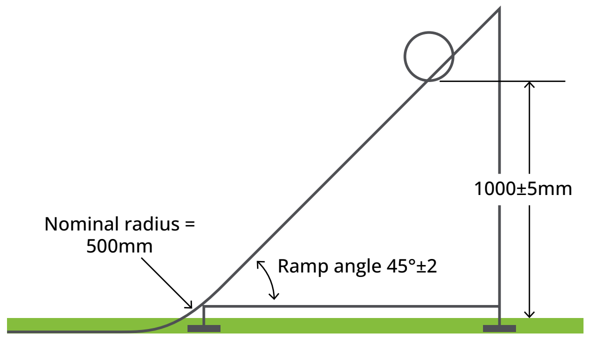
b. A football as specified in section 8: Balls used for test.

c. A distance-measuring device, capable of measuring up to 1mm to an accuracy of ±1mm.

d. An optically activated timing gate system, accurate to a minimum of 1ms, that is triggered by the rolling ball travelling over a distance of 0.2±0.01m. Two sets of timing gates are required to calculate the ball speed between two points.

e. An indoor floor brush with soft bristles used to restore the surface pile at specified intervals during the test.

Figure 5: ball roll ramp



12.3 Test procedure

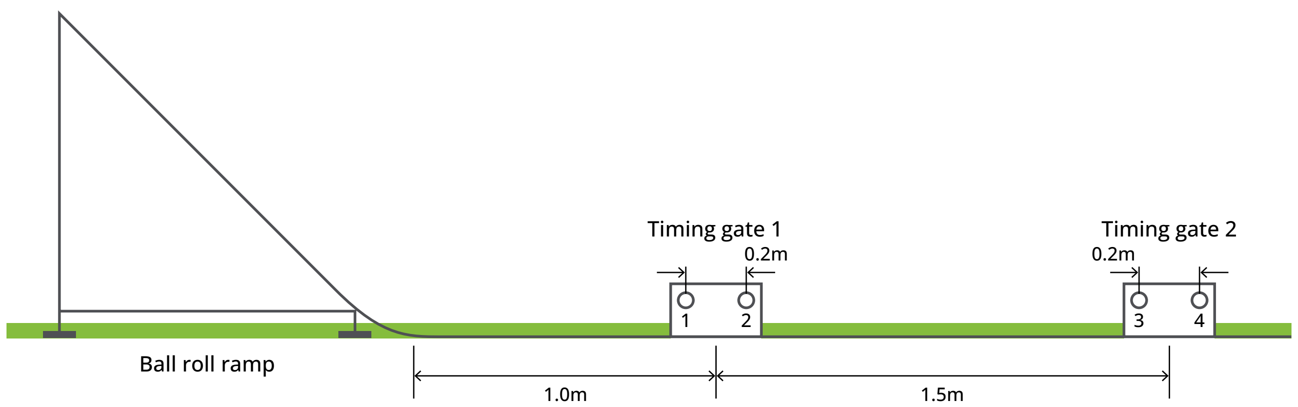
12.3.1 Apparatus set-up

Position the ramp so that it is centred at one end of the test specimen, ensuring that the rails are parallel to the direction being tested. The end of the ramp curve should rest on the infill material, when using filled systems, or on the compressed thatch when using unfilled systems, to ensure that the ball rolls smoothly from the ramp onto the test specimen.

Set up the apparatus as shown above in Figure 5: ball roll ramp.

Timing gates consist of two sensors that activate a timer as the ball passes. These sensors are spaced 200±10mm apart. Measure the exact distance and include this measurement in the calculation of the results. The distance from the ball roll ramp, where the ball contacts the surface, to the centre of the first timing gate must be 1.0±0.01m. This is to ensure that the ball rolls smoothly along the surface before it passes the timing gates. The distance between the centres of timing gate 1 and timing gate 2 must be 1.5±0.01m.

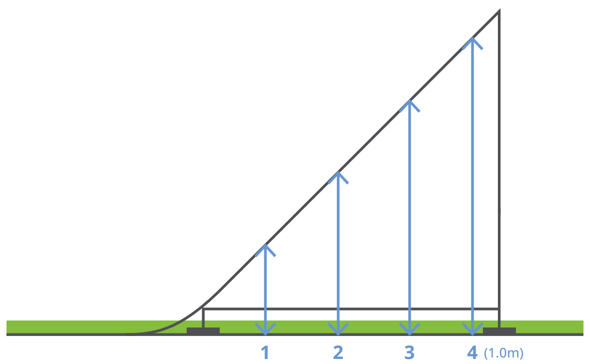
Figure 6: ball roll ramp and timing gate positions



Four release heights should be selected on the ramp from which to release the ball, as shown in Figure 7: ball release heights. Release height 1 should be the lowest height selected on the ball ramp. This should be adjusted to ensure that the ball stops between 0.1m and 0.25m past the second timing gate. The final release height is the highest and should be the same as a standard ball roll, namely 1.0±0.01m.

The other two release heights are intermediate release heights and should be evenly incremented between heights 1 and 4. Release heights are measured vertically as the distance from the lowest point on the ball, when placed on the ramp, to the infill level on the turf using the distance measuring device. All release heights must be repeatable to ±0.01m.

Figure 7: ball release heights



12.3.2 Test specimens

To conduct this test method, a specimen of at least 3x1m must be prepared and infilled, where appropriate, in accordance with EN 12229:2014 to the manufacturer's specification.

12.3.3 Procedure

Place the ball on the ramp so that the lowest point of the ball is in contact with position 1 as defined above in Figure 7: ball release heights. Release the ball and allow it to roll freely across the test specimen at a minimum of 250mm from the edges of the test specimen and through the timing gates using the optically activated timing gate system specified in section 12.2: Test apparatus. Record the initial speed, "v_{start}", at timing gate 1 and the final speed of the ball, "v_{end}", as recorded by timing gate 2.

v_{start} and v_{end} are calculated using the relationship between speed, distance and time using t_{gate1} and t_{gate2}.

Equation 1: relationship between speed, distance and time

$$v = \frac{S_s}{t}$$

"S_s" is defined as the exact distance between each timing sensor as measured. "t" is the time taken for the front of the ball to traverse between timing sensor 1 and timing sensor 2 (t_{gate1}). The same calculation is conducted for v_{end} using timing sensor 3 and timing sensor 4 (t_{gate2}).

The process is then repeated twice more to give three sets of results for the three ball release heights.

The surface must be restored using a brush each time that two ball rolls have been conducted. The brushing is conducted as a drag motion and repeated only once at a walking pace.

These steps should be repeated for all four release heights. Three sets of v_{start} and v_{end} must be collected for the first two lower release heights, but only two sets of v_{start} and v_{end} must be collected for the top two heights.

12.4 Calculation and expression of results

At the completion of the test procedure, ten combinations of v_{start} and v_{end} should have been collected for four different release heights.

The first stage of the calculation is to determine the averages of v_{start} and v_{end} for each height. This will give four values of v_{start} and four for v_{end}. Using the four combinations of starting and ending speeds, it is possible to represent a relationship between v_{start}/v_{end} as a second-order polynomial equation that reflects the interaction between the ball and the surface over a variety of ball roll speeds.

A second-order polynomial for this relationship is as follows:

Equation 2: second-order polynomial equation construction

$$v_{end} = a\,(v_{start})^2 + b\,(v_{start}) + c$$

Using this relationship and the average v_{start} from height 4 on the ramp, which is the release height for standard ball roll measurements, this equation can be used to estimate v_{end} of the ball after 1.5m. The predicted v_{end} value is then used as the value, v_{start}, for another iteration of this process. This process is repeated until $v_{end} \leq 0$.

To obtain the first part of the ball roll length:

Equation 3: primary ball roll calculation

$$S_p = \text{Number of iterations} \times S_g$$

"S_p" is the distance the ball has travelled in the initial phase of the ball roll calculation. "S_g" is the distance measured between each set of timing gates and is defined in this method as 1.5m. The "number of iterations" is the number of times the polynomial equation is repeated before the iteration where $v_{end} \leq 0$.

The second part of the ball roll length, or residual ball roll, is a calculation based on predicting the time taken for the ball to come to a complete stop from the v_{start} of the last iteration – where v_{end} becomes negative. To calculate this, first calculate the deceleration of the ball through the second-last iteration:

Equation 4: kinematic equation for time-independent acceleration

$$a_1 = \frac{(v_{end})^2 - (v_{start})^2}{2S}$$

This deceleration value can then be used to calculate the deceleration for the final phase of the ball roll until v_{end} = 0m/s. This equation is constructed using a_1 and v_{start} from the final iteration of the polynomial process where $v_{end} \leq 0$. Equation 5 can then be used to calculate the last portion of the ball roll distance, S_r, which occurs from the end of S_p until v_{end} = 0m/s where the ball would be at rest.

Equation 5: rearranged form of equation 4 to give distance as the subject

$$S_r = \frac{-(v_{start})^2}{2a_1}$$

The predicted ball roll calculation, which is comparable to a standard full-length ball roll, comprises:

Equation 6: predicted ball roll calculation using results from equations 3 and 5

$$\textbf{Predicted ball roll} = S_i + S_p + S_r$$

"S_i" is the distance specified between the end of the ramp and the middle of the first light gate (1.0m).

Predicted ball roll results must be reported for both test specimen directions. Each direction must be reported individually to an accuracy of 0.1m.

13. DETERMINATION OF SHOCK ABSORPTION (FIFA TEST METHOD 2024-03)

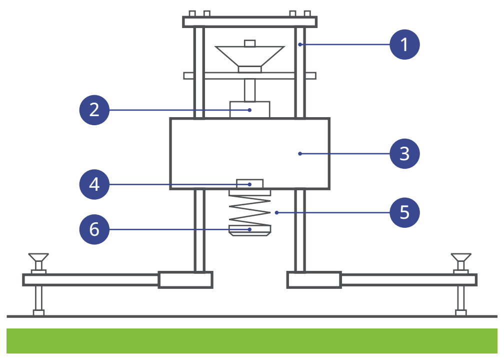
13.1 Scope

The shock absorption test method for a football turf surface involves releasing a mass with an attached spring onto the test specimen and recording its acceleration from release to impact. The shock absorption is determined by comparing the maximum force exerted on the test specimen with the reference force of impact on concrete, allowing for the calculation of the reduction in impact force on the sample. The reference force (F_{ref}) is a fixed value of 6,760N, which is a theoretical calculation for a concrete floor.

13.2 Test apparatus

The apparatus used to measure shock absorption is called the advanced artificial athlete (AAA). The schematic design of the AAA apparatus is depicted below in Figure 8: AAA test apparatus, together with a list of its main components, which are further specified below.

Figure 8: AAA test apparatus



Key:

1 Guide for the falling mass	4. Accelerometer
2. Electromagnet	5. Spring
3. Falling mass	6. Test foot

13.2.1 Electromagnet (2)

The electromagnet holds the mass (3) at the specified height, which can be set to an accuracy of ±0.25mm.

13.2.2 Falling mass (3)

The falling mass incorporates an accelerometer (4), a spiral metal spring (5) and a steel test foot (6).

The total mass of (3) + (4) + (5) + (6) must be 20,000±100g.

The falling mass must have the guiding system systematically cleaned. Since it is normally lubricated, dust and dirt can remain on the sliding part, creating an alteration in the falling velocity. Sometimes this is visible on the graph during the calibration, but sometimes this behaviour is not linear so it can again alter the reading of the values as the mass slows down during the free-falling phase, giving incorrect values.

Due to the importance of having a constant acceleration profile of the falling mass, the guiding system should not introduce any friction to the system. A simple bronze bush or a self-lubricating plastic bush should be used as a guide as opposed to using a bearing system. A system using a bronze or plastic bush is more reliable and easier to keep clean, retaining less dust and dirt. When removable masses are used to make the device transportable, these should have a screwing system so that the masses can be locked firmly into the working position.

13.2.3 Verticality of the device

The device must be positioned vertically (90±1°) on the surface to be tested with the help of the bubble/spirit level mounted on it. If the device is inclined, the velocity of the mass can change during the free-falling phase, introducing errors into the measurements. This point is especially important for the energy return value. If the device is not placed vertically on the surface, the slope and consequently the friction generated on the guiding system during the free-falling phase will result in a great variation of the energy return value.

13.2.4 Direct-current accelerometer (4)

The accelerometer has a full-scale capacity of 40-50g, with a direct current response (0Hz response) and the following characteristics:

Minimum cut-off frequency: 1,000Hz (attenuation of -3db)

Linearity: below 2% around 100Hz between the two ranges of calibration (e.g. 1-5g and 30-40g)

The g-sensor should be positioned on the vertical line of gravity of the falling mass over the spiral steel spring. The g-sensor should be firmly attached to the mass to avoid natural filtering or extraneous vibrations of the accelerometer.

13.2.5 Spiral steel spring (5)

The spring rate is 2,000±100N/mm and is linear over the 0.1-7.5kN range.

The linear characteristic of the spring is controlled with a maximum increment of 1,000N.

The spring must be positioned centrally below the point of gravity of the falling mass.

The spring must have three coaxial coils rigidly fixed together at their ends.

The mass of the spring must be 800g±50g.

13.2.6 Test foot (6)

The test foot has a diameter of 70±1mm and a minimum thickness of 10mm.

The lower side part of the test foot is rounded with a radius of 500±50mm and has an edge radius of 1mm.

The mass of the test foot must be 400±50g.

13.2.7 Test apparatus frame

The frame consists of three adjustable supporting feet.

- The feet are at a distance of not less than 250mm from the point of impact of the falling mass on the test specimen.
- The frame is designed to ensure that the mass of the apparatus is equally distributed on its three feet.
- For the apparatus with the mass, the pressure resulting on each foot must be less than 0.020N/mm². For the apparatus without the mass, the pressure resulting on each foot must be more than 0.003N/mm².

13.2.8 Signal recording

A means of filtering and recording the signal from the accelerometer and a means of displaying the recorded signal (see Figure 9: example of curve representing falling mass acceleration v. time).

Sampling rate: minimum 9600Hz.

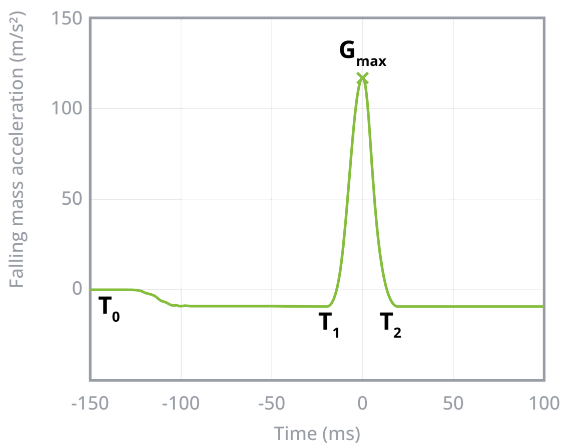
Electronic analogue-to-digital converter with a minimum resolution of 16 bits.

Signal filtration with a second-order low-pass, Butterworth filter with a cut-off frequency of 500Hz.

Signal sensor is equal to 0 before any displacement of the mass (offset can be applied).

Acceleration signal data with time base must be recorded and stored.

Figure 9: example of curve representing falling mass acceleration v. time



Where:

- T_0 = time when the mass starts to fall
- T_1 = time when the test foot makes the initial contact with the surface (algorithm described in 14.4.1)
- T_2 = time when the test foot makes the final contact with the surface (algorithm described in 14.4.1)
- G_{max} = peak acceleration

13.3 Auxiliary equipment for tests at -5°C

A conditioning cabinet capable of maintaining a temperature of -8°C to -12°C.

A tray for test specimens with the following design specifications:

Internal dimensions of at least 450x450mm.

Depth at least 10mm higher than the test specimen thickness.

Base of rigid mesh to allow the free draining of water from the test specimens.

A thermometer capable of recording from a minimum range of -15°C to + 60°C, accurate to ±0.5°C, to record the surface temperature.

13.4 Auxiliary equipment for tests at 50°C

An air-circulating oven compliant with ISO 188.

A thermometer capable of recording from a minimum range of -15°C to + 60°C, accurate to ±0.5°C, to record the surface temperature.

A thermometer capable of recording from a minimum range of -10°C to + 60°C, accurate to ±0.5°C, to record the surface temperature for site testing.

13.5 Verification of the apparatus: falling mass impact velocity and lift height

This verification is essential to ensure the correct functioning of the apparatus and is compulsory.

For laboratory tests: at regular intervals, in accordance with the intensity of usage of the apparatus. The recommendation is for one verification for every day of testing.

For field tests: before any on-site field testing.

The verification procedure consists of four steps and must be carried out on a concrete floor of minimum thickness of 100mm and of minimum hardness of 40MPa, verified according to EN 12504-2: Testing concrete in structures – Part 2: Non-destructive testing – Determination of rebound number.

Step one

Set up the apparatus for a vertical free drop. Verticality tolerance: maximum of 1°.

Set the height of the lower face of the test foot at 55.00±0.25mm above the rigid floor.

Drop the mass on the concrete floor and record the acceleration of the falling mass.

Step two

Repeat step one twice more, creating a total of three impacts.

Step three

For each impact, integrate the acceleration signal from T_0 to T_1 and calculate the initial impact velocity. Calculate the mean impact velocity of the three impacts.

The mean impact velocity must be in the 1.02-1.04m/s range.

Step four

After verification of the impact velocity, place the falling mass on the rigid floor.

Measure the height between a static reference point on the apparatus (e.g. the underside of the electromagnet) and the top of the falling mass.

This height will be a reference and must be used for all subsequent measurements; it is designated as the "lift height".

13.6 Test procedure

Set up the apparatus vertically (90±1°) on the test specimen.

Lower the test foot smoothly onto the surface of the test specimen.

Within ten seconds, set the reference lift height described in step four of the verification of the apparatus above and attach the falling mass to the electromagnet.

First impact

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

Within ten seconds of the impact, check the lift height and reattach the mass to the electromagnet.

13.6.1 Shock absorption calculation

Calculate the peak force (F_{max}) upon impact with the following formula:

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

Where

- F_{max} = the peak force, expressed in newtons (N)
- G_{max} = the peak acceleration during the impact, expressed in multiples of the acceleration due to gravity (g) (1g = 9.81m/s²) considering that sensor value is equal to 0g at the beginning of the recording when the mass is static

$$F_{(t)} = m \times g \times (G_{(t)} + 1)$$

- m = the falling mass, including spring, test foot and accelerometer, expressed in kilograms
- g = the acceleration by gravity (9.81m/s²)

Calculate the peak force (F_{max}) upon impact as the maximum force value (see Figure 10: example curves showing falling mass acceleration v. time (left) and force on test specimen v. time (right)).

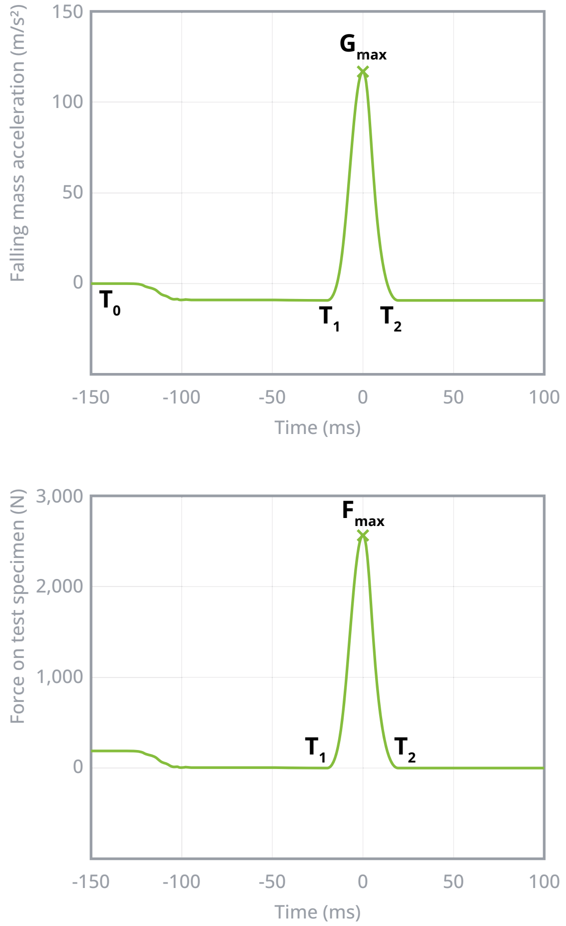
Calculate the shock absorption using the following formula:

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

Where:

- SA = the shock absorption, expressed as a percentage
- F_{max} = the force max measured on the sport surface, in newtons
- F_{ref} = the reference force fixed to 6,760N (theoretical value calculated for a concrete floor)

Figure 10: example curves showing falling mass acceleration v. time (top) and force on test specimen v. time (bottom)



13.6.2 Expression of results

Report the shock absorption value to the nearest 0.1%, e.g. 56.9%.

13.7 Laboratory tests

The laboratory test floor must be a concrete floor with the following characteristics:

A minimum thickness of 100mm.

Concrete hardness of a minimum of 40MPa, verified according to EN 12504-2: Testing concrete in structures, Part 2: Non-destructive testing – Determination of rebound number.

13.7.1 Laboratory tests at 23±2°C

Make a single impact on the test specimen according to the test procedure described in section 13.6: Test procedure.

Repeat the procedure in three positions, each at least 100mm apart and at least 100mm from the edges of the test specimen.

Calculate the mean value of shock absorption of the three positions.

Undertake tests under dry and wet conditions, as appropriate.

13.7.2 Laboratory tests at -5°C

Place the test specimen in the sample tray and immerse in water to a depth of at least 10mm above the top of the artificial-turf pile.

After a minimum of one hour, remove the test specimen from the water and place it on a free-draining base to allow it to drain by gravity for 30±2 minutes.

Place the test specimen and sample tray in a conditioning cabinet at a maximum temperature of -8°C.

After a minimum of 24 hours, remove the test specimen and tray from the conditioning cabinet. Unless the test specimen includes an unbound mineral base, carefully remove it from the tray, ensuring any infill materials are not disturbed.

Place the test specimen on the test floor and allow it to warm. Monitor its temperature by inserting a temperature probe into the top of the performance infill on filled systems or on the top of the primary backing for non-filled systems.

When the temperature probe reads -5°C, record the shock absorption (force reduction) (only one impact). Move the AAA and repeat to obtain three results.

The temperature of the test specimen must not rise above -3°C during the test.

Do not brush or adjust the surface in any way before the impacts.

Undertake tests under dry conditions only.

Calculate the mean value of shock absorption (force reduction) (-5°C) of three initial impacts.

NB: Cooling a concrete slab in the freezer and using this as the test floor will extend the length of time available to undertake the tests. The concrete slab must be flat and not move during the tests.

13.7.3 Laboratory tests at 50°C

Preheat the oven to a temperature of 50+2°C.

Place the test specimen inside the oven.

Inside the oven, the test specimen must be stable, unrestrained and exposed to circulating air on all sides.

After 240±5 minutes, remove the test specimen from the oven and place it on the test floor.

Monitor the temperature of the test specimen by inserting a temperature probe into the top of the performance infill on filled systems or on the top of the primary backing for non-filled systems.

Determine the shock absorption, making a single impact on one location, according to the test procedure described in section 13.6: Test procedure.

The temperature of the test specimen must not fall below 48°C.

Undertake tests under dry conditions only.

Calculate the shock absorption (force reduction) (50°C).

If the result of this initial (first) position fails the requirement, repeat the procedure on two other locations, at least 100mm apart from each other and at least 100mm from the edges of the test specimen.

Calculate the mean value of the shock absorption (50°C) of the three test positions.

NB: Heating a concrete slab in the oven and using this as the test floor extends the length of time available to undertake the tests. The concrete slab must be flat and not move during the tests.

13.7.4 Laboratory tests after simulated use (Lisport XL)

Condition the test specimen for the specific quality level in accordance with Appendix I – Lisport XL: sample preparation procedure.

Whenever possible, perform the tests with the test specimen inside the Lisport XL machine or carefully remove the test specimen from the Lisport XL machine and place it on the test floor.

Determine the shock absorption of the test specimen from a single impact in five positions.

Each measurement must be made on the fully conditioned area of the test specimen, at least 250mm from any edge and at least 150mm from any other test position.
Undertake tests under dry conditions only.

Calculate the mean value of shock absorption (force reduction) of the second and third impacts for each test position.

Calculate the mean value of shock absorption (force reduction – simulated use) from the five test positions.

13.8 Field tests

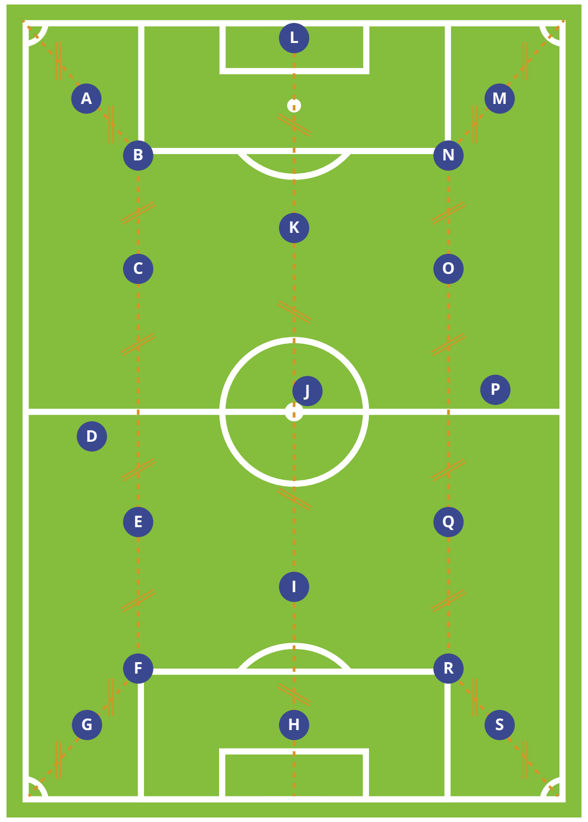
13.8.1 Test conditions

Tests must be conducted under the meteorological conditions found at the time of the test, subject to the limits of section 5: Field (site) tests. The conditions must be reported.

13.8.2 Procedure

Tests must be conducted in the 19 test positions shown below in Figure 11: field test positions. Fifteen test positions are essentially fixed and must be in the general positions shown. Positions F, R, N and B may be in the positions shown or other locations selected at the discretion of the FIFA-accredited technician. Bonded carpet joints should be avoided unless they are the cause of complaint or concern.

Figure 11: field test positions



13.8.3 Calculation of results

Report the values of shock absorption for each test location.

14. DETERMINATION OF PEAK DEFORMATION (FIFA TEST METHOD 2024-04)

14.1 Scope

The peak deformation test method for a football turf surface involves releasing a mass with a spring attachment onto the test specimen and recording its acceleration from release to impact. The maximum displacement of the falling mass into the test specimen after impact is used to calculate the peak deformation of the specimen. This test assesses the extent of deformation experienced by the test specimen upon impact.

14.2 Test apparatus

See the description in section 13.2: Test apparatus.

14.3 Verification of the apparatus

See the description in section 13.5: Verification of the apparatus: falling mass impact velocity and lift height.

14.4 Test procedure

See the description in section 13.6: Test procedure.

14.4.1 Calculation and expression of results

The velocity (V_{mass} (t)) and displacement (D_{mass} (t)) of the falling mass are calculated by single and double integration respectively of the falling mass acceleration over the full signal (see section 13.6.1: Shock absorption calculation). For the velocity integration, $V_{mass}(t)$ is 0m/s at the start of the signal (before the drop commences). For the displacement integration, the D_{mass} (t) is 0mm at the time of initial contact between the test foot and test specimen (T1 in section 13.6.1: Shock absorption calculation).

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

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

Where:

- $D_{spring}(t)$ = the compression of the spring (mm)
- F(t) = the force applied by the falling mass on the test specimen, as detailed in section 13.6.1: Shock absorption calculation, expressed in newtons
- C_{spring} = the spring rate, as detailed in section 13.2.5: Spiral steel spring, expressed in newtons per millimetre

Deformation of the test specimen, $D_{specimen}(t)$, throughout the time interval [T1, T2] is given by:

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

Where:

- $D_{specimen}(t)$ = the deformation of the test specimen, expressed in millimetres
- $D_{test\ foot}(t)$ = the displacement of the test foot, expressed in millimetres

The time interval [T1, T2] is determined as follows:

Calculate the gradient of the force versus time curve through numerical differentiation of the data. Low pass filter the output using a second-order Butterworth filter with a cut-off frequency of 250Hz. The resulting curve is termed the force gradient.

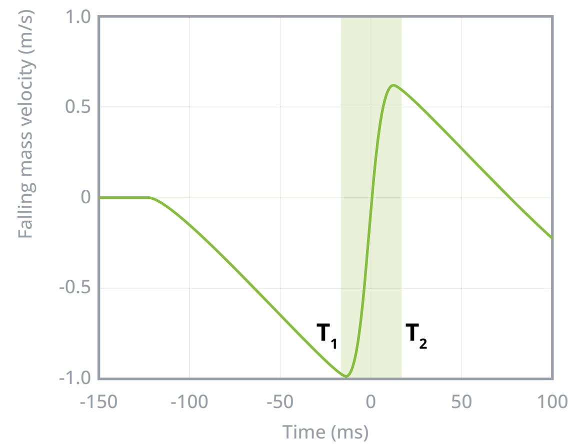
T1: Find the last point before peak force where the force versus time curve crosses the 30N line. If the force gradient at this point exceeds 10kN/s, this is defined as T1. If the force gradient at this point does not exceed 10kN/s, move forwards in time until this condition is first met, and this is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

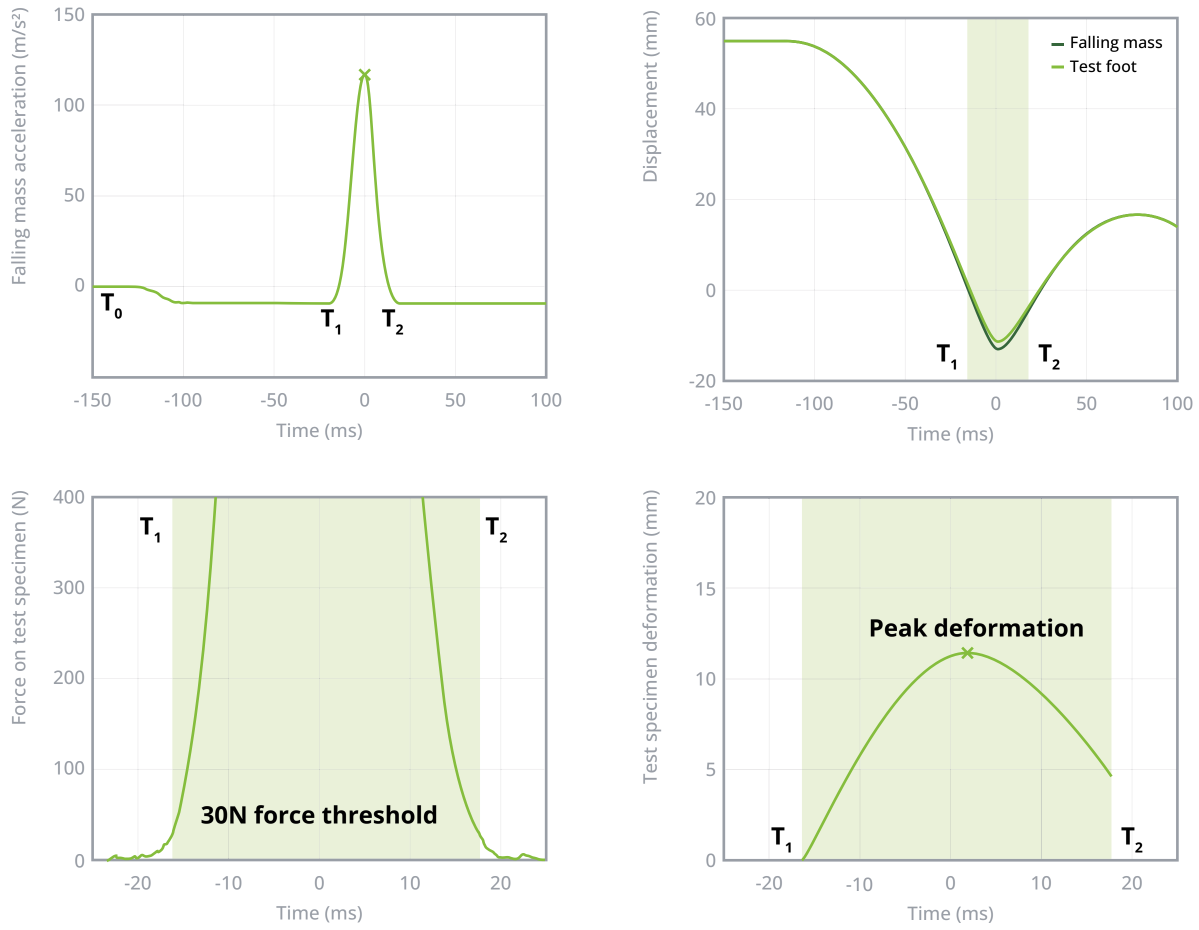
T2: Find the first point after peak force where the force versus time curve crosses the 30N line. If the absolute force gradient at this point exceeds 10kN/s, this is defined as T2. If the absolute force gradient at this point does not exceed 10kN/s, move backwards in time until this condition is first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

Peak deformation (Dpk) of the test specimen is defined as the maximum value of $D_{specimen}(t)$ on the interval [T1, T2]. Please see Figure 12: example curves of falling mass acceleration v. time (top left), test specimen force (illustrating the contact phase) v. time (top right), falling mass velocity v. time (middle left), falling mass and test foot displacements v. time (bottom left) and test specimen deformation v. time (bottom right).

Figure 12: example curves of falling mass acceleration v. time (below left), test specimen force (illustrating the contact phase) v. time (bottom left), falling mass velocity v. time (top right), falling mass and test foot displacements v. time (below right) and test specimen deformation v. time (bottom right)

Peak deformation is reported to the nearest 0.1mm.





14.5 Laboratory tests

14.5.1 Laboratory tests at 23±2°C

Peak deformation is calculated for the three positions tested for shock absorption (see section 13.7.1: Laboratory tests at 23±2°C).

Calculate the mean value of peak deformation of the three test positions.

Undertake tests under dry and wet conditions, as appropriate.

14.5.2 Laboratory tests at -5°C

Peak deformation is calculated for the position tested for shock absorption (see section 13.7.2: Laboratory tests at -5°C).

Calculate the mean value of peak deformation (-5°C) of the three initial impacts.

14.5.3 Laboratory tests at 50°C

Peak deformation is calculated for the position tested for shock absorption (see section 13.7.3: Laboratory tests at 50°C).

If required, calculate the mean value of peak deformation (50°C) from the three test positions.

14.5.4 Laboratory tests after simulated use (Lisport XL)

Peak deformation is calculated for the position(s) tested for shock absorption (see section 13.7.4: Laboratory tests after simulated use (Lisport XL)).

Undertake tests under dry conditions only.

Calculate the mean value of peak deformation (simulated use) from the five test positions.

14.6 Field tests

14.6.1 Test conditions

Tests must be conducted under the meteorological conditions found at the time of the test, subject to the limits of section 5: Field (site) tests. The conditions must be reported.

14.6.2 Procedure

Peak deformation is calculated for the positions tested for shock absorption (see section 13.8.2: Procedure).

14.6.3 Calculation of results

Report the values of peak deformation for each test location.

15 DETERMINATION OF ENERGY RETURN (FIFA TEST METHOD 2024-05)

15.1 Scope

The energy return test method for a football turf surface involves releasing a mass with a spring attachment onto the test specimen and recording its acceleration from release to impact. The energy return is determined by analysing the energy transferred back to the falling mass during the unloading phase. This test assesses the ability of the surface to return energy upon impact.

15.2 Test apparatus

See the description in section 13.2: Test apparatus.

15.3 Verification of the apparatus

See the description in section 13.5: Verification of the apparatus: falling mass impact velocity and lift height.

15.4 Test procedure

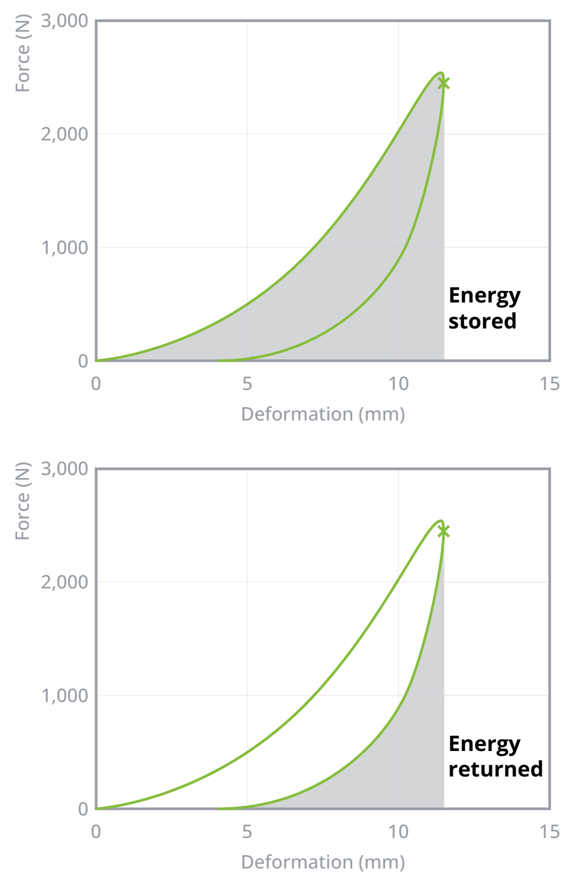
See the description in section 13.6: Test procedure.

15.4.1 Calculation and expression of results

The energy return to the falling mass is determined from the area under the unloading phase of the test specimen force versus the deformation curve. The area is calculated using the trapezium rule (see Figure 13: example curves of test specimen force v. deformation, illustrating the area under the loading curve or energy stored (right) and the area under the unloading curve or energy returned to the falling mass (left)). The force is calculated as described in section 13.6.1: shock absorption calculation and the deformation is calculated as described in section 14.4.1: calculation and expression of results.

Energy return is reported to the nearest 0.1J.

Figure 13: example curves of test specimen force v. deformation, illustrating the area under the loading curve or energy stored (right) and the area under the unloading curve or energy returned to the falling mass (left)



15.5 Laboratory tests

15.5.1 Laboratory tests at 23±2°C

Energy return is calculated for the three positions tested for shock absorption (see section 14.5.1: Laboratory tests at 23±2°C).

Undertake tests under dry and wet conditions, as appropriate.

Calculate the mean value of energy return of the three test positions.

15.5.2 Laboratory tests at -5°C

Energy return is calculated for the three positions tested for shock absorption (see section 14.5.2: Laboratory tests at -5°C).

Calculate the mean value of energy return of the three test positions.

15.5.3 Laboratory tests at 50°C

Energy return is calculated for the three positions tested for shock absorption (see section 14.5.3: Laboratory tests at 50°C).

Calculate the mean value of energy return of the three test positions.

15.5.4 Laboratory tests after simulated use (Lisport XL)

Energy return is calculated for the position tested for shock absorption (see section 14.5.4: Laboratory tests after simulated use (Lisport XL)).

Undertake tests under dry conditions only.

Calculate the mean value of energy return (simulated use) of the five test positions.

15.6 Field tests

15.6.1 Test conditions

Tests must be conducted under the meteorological conditions found at the time of the test, subject to the limits of section 5: Field (site) tests. The conditions must be reported.

15.6.2 Procedure

Energy return is calculated for the position tested for shock absorption (see section 14.6.2: Procedure).

15.6.3 Calculation of results

Report the values of energy return for each test position.

16. DETERMINATION OF PEAK TORQUE (FIFA TEST METHOD 2024-06)

16.1 Scope

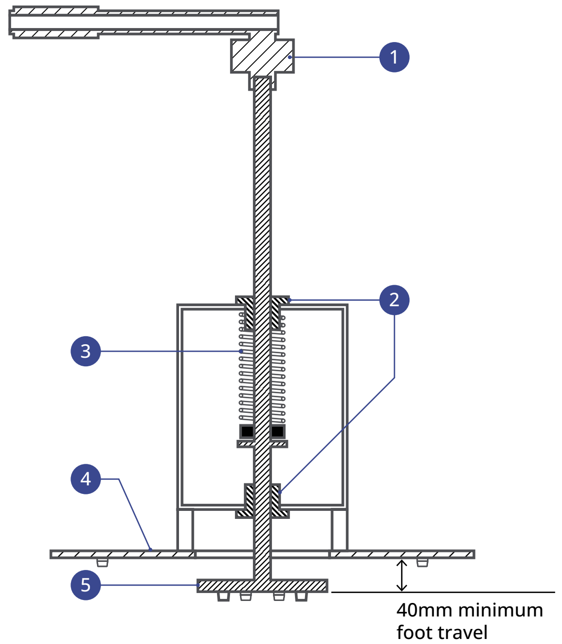
The peak torque test method for a football turf surface measures the maximum torque needed to rotate a loaded foot placed flat on the test surface, with a central axis of rotation perpendicular to the surface. This measurement determines the rotational resistance of the surface.

16.2 Test apparatus

A schematic presenting the mechanical configuration of the apparatus is provided below in Figure 14: rotational traction athlete (RTA) apparatus. It comprises the following components:

- A circular test foot of diameter 150±2mm, with six football studs (as described above in section 9: Football studs used for test) equally spaced on the underside of the test foot on a pitch radius of 46±1mm from the centre of the disc.
- A shaft is rigidly attached to the test foot and supported by a minimum of two low-friction bushings or bearings positioned at least 200mm from one another. The shaft-foot assembly must freely rotate around the vertical (Z) axis only. When in operation, the shaft-foot assembly slides linearly in the vertical axis, facilitating compression of the internal spring.
- The body of the device is rigidly attached to a baseplate upon which the operator stands or kneels. A minimum of six football studs (as described in section 9: Football studs used for test) are arranged on the underside of the baseplate to minimise any counterrotation during operation.
- A single-handled torque wrench of length 500±10mm that attaches to the top of the shaft. The mass of the torque wrench should not exceed 2.5kg.
- A torque sensor (minimum range 0-60Nm, to an accuracy of ±1Nm including calibration uncertainty) and an angle sensor both attached to the shaft and capable of recording the torque and angle data throughout the full rotation of the test foot. There should be a means to calibrate the angle sensor to an accuracy of 0.5° between 0° and 90°. The total mass of the sensors and attachments should not exceed 1.0kg.
- A means of recording and filtering the signals from the torque and angle sensors and a means of displaying the resulting signals (see Figure 15: example plots of torque v. angle (top) and angle v. time (bottom) from an RTA trial). The minimum sampling rate should be 250Hz and the A/D (analogue-to-digital) converter should have a minimum resolution of 16 bits. Angle and torque signals data with time base must be recorded and stored.
- The device houses a spring of 4±1N/mm stiffness. The spring stiffness must remain within this tolerance over a compressed distance of at least 50mm following any precompression, or 150mm when no precompression is used.

Figure 14: RTA apparatus



Key:
1 Digital torque transducer
2. Low-friction bush or bearing to enable free linear and rotational movement
3. Compression spring of 4±1N/mm stiffness
4. Studded baseplate
5. Studded test foot

The device applies a force of 450N±20N through the test foot onto the surface when compressed by the operator standing mounting the baseplate. The spring must compress by a minimum of 40mm when the device is mounted, at which point the underside of the test foot must align horizontally with the underside of the baseplate.

The applied force must include the force generated by the compression spring in addition to any downward force resulting from the mass of the shaft-foot assembly and any rigidly affixed components thereof.

When standing on the baseplate, the technician must take extra care to ensure that the underside of the studded disc is parallel to the underside of the baseplate and no counterrotation of the baseplate occurs whilst applying torque to the shaft-foot assembly.

In the equipment design, thought must be afforded to reducing to a minimum any source of rotational friction not resulting from the interaction between the test foot and surface, including but not limited to the shaft support mechanism, spring support mechanism and any other mating surface that may affect the peak torque value measured.

16.3 Test procedure

Before conducting each test, ensure that the disc and studs are cleared of any infill/detritus.

Assemble the apparatus and ensure the free movement of the shaft and test foot. Place the test foot onto a representative area of the surface and avoid any large particles that may be present, which could affect the stability of the baseplate or the values recorded by the test foot.

The technician puts their first foot or knee on the baseplate and then puts their second foot or knee on the baseplate.

The technician then lifts their first foot/knee from the baseplate and puts it back on the baseplate. They also lift their second foot/knee from the baseplate and put it back on the baseplate. This balancing operation serves to force the baseplate studs into the surface, ensuring that it is both flat and stable upon the surface. Without placing any vertical pressure on the torque wrench and applying minimum rotational torque to the torque wrench, the technician turns the wrench and test foot smoothly, without jerking, a minimum of 90° for a duration of approximately four seconds.

Record the maximum value displayed on the torque meter to the nearest 0.1Nm.

16.4 Laboratory tests

Determine the peak torque in five positions, ensuring each test position is at least 100mm (outside edge of the test foot to the outside edge) apart and at least 100mm (outside edge of the test foot) from the sides of the test specimen. If the mean rotational velocity for any trial is below 20°/s or above 50°/s, repeat the trial in a new position. Calculate the mean from the five test positions.

Undertake tests under dry and wet conditions, as appropriate.

16.5 Laboratory test after simulated use

Whenever possible, perform the tests with the test specimen inside the Lisport XL machine or carefully remove the test specimen from the Lisport Wear machine and place it on the test floor. Determine the peak torque, the rotational shear stiffness and the torque at 10° of the test specimen in five positions. Each measurement must be conducted on the fully conditioned area of the test specimen, at least 250mm from any edge and at least 100mm from any other test position. If the mean rotational velocity for any trial is below 20°/s or above 50°/s, repeat the trial in a new position. Calculate the mean from the five test positions.

16.6 Field tests

16.6.1 Test conditions

Tests must be conducted under the meteorological conditions found at the time of the test, subject to the limits of section 5: Field (site) tests. The conditions must be reported.

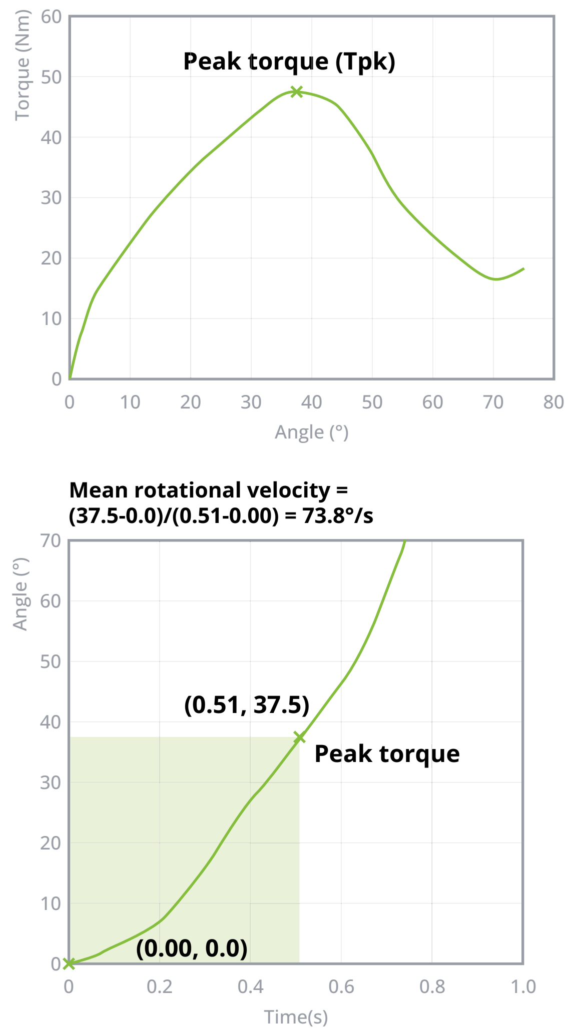
16.6.2 Procedure

At each test location, conduct five individual measurements, each at least 100mm (outside edge of the baseplate to outside edge of the baseplate) apart. If the mean rotational velocity for any test is below 20°/s or above 50°/s, repeat the test in a new position.

16.7 Calculation and expression of results

Low pass filter both the torque and angle data at 10Hz using a second-order Butterworth filter. Correct any baseline drift in the torque and angle data sets by subtracting the minimum value from the whole signal, so that the minimum torque becomes 0.0Nm and the minimum angle becomes 0.0°.

Figure 15: example plots of torque v. angle (top) and angle v. time (bottom) from an RTA trial



Find the peak torque and the time at which it occurs. The peak torque represents the rotational resistance.

Find the angle and the time corresponding to peak torque.

Working backwards from the peak torque, find the time when the torque first drops below 1Nm, which is assumed to represent the start of rotation.

Find the angle at the start of rotation.

Calculate the mean rotational velocity from the start of rotation to peak torque as the change in angle divided by the change in time:

$$RV_{MN} = \frac{(A_{PK} - A_S)}{(t_{PK} - t_S)}$$

Where:

- RV_{MN} = the mean rotational velocity from the start of rotation to peak torque, expressed in degrees per second
- A_{PK} = the angle of peak torque, expressed in degrees
- A_S = the angle at the start of rotation, expressed in degrees
- t_{PK} = the time of peak torque, expressed in seconds
- t_S = the time at the start of rotation, expressed in seconds

Calculate the mean value of peak torque.

Report the mean result to the nearest 0.1Nm, e.g. 40.3Nm.

17. DETERMINATION OF ROTATIONAL SHEAR STIFFNESS (FIFA TEST METHOD 2024-07)

17.1 Scope
The test method for rotational shear stiffness on a football turf surface assesses the rate of torque increase with the rotation angle necessary to rotate a loaded test foot positioned flat on the surface. The test foot has a central axis of rotation perpendicular to the surface. Rotational shear stiffness quantifies the gradient from the surface's resistance to rotational forces and determines the torque required along the rotation.

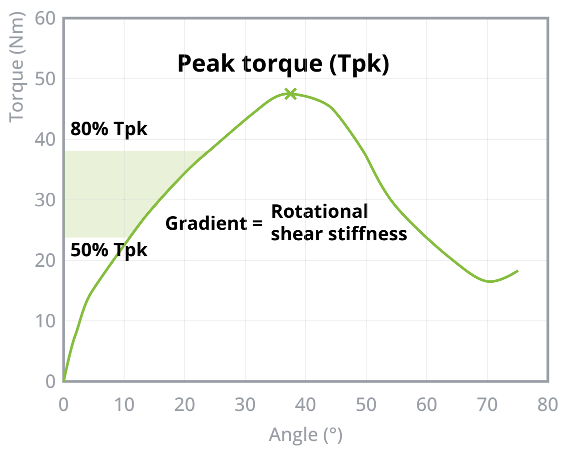
17.2 Test apparatus
Rotational shear stiffness can be determined using the RTA (see section 16.2: Test apparatus).

17.3 Test procedure
See the description in section 16.3: Test procedure.

17.4 Calculation and expression of results
Fit a straight line to all the torque (y-axis) and angle (x-axis) data between 50% and 80% of peak torque during the build-up to the peak (see Figure 16: example plot of torque v. angle, illustrating the region used to calculate the rotational shear stiffness below). The gradient of this line represents the rotational shear stiffness.

Figure 16: example plot of torque v. angle, illustrating the region used to calculate the rotational shear stiffness

Calculate the mean value of rotational shear stiffness.



Report the mean rotational shear stiffness to the nearest 0.01Nm/°, e.g. 0.92Nm/°. The uncertainty of measurement in rotational shear stiffness is ±0.05 Nm/°.

17.5 Laboratory tests
The rotational shear stiffness is calculated for the five positions tested for (lightweight) rotational resistance. Calculate the mean rotational shear stiffness from the five test positions.

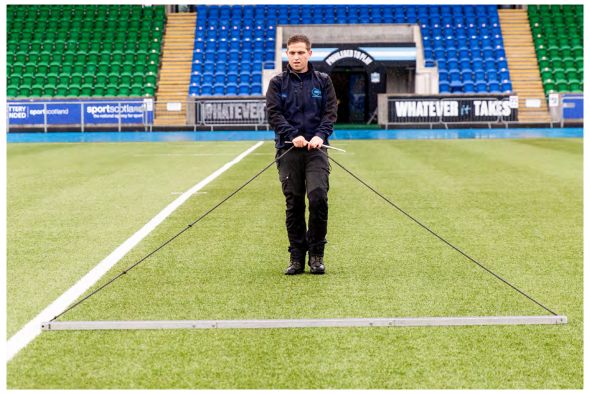
17.6 Laboratory test after simulated use (Lisport XL)
Undertake tests under dry and wet conditions, as appropriate.

The rotational shear stiffness is calculated for the five positions tested for (lightweight) rotational resistance. Calculate the mean rotational shear stiffness from the five test positions.

17.7 Field tests

17.7.1 Test conditions
Tests must be conducted under the meteorological conditions found at the time of the test, subject to the limits of section 5: Field (site) tests. The conditions must be reported.

17.7.2 Procedure
The rotational shear stiffness is calculated for the positions tested for (lightweight) rotational resistance.



18. PROCEDURE FOR ASSESSMENT OF SURFACE PLANARITY (FIFA TEST METHOD 2024-08)

18.1 Scope
The assessment of surface planarity on a football turf surface involves evaluating the evenness of the playing surface using a straight edge that is pulled longitudinally and transversely between the playing lines. A calibrated graduated wedge called a slip gauge is used to measure deviations beneath the straight edge. This test method provides quantifiable measurements of surface irregularities, ensuring that the playing surface meets the required standard of flatness.

18.2 Test apparatus
18.2.1 A straight edge with the following characteristics:

a. Length: 3,000±20mm; width: 75mm ±25mm; height: 40±10mm.

b. Minimum weight: 6.6kg. The weight of the test device may need to be increased if the straight edge does not sit on top of the infill due to resilient yarn. Add enough weight for the straight edge to sit on top of the infill.

c. Linearity of the straight edge: ±2mm.

d. Rigidity of the straight edge: 2mm (minimum).

e. Sliding side on the surface: 75±25mm x 3,000±20mm.

f. A means to pull the straight edge along, typically a rope. This can be attached to the straight edge directly or passed through a hollow core in the straight edge. The length of the rope should be sufficient to allow the technician to pull the straight edge in a straight line and observe the potential deviations under it. The technician must be at a distance of a minimum of 3.0m and a maximum of 5.0m from the straight edge when pulling it.

18.2.2 Wedge (slip gauge)

a. Length: 200.0mm (minimum). If the 200mm wedge is too big, a small wedge or small ruler may be used to assess the deviation.

b. Width: 15.0mm (minimum).

c. Height: 2-18mm (minimum).

d. Angle of the wedge: 5±1°.

The slip gauge should be graduated on its upper surface at intervals corresponding to a 1.0mm increase in height.

18.3 Test procedure

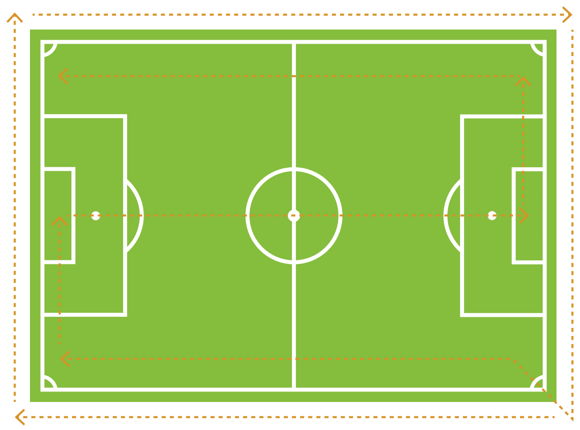
- Starting from one of the corners, with the centre of the straight edge on the centre of the touchline, the straight edge should be dragged across the playing surface parallel to the longitudinal lines.
- The straight edge should be pulled along the surface at such a speed and without sudden movements to ensure that it remains in contact with the surface and does not bounce off it.
- To ensure that the playing surface is completely checked, a minimum overlap of approximately 0.25m between each successive pass is recommended.
- When a deviation is suspected, the test engineer must place the straight edge over the suspected deviation and rotate it to find the largest gap under the straight edge.
- All deviations ≥10mm should be recorded on a site plan. It should be made clear whether the deviation is a high or low spot.
- At the discretion of the test engineer present on-site and upon completion of the surface check parallel to the longitudinal lines, the procedure could be repeated perpendicularly to the longitudinal lines.

19. PROCEDURE FOR VISUAL INSPECTION OF PITCH (FIFA TEST METHOD 2024-09)

19.1 Scope

The FIFA-accredited technician systematically walks across the pitch, following a predetermined pattern. During this inspection, any visual non-compliances or deviations from the required standards are carefully observed and documented on a site plan. This method ensures that all visible issues or discrepancies on the pitch are accurately recorded for further assessment and the relevant corrective measures.

Figure 17: walk pattern for the visual inspection



Planarity defects – legend

Planarity
Hxx – high spot of +xxmm
Lxx – low spot of -xxmm

Defects – seams
SF – seam failure
SG – gap in seam

Defects – fibres
FL – loose fibres
FA – adhesive on fibres
FB – burnt fibres
FW – worn fibres (high wear)

Defects – infill
IH – excess (high) infill
IL – lack of (low) infill

Defects – line marking
LMS – lines not straight
LML – line material loose
LMW – line markings in wrong position

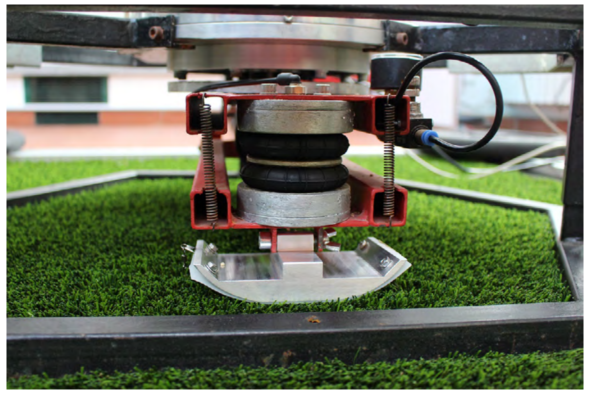
Defects – others
DD – debris on surface
DW – wrinkles
DO – other

Perimeter drains
PDB – broken perimeter drain
PDM – missing perimeter drain covers

Pop-up sprinklers
SPD – pop-up sprinkler cover uneven (minor damage)

Goalposts
GPA – goalpost retainer collar ("A" for anchorage) above the infill level
GPL – goalpost incorrectly positioned on the line
GPN – goal net broken
GPP – paint missing on goalposts
GPG – dangerous bracket (G for gap) between goalpost and net-retainer bar
GPU – goalposts not upright
GPD – goalpost damaged

Corner flags
CFU – corner flags not upright
CFD – corner flags damaged
CFP – corner flags incorrectly positioned



20. DETERMINATION OF SKIN AND SURFACE FRICTION AND ABRASION (FIFA TEST METHOD 2024-10)

20.1 Scope

The test method for the skin and surface friction and abrasion on a football turf surface involves a rotating test foot with a silicon skin that moves in a circular motion across a test specimen. The coefficient of friction between the silicon skin and the specimen is determined through this movement. The abrasion of the silicon skin occurs during this circular motion on the surface. Skin abrasion is quantified by comparing the force needed to pull the test foot with the silicon rubber over a metal plate before and after conditioning on the surface, indicating any changes in friction and wear.

20.2 Test apparatus

The test apparatus comprises the following:

a. A Securisport® Sports Surface Tester

b. A test foot as detailed in Figure 26: drawing of test foot

c. Silicon Skin Article Code #13110952 1mm thickness, supplied by Silicone Engineering Ltd. Greenbank Business Park, Blakewater Road, Blackburn, Lancashire, United Kingdom

d. A bubble/spirit level

e. A polished steel test plate (0.2µm <Ra <0.4µm)

20.3 Conditioning of samples by removal of excess spin oil

20.3.1 Apparatus

A shower with a water temperature of 40±5°C

A ventilated oven compliant to ISO 188

20.3.2 Procedure

Cut out the sample size required for the test.

The sample is rinsed in a shower for five minutes for a sample of 50x50cm.

If the sample size is larger, the rinsing time needs to be adjusted accordingly, so, for example, a 1x1m sample requires 20 minutes.

During the rinsing action, the shower head is moved in a way to distribute the water uniformly over the sample.

After the rinsing action, the sample needs to dry for a minimum of 24 hours, until a constant mass is achieved. A constant mass is defined as the mass attained when successive weighings at hourly intervals over a period of three hours do not vary by more than 1% (definition: ISO 8543).

NB: The drying period can be reduced by drying in a ventilated oven at a maximum temperature of 50°C.

20.4 Test procedure

20.4.1 Silicon skin preparation

Cut three silicon skins from the roll with dimensions of 150x80mm (±1mm) using a sharp blade (a cutter is suitable), being careful to keep the surface that will be in contact with the product facing upwards. More precisely, the smooth surface of the silicon skin is the test face and will have to be kept facing upwards while the grooved side has to be attached to the test foot and can be in contact with the surface where the silicon skin will be cut.

Figure 18: roll of silicon skin with smooth side upwards

Figure 19: measuring and cutting of the silicon skins

Figure 20: silicon skins cut and ready to be cleaned

20.4.2 Skin cleaning

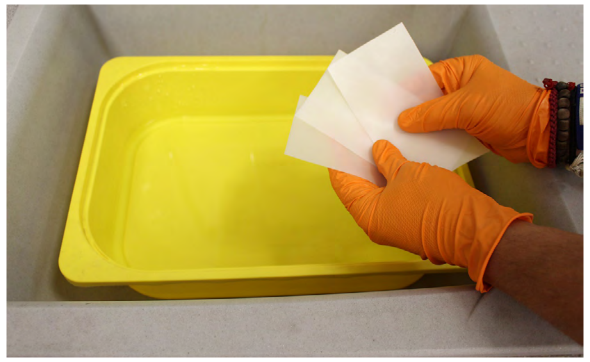
Skin cleaning is one of the most important steps of the test phase and must be done properly as described below.

After the skins are cut, they must be handled using dust-free nitrile gloves. Take a plastic (preferable) container and fill it with demineralised water.

Figure 21: container with demineralised water

Using the gloves, take the skins and immerse them in water for five minutes, taking care to keep the smooth side upwards.

Figure 22: silicon skin handled with dust-free nitrile gloves



Ensure that the skins are not superimposed over each other, i.e. make sure that the entire surface is exposed to water.

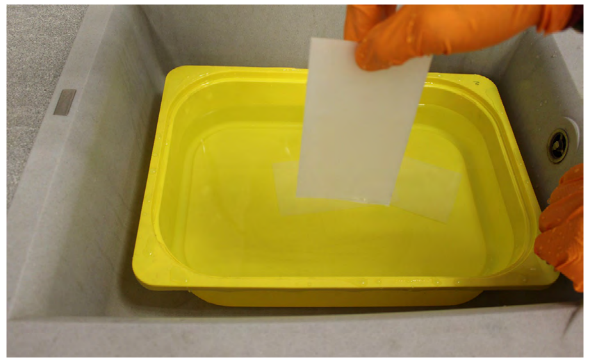
Figure 23: skins immersed in water with smooth surface facing upwards

Take each of the skins and, by rubbing the smooth surface, remove all of the talcum powder present from the production process while keep the skin immersed in water.

Figure 24: cleaning the silicon skins

Once all skins have been cleaned, remove them from the water and hang them using clamps, letting them dry in the air for 24 hours at 23±2°C.

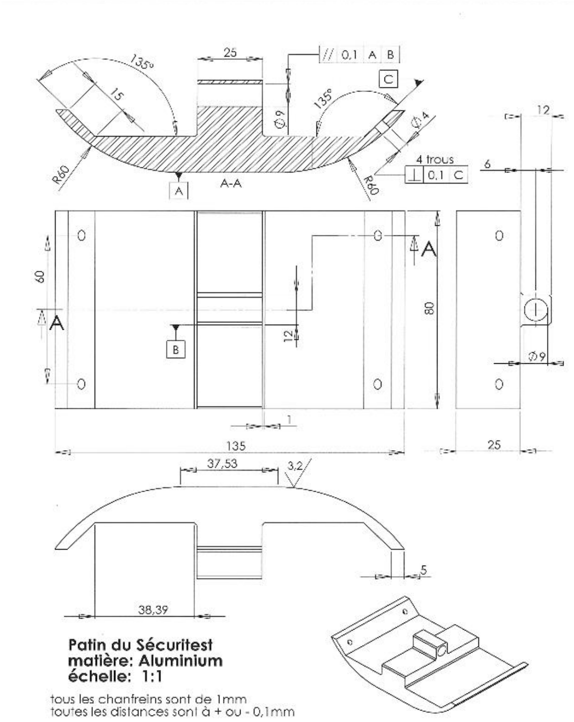
Figure 25: drying the skins



20.4.3 Test foot preparation

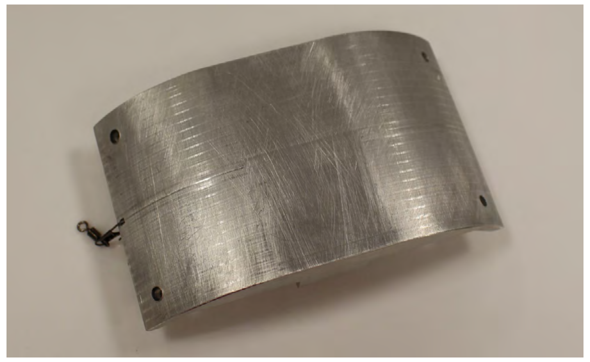
Once the skins have been dried, they have to be mounted on the test foot. The test foot must be aluminium and fully in accordance with the technical drawing below.

Figure 26: drawing of test foot



Take the test foot and clean it with acetone to remove any residue where the skin will have to be placed.

Figure 27: a test foot



Apply double-sided tape to the test foot, as shown in the picture below.

Figure 28: test foot with double-sided tape

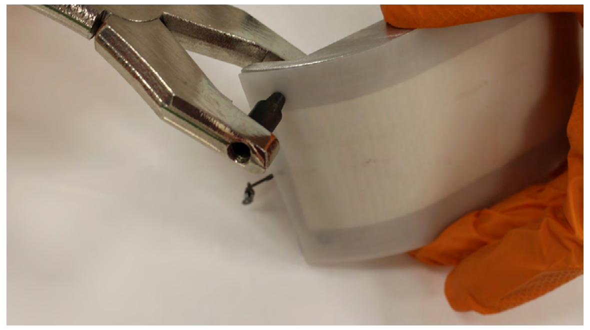
Leave some spaces at the edges to ensure that the glue of the double-sided tape does not touch the carpet surface and generate inaccurate readings.

Remove the protection and carefully apply the skin, using the gloves at all times and ensuring that the test surface is not touched at any stage.

Figure 29: test foot with silicon skin taped

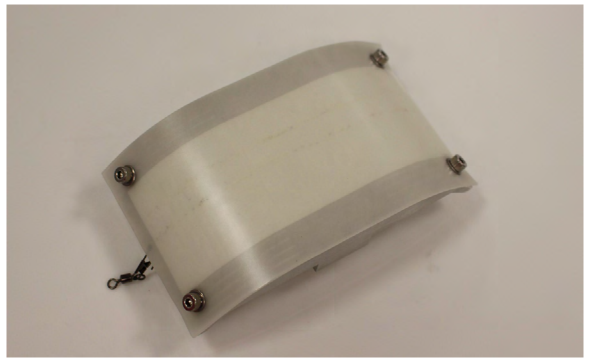
Punch holes on the silicon skin to apply the fixing screws using a die cutter or a suitable tool.

Figure 30: hole punching



Insert the screws to fix the skin.

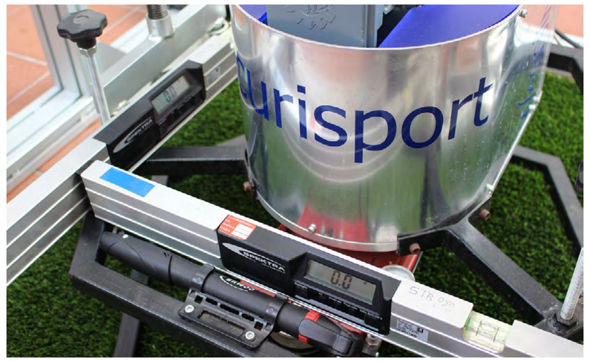
Figure 31: test foot ready for testing



20.4.4 Set-up

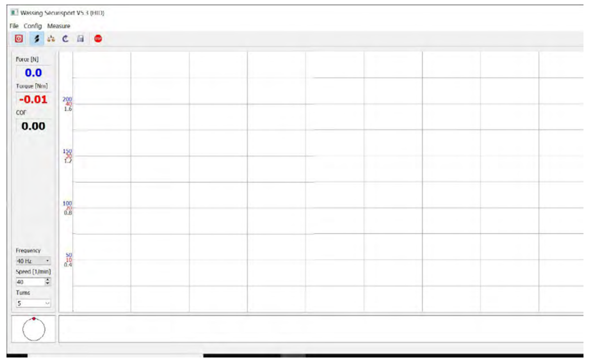
Position the Securisport® Sport Surface Tester over the test specimen and adjust it to level it in all directions.

Figure 32: machine levelled



Check that the machine parameters have been reset.

Figure 33: Securisport® set at zero prior to testing

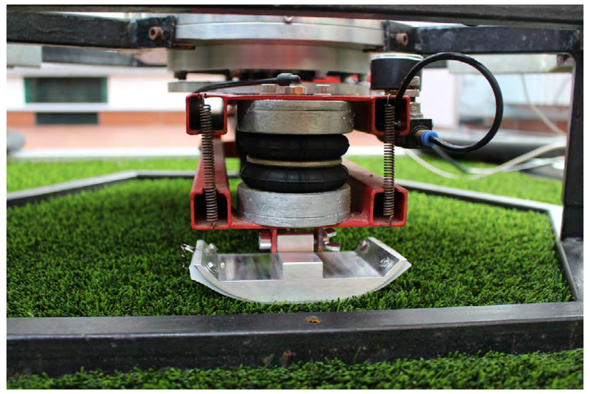


Attach the first of the three test foots to the machine. The direction of rotation must correspond to the direction of traction of the skin during the measurement of the sliding force.

Apply, by means of the cylinder, a vertical force to the test foot of 100±10N.

Figure 34: applying pressure to obtain 100±10N

Figure 35: test foot in position having the load applied



Start the rotation of the test foot. Allow the test foot to make five complete revolutions at a speed of 40±1rpm, sampling at a minimum frequency of 40Hz.

Ignoring any peak value occurring as the test foot starts to rotate, calculate the mean coefficient of friction value as displayed on the Securisport® software.

Repeat the same procedure on two further samples of silicon skin for a total of three samples, replacing any infill between tests.

20.5 Calculation and expression of results

Calculate the mean value of coefficient of friction.

Report the mean result to the nearest 0.01 CoF (μ).

03.

PRODUCT IDENTIFICATION AND ARTIFICIAL WEATHERING

21. PROCEDURE FOR ARTIFICIAL WEATHERING (FIFA TEST METHOD 2024-11)

21.1 Scope

The test method for artificial weathering on football turf yarns or polymeric infill materials involves subjecting test pieces of pile yarn and polymeric infill materials to controlled environmental conditions and fluorescent UVA lamps, the purpose of which is to simulate the effects of UV weathering on these materials. Changes in colour, appearance and selected physical properties are assessed to determine the impact of artificial UV weathering on the yarns and infill used in the football turf system.

21.2 Test apparatus

An artificial weathering cabinet using fluorescent UV lamps and environmental controls with the features listed below.

- UVA-340nm lamps (Type 1A), in accordance with EN ISO 4892-3:2016 and with a spectrum in accordance with EN ISO 4892-3:2006 and capable of uniformly applying radiation to the test specimen at an irradiance of $0.80W/m^2/nm$ at 340nm.

- An exposure chamber, constructed from inert material and that provides uniform irradiance in accordance with item a) and that includes a means of controlling and measuring the relevant parameters.

- A wetting mechanism, either condensation or water spray, to wet the exposed face of the specimen, in accordance with EN ISO 4892-3:2006.

- An apparatus designed to wet the exposed faces of the specimens by means of a humidity-condensing mechanism. The water vapour must be generated by heating water in a container located beneath and extending across the whole area occupied by the specimens. Specimen holders (filled with specimens) must constitute the sidewall of the exposure chamber, so that the backs of the specimens are exposed to the cooling effect of the ambient room air. If wetting is provided by spraying the specimens, the water must conform to EN ISO 4892-3:2006.

- A radiometer, conforming to EN ISO 4892-1:2000, 5.1.7, to monitor irradiance and radiant exposure.

- A black-panel thermometer, conforming to EN ISO 4892-1:2000.

- Specimen holders made from inert materials that will not affect the results of the exposure.

21.3 Exposure conditions

The exposure cycle must comprise 240±4 minutes of dry UV exposure at a black-standard temperature of 55±3°C, followed by 120±2 minutes of condensation exposure, commencing once equilibrium has been attained, without radiation, at a black-standard temperature of 45±3°C.

21.4 Test specimens

For products with the same differential scanning calorimeter trace (no more than ±3°C difference of the peak(s)), the same percentage of UV stabiliser and the same cross-sectional shape with different yarn thicknesses, only the thinnest product needs to be tested. The results from this test can apply to the entire range of the thicker products.

21.5 Test procedure

Wrap, without strain, a specimen of the yarn around the specimen holders so that the exposed strands do not overlap and mount each other in the test cabinet, with the flattened test surface facing the lamps. Fill any spaces, using blank panels, to ensure uniform exposure conditions.

Expose the specimen, measuring the irradiance and radiant exposure at the surface of the specimen. The exposure cycle must comprise 240±4 minutes of dry UV exposure at a black-panel temperature of 55±3°C, followed by 120±2 minutes of condensation exposure, without radiation, at a black-panel temperature of 45±3°C. If sample wetting is by condensation, allow at least 120 minutes per interval to ensure a state of equilibrium exists. This time does not form part of the exposure cycle. After an exposure of 9,600±125kJ/m2/340nm, carefully remove the specimen from the exposure cabinet and test as required by the product specification.

NB: An exposure of 9,600±125kJ/m2/340nm will require approximately 5,000 hours with cycling to complete to moisture cycling.

21.6 Assessment of test specimens

21.6.1 Pile yarn(s)

Assess the change in colour of the exposed test specimen when compared to an unexposed test specimen using the grey scale in accordance with EN ISO 20105-A02.

Determine the peak breakage force of the exposed pile yarn(s) in accordance with EN 13864 (minimum gauge length 100mm) and calculate the percentage change in peak breakage force (in newtons) compared to unexposed yarn.

21.6.2 Polymeric infill materials (rubbers, thermoplastics, etc.)

Assess the change in colour of the exposed test specimen (minimum 38cm^2) when compared to an unexposed test specimen using the grey scale in accordance with EN ISO 20105-A02.

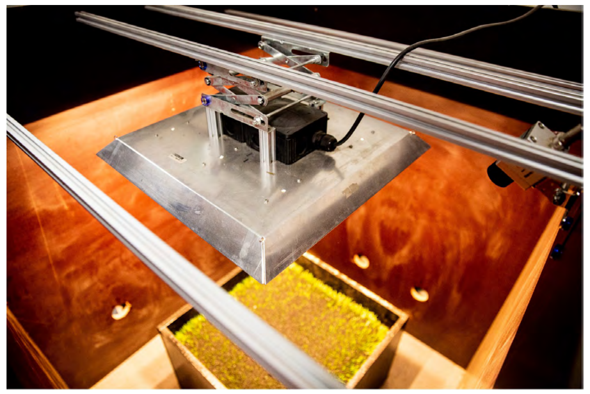
Photograph specimens of exposed and unexposed polymeric infills to show any visual effects of the artificial weathering.

NB: Organic infills or organic parts of mixed infills do not need to be exposed to artificial weathering.

22 DETERMINATION OF HEAT RETENTION ON FOOTBALL TURF PRODUCTS (FIFA TEST METHOD 2024-12)

22.1 Scope

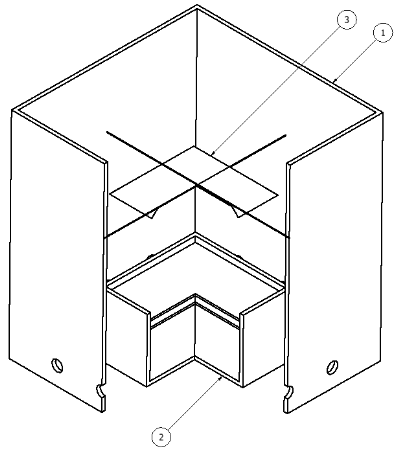
The test method for heat retention on football turf products involves measuring and evaluating the temperature retention properties of the surface under specific conditions. The surface temperature is recorded and analysed to assess its ability to retain heat. This test helps to determine the heat-related characteristics of football turf products and provides insights into their thermal performance during use.



22.2 Test apparatus

The primary components of the surface temperature apparatus are presented below in Figure 36: sectional schematic of apparatus for measuring heat (temperature increase), together with a list of the principle components.

Figure 36: sectional schematic of apparatus for measuring heat (temperature increase)



22.2.1 Apparatus enclosure marked as "1" in Figure 36: sectional schematic of apparatus for measuring heat (temperature increase) above

The apparatus consists of an external box with the following internal dimensions: length: 1,000mm, breadth: 1,000mm and height: 1,200mm, constructed from an unpainted wood-based material of a thickness of 15mm. All internal dimensions have a tolerance of ±10mm.

Three holes of a diameter of 60±5mm should be cut into each face of the enclosure at a height of 250±5mm from its base. Holes must be positioned on and 250±5mm either side of the centre of the enclosure panel.

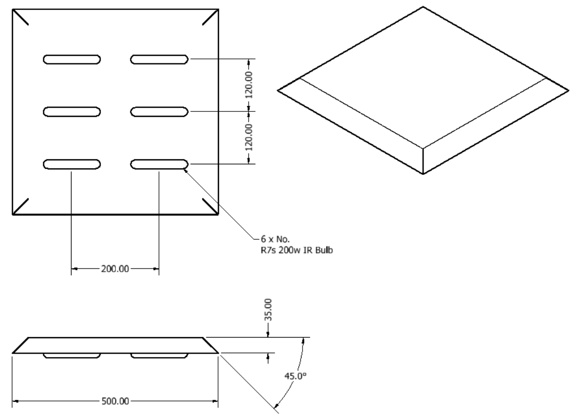
22.2.2 Sample container marked as "2" in Figure 36: sectional schematic of apparatus for measuring heat (temperature increase)

The sample container has the following internal dimensions: length: 500mm, breadth: 500mm and height: 350mm, constructed from an unpainted, wood-based material of a thickness of 15mm. All dimensions carry a tolerance of ±5mm.

22.2.3 Infrared lamp and reflector as marked "3" in Figure 36: sectional schematic of apparatus for measuring heat (temperature increase)

A square profile reflector of the dimensions shown below in Figure 37: lamp and reflector arrangement, in which all dimensions are in millimetres.

Figure 37: lamp and reflector arrangement



Six bulbs are mounted in the positions shown above in Figure 37: lamp and reflector arrangement. Each bulb must have a rated output of 200W and be of clear glass type. All bulbs should be replaced after a maximum of 150 hours of operation.

22.2.4 Infrared pyrometer

An infrared pyrometer or similar equipment, such as an infrared camera, that meets the following specifications:

a. Minimum temperature range: 0-100°C

b. Accuracy: ±5°C or 3% (whichever is greater)

c. Resolution: 0.1°C

d. Response time: 1s

e. Spectral response: 8-14um

f. Emissivity value: 95%

22.2.5. Thermocouple

A thermocouple that meets the following specifications:

a. Minimum temperature range: 0-100°C

b. Sensitivity: 0.1°C

c. Type: K-type

d. Resolution: 0.1°C

22.2.6 Luxmeter

A luxmeter of the following or higher specifications:

a. Minimum measurement range: 0-1,000lx

b. Resolution: 1lx

c. Accuracy: C class in accordance with DIN 5032-7

22.3 Sample preparation

Condition all sample material for 24 hours at 23±2°C prior to testing. For specific requirements relating to samples containing organic infill material, refer to section 22.3.3: Organic infill material.

22.3.1 Stone sub-base preparation

A sub-base with the following properties should be constructed within the sample container:

Moisture content of 0% by oven-drying the stone base

Particle size of 0/40mm when tested in accordance with EN 933-1

Layer thickness of 250±5mm (approximately 100kg of aggregate)

Stone should be manually compacted using a 10kg tamper to produce a density >90% calculated from the mass of the material and the measured volume

Level with 2kg of oven-dried 0.4-0.8mm sand

22.3.2 Test specimen preparation

A 500x500mm sample of the turf to be tested should be placed directly onto the levelled stone sub-base material within the sample container.

The K-type thermocouple should be attached with adhesive tape to the centre of the carpet backing in both samples, with and without shockpads.

The infill should be evenly distributed into the carpet sample in accordance with the manufacturer's specification. If a sample requires a shockpad, the shockpad should be placed into the sample container onto the prepared stone base prior to the carpet sample.

22.3.3 Organic infill material

Organic infill material must be prepared and conditioned in the following stages:

Organic infill must be oven-dried to a moisture content of 0%.

Dried infill should be placed in a moisture-proof bag or other appropriate airtight container, and water added via mist spray to achieve the supplier's specified moisture content.

Moistened infill must be sealed and conditioned within its container for a period of 24 hours at 23±2°C.

Carpet sample should be filled immediately prior to testing to avoid loss of moisture in the infill.

22.4 Test procedure

The test must be conducted at an ambient laboratory temperature of 23±2°C.

Care should be taken not to conduct testing in close vicinity to sources of turbulent airflow, such as doorways, air-conditioning units, heavy machinery or windows.

The sample container is placed in the centre of the test enclosure.

The infrared reflector should be positioned centrally at a height of 675mm above the infill of the test specimen. The lamp must be positioned in such a way as to avoid significantly reducing airflow from the top of the test enclosure, e.g. by using steel wire.

The measurement of ambient air, specimen surface and carpet backing temperatures, in addition to relative humidity, should be recorded at the time periods laid out in the table below.

Phase	Elapsed time (min)				
1	0	5	10	15	20
2	30	40	50	60	
3	75	90	105	120	135
	150	165	180		

Three surface temperature measurements are recorded at each period taken from the central portion of the specimen surface using the IR pyrometer. The IR pyrometer should be held at 500±10mm above the specimen surface when taking measurements.

A measurement of the bulb lux output should be recorded after an elapsed time of 180 minutes. The luxmeter sensor should be positioned in the centre of the sample surface and a measurement recorded. Where the intensity of the light falling upon the surface falls below an acceptable level, all bulbs must be replaced and any recorded data discarded.

22.5 Expression of results

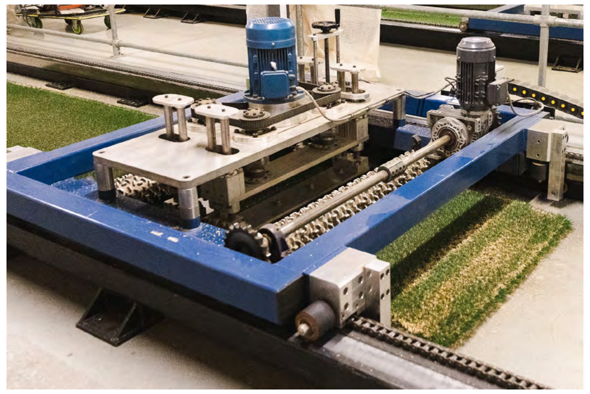
22.5.1 Reporting

The test report must include the following information:

- Maximum surface temperature reached and relevant categorisation
- All temperature measurements of specimen surface, carpet backing and ambient air, in addition to relative humidity, in graphical and tabulated formats
- Final lux measurement after 180 minutes of elapsed time

22.5.2 Categorisation

Category	Temperature range (°C)
1	<50
1-2	50-54
2	55-59
2-3	60-65
3	>65



23 PROCEDURE FOR SIMULATED MECHANICAL WEAR ON ARTIFICIAL TURF – LISPORT XL (FIFA TEST METHOD 2024-13)

23.1 Scope

The Lisport XL features a trolley that moves back and forth along a test specimen of synthetic football turf. It consists of two rotating plates and two studded rollers mounted on the trolley. The main purpose of the Lisport XL is to simulate the mechanical wear and infill compaction that occur on synthetic turf playing surfaces during actual use. The machine serves to ensure that the tested systems can maintain their surface properties over time.

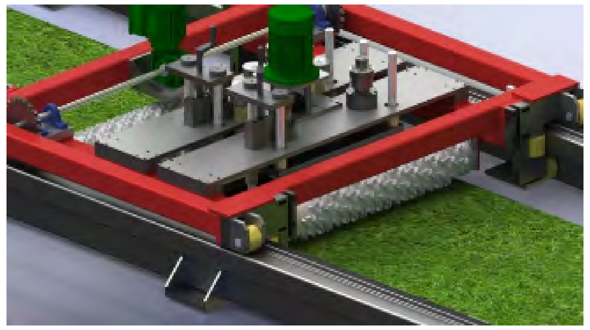
It should be noted that the Lisport XL test does not provide a specific guarantee for the number of years of use. Instead, it accurately assesses whether the complete system, including infill and/or shockpads, can retain its surface properties and meet the performance requirements outlined in the FIFA Quality Programme for Football Turf – Test Manual: Test Requirements during practical use. Additionally, the durability of a FIFA-approved system relies heavily on maintenance, which is a crucial factor.

The number of Lisport XL cycles (3,000 or 6,000 cycles) referred to in the FIFA Quality Programme for Football Turf – Test Manual: Test Requirements represents the outcome of years of development. These cycles are deemed appropriate for assessing the behaviour of the system during the practice of football, taking into account the wear and tear to which it is subject.

23.2 Test apparatus

The Lisport XL must comprise a trolley (or other means) onto which two rotating plates are mounted in the x, y plane and two bladed rollers that must be dragged by the trolley and not be motorised. The trolley traverses the test specimen with a velocity of 0.15±0.01m/s.

Figure 38: Lisport XL machine



23.2.1 Rotating plates

Each rotating plate must have a mechanical degree of freedom

$$\left\{ \begin{array}{c|c} Tx & 0 \\ Ty & 0 \\ Yz & Rz \end{array} \right\}$$

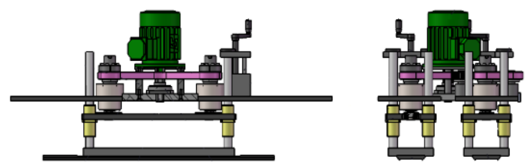
and the following characteristics:

a. The rotating plates must be vertically independent of each other (see Figure 38: Lisport XL machine) and be spaced (centres of each plate) from 250-350mm apart (this large range owes to the 40mm movement between the two plates and the 60mm tolerance for conception). Each rotating plate must be fitted with a rectangular piece of rubber of 89x900±1mm (x, y) and have a circular translational movement based on a radius of 10.0mm±0.25mm, with a rotational speed of 540±10rpm rotating in the same direction but 180° out of phase.

b. The rotating plates must be designed to ensure that a constant pressure of 30±1g/cm^2 is applied over the whole test specimen. To ensure this, the two rotating plates must:

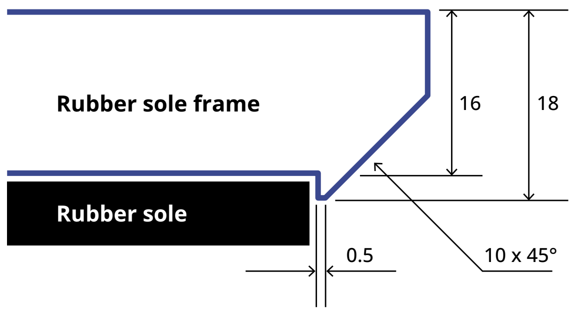
- be designed with one degree of freedom (Z axis);
- be independent of each other so that any vertical movement of one plate does not influence the vertical movement of the other plate; and
- be free to move vertically up to 10mm above the level of the test specimen.

Figure 39: configuration of machine



To avoid damage generated by the metal frame supporting the rubber sole, a 45°x10mm chamfer must be attached on the edge of the frame (see Figure 39: configuration of machine).

Figure 40: rubber sole configuration



23.2.2 Rubber test sole

The wearing surface of each vibrating plate must be Autosoler 6mm, Profile 26 Fine Crepe, supplied by nora systems GmbH; 2-4 Höhnerweg, 69469 Weinheim, Germany, www.nora-shoe.com. The test sole must have a Shore hardness of 93±2.

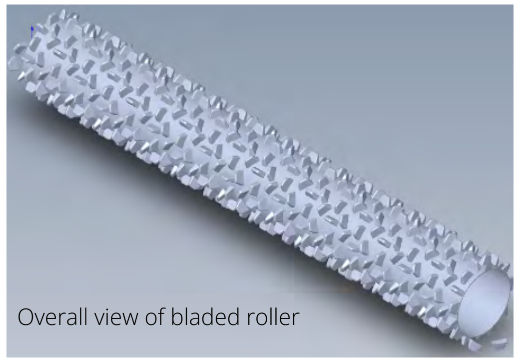
23.2.3 Bladed roller

Each bladed roller must comprise a metal cylinder measuring 955±10mm in length with a diameter of 120±1mm fitted with a polyamide (PA 12) moulded profile of studs/blades as shown below in Figure 41: bladed roller. The total weight of each roller must be 95±5kg.

NB: In practice, it is recommended that the sleeve be manufactured in two half cylinders that are subsequently screwed onto the metal roller.

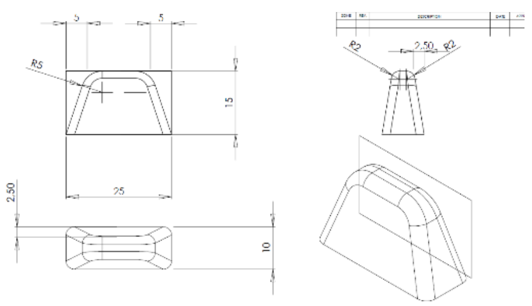
All dimensions have a tolerance of ±5%.

Figure 41: bladed roller



Overall view of bladed roller

Blade detail (all dimensions are in millimetres)



NB: A digital 3D file suitable for the manufacturing of the roller sleeve can be requested from FIFA by emailing FootballTurf@fifa.org. It is recommended that a professional 3D printing method be used for manufacturing.

The rollers must be fitted adjacent to the vibrating plates within the trolley carriage. They must be designed to roll in the direction of the Z axis only, with a view to ensuring that the full weight of the roller is applied to the surface. The distance between each roller axis and the middle of each nearest vibrating plate must be 200-300mm.

The design of the machine must ensure unrestricted rotation of the leading roller at the end of the traversal of the test specimen to ensure that the studs do not repeatedly impact the same position on the sample.

NB: The vibrating plates must remain in contact with the test specimen at the end of each traversal.

23.3 Test procedure

23.3.1 Test specimen

The test specimen must be fixed to the floor to ensure that there is no movement during the wear simulation.

NB: To minimise heterogeneous wearing of the sample, it is recommended that it be placed on a floor with a maximum deviation under a 3.0m straight edge of 2.0mm. Double tape, flanges, etc. could be used for this purpose. It is necessary to seal perforation holes before filling in the sample to avoid slippage between the floor and the backing, usually due to sand.

The test specimen of the football turf system must be as specified by the manufacturer. It must include the specified performance and stabilising infill and, where appropriate, any shockpad or elastic layer.

The dimensions of the test specimen must ensure a uniformly conditioned area of at least 2.5x0.9m to allow the necessary performance measurements to be made.

23.3.2 Test base

The test specimen must be laid on a flat, smooth, rigid, solid concrete floor with a minimum thickness of 100mm and a minimum stiffness of 40MPa when measured in accordance with EN 12504-2, part 2.

23.3.3 Preparation of the test specimen

Check the condition of the studded rollers for signs of stud wear. If significant damage or burring of the stud profile is observed, or if the height of at least ten studs is 14mm or less, replace the stud sleeve.

Replace the rubber sole with a new one before each new sample.

23.3.4 Test specimen preparation and pretests

Within the Lisport XL, build the test specimen strictly in accordance with the manufacturer's specification, EN 12229 and the instructions in Appendix I.

Unless the performance infill is designed to have a specific moisture content (e.g. an organic infill), all FIFA product assessment tests must be undertaken on a dry test specimen. Consolidate the infill with five conditioning cycles (one cycle comprises one pass up and down the test specimen) and undertake the initial performance tests. Check that the initial performance test results correspond with the values normally associated with the system to be tested.

NB:

- All other FIFA performance tests must be conducted on separate test specimens to eliminate the effects of wetting the test specimens.
- If a manufacturer requires wet or damp tests to be conducted, this must be noted in the test report, and the results must not be used in any official FIFA test report.
- All performance testing must be carried out at least 250mm from the edge of the sample.

23.3.5 Conditioning procedure

Undertake 500 cycles of continuous conditioning and stop. Maintain the test specimen using the procedure described in Appendix I.

Repeat at 500-cycle continuous intervals until the specified number of cycles are complete. Carry out a final maintenance procedure (reintroduce the infill and ensure that it is evenly distributed) and run the Lisport XL for a further five cycles using the procedure described in Appendix I. Undertake the performance tests without any further maintenance on the test specimen.

For **FIFA Quality Pro** product assessment tests, undertake a total of 3,000 cycles as follows:

- Five consolidation cycles prior to initial performance tests
- To be conditioned at 500-cycle intervals
- Refill any dislodged infill in accordance with 23.3.7: Performance infill replacement
- Five cycles following surface maintenance after the final 500 cycles and prior to performance tests

- The surface must be maintained sufficiently with a hard rake to decompact the performance infill (as described in Appendix I)

For **FIFA Quality** product assessment tests, undertake a total of 6,000 cycles as follows:

- Five consolidation cycles prior to initial performance tests
- To be conditioned at 500-cycle intervals
- Refill any dislodged infill in accordance with section 23.3.7: Performance infill replacement
- Five cycles following surface maintenance after the final 500 cycles and prior to performance tests
- The surface must be maintained sufficiently with a hard rake to decompact the performance infill (as described in Appendix I)

23.3.6 Conditioning procedure for vegetal infill materials

Undertake 250 cycles of continuous conditioning and stop. Maintain the test specimen using the procedure described in Appendix I.

Repeat at 250-cycle continuous intervals until the specified number of cycles are complete. Carry out a final maintenance procedure (reintroduce the infill and ensure that it is evenly distributed) and run the Lisport XL for a further five cycles using the procedure described in Appendix I. Undertake the performance tests without any further maintenance on the test specimen.

For **FIFA Quality Pro** product assessment tests, undertake a total of 3,000 cycles as follows:

- Five consolidation cycles prior to initial performance tests
- To be conditioned at 250-cycle intervals
- Refill any dislodged infill in accordance with section 23.3.7: Performance infill replacement. New infill can be added to compensate the breakage/loss of vegetal infill material
- Five cycles following surface maintenance after the final 250 cycles and prior to performance tests
- The surface must be maintained sufficiently with a hard rake to decompact the performance infill (as described in Appendix I)
- The humidity level of the vegetal infill material should be maintained according to the manufacturer's specifications

For **FIFA Quality** product assessment tests, undertake a total of 6,000 cycles as follows:

- Five consolidation cycles prior to initial performance tests
- To be conditioned at 250-cycle intervals
- Refill any dislodged infill in accordance with section 23.3.7: Performance infill replacement. New infill can be added to compensate the breakage/loss of vegetal infill material
- Five cycles following surface maintenance after the final 250 cycles and prior to performance tests
- The surface shall be maintained sufficiently with a hard rake to decompact the performance infill (as described in Appendix I).
- The humidity level of the vegetal infill material should be maintained according to the manufacturer's specifications

23.3.7 Performance infill replacement

Using a vacuum cleaner, collect any infill; material that has been dislodged from the test specimen (see Figure 42: examples of infill dispersion and infill collection and Figure 43: examples of infill collection). Refill the test specimen with material that has been dislodged from the test specimen.

Figure 42: examples of infill dispersion and infill collection

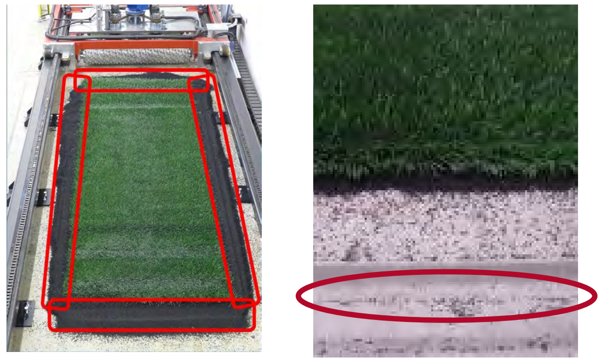
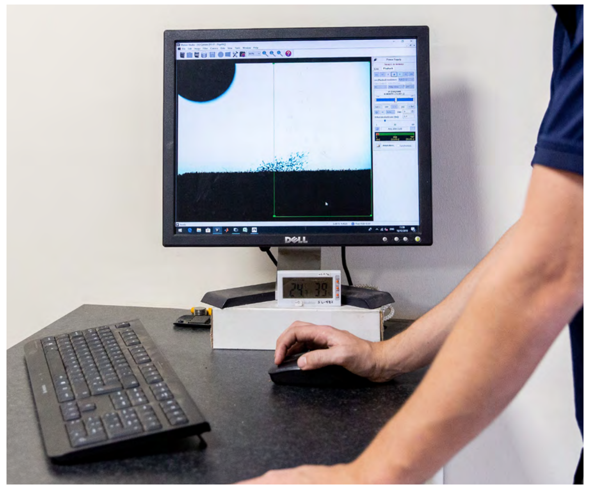


Figure 43: examples of infill collection

Carefully redistribute the infill material collected over the conditioned area; ensure a homogeneous distribution using an appropriate application device as shown below in Figure 44: redistribution of dispersed infill.

Figure 44: redistribution of dispersed infill



24 DETERMINATION OF INFILL SPLASH AND ANGLE BALL REBOUND (FIFA TEST METHOD 2024-14)

24.1 Scope

The test method for infill splash and angle ball rebound on football turf products uses a high-speed camera to capture the impact of a ball on a test sample. The resulting images are analysed, with the infill appearing as black pixels against a white background. From these images, the density of infill splash is calculated as a percentage of black-to-white pixels, and the angle ball rebound is determined by measuring the ratio of the ball's velocities before and after impact. This method provides both visual representation and numerical rankings to assess the splash characteristics of the turf system, enabling both qualitative and quantitative analysis of the data.

24.2 Test apparatus

The test apparatus comprises the following:

- A ball cannon used to project the ball at an angle of 30±2° onto test locations at a speed of 50±2km/h. The cannon must not impart spin of greater than 3rps, to be verified on the images of the high-speed camera.
- A high-speed camera capable of recording images at 1280x1024px at a minimum rate of 300Hz. Attached to the camera sensor aperture must be an optical lens that has a focal length of 50mm and a minimum f-stop range of ƒ/1.4-ƒ/16.
- A uniform light source that will provide strong white backlighting. The device must be considered to be flicker-free.
- A FIFA-approved football with the pressure adjusted to ensure a ball rebound of 1.45±0.03m on concrete when released from 2.00±0.01m.
- A distance-measuring device capable of measuring to an accuracy of ±0.01m and with the ability to angle to ±0.1°.
- The ball speed as it leaves the cannon should be measured using the high-speed camera.

24.3 Test specimens

In order to conduct this test method, two football turf samples of minimum dimensions of 1x1m must be prepared and infilled in accordance with EN 12229:2014. The test specimen must be filled evenly and conform to a consistent procedure to ensure repeatability of test values. Sample movement must be minimised to ensure that the prepared test specimen is not disturbed.

To ensure the homogeneity of the test specimen during testing, sample drainage holes must be sealed prior to adding infill material.

24.4 Apparatus set-up

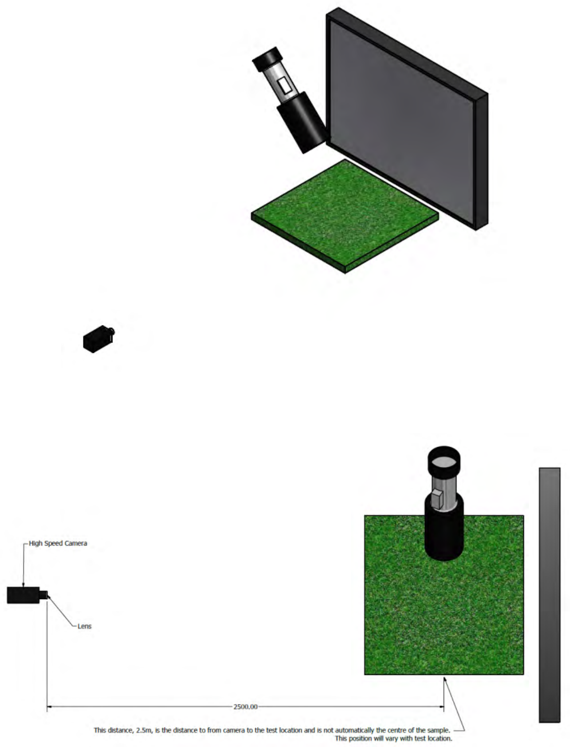
24.4.1 Equipment positioning

The ball cannon must be positioned in such a way as to ensure that the ball impacts a specific location on the turf sample at an angle of 30±2°. The locations are specified in section 24.5.1: Test procedure for a single location.

A high-speed camera must be placed perpendicularly to the direction the ball strikes the surface. The distance between the location to be tested and the lens of the camera must be 2.5±0.01m. The camera may be moved if required to ensure that the resultant displaced infill plume is visible, whilst it is important to make sure that the specified distance and perpendicularity are unaffected.

An optional uniform light source is positioned facing the camera to provide a backlighting function. This may be required in certain types of lighting conditions to ensure a high-contrast image.

Figure 45: pictorial representation of the set-up



The camera must be angled with the lens to the horizontal at 5±1° and the height off the ground adjusted so that the cross-sectional profile of the sample is visible with the visible splash window as large as possible.

24.4.2 Calibration of camera and environment

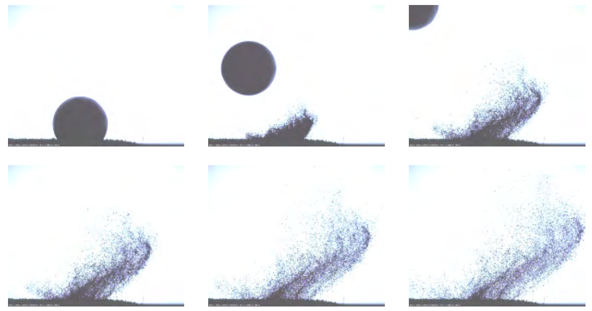
The camera should be set up so that, on the two-colour image, the whole usable picture is white. Image cropping can be used to remove any dark areas on the image that are not due to splash. At this stage, the camera focus, exposure and environmental lighting conditions should be adjusted to ensure that it is possible to detect a black 1mm diameter dot on the two-colour image but nothing smaller than a 0.5mm dot. The dot should be visible from the camera to the centre of the sample where the impact will occur and should be detectable from all positions on the image during calibration.

NB: Any dark points visible on the image will distort the results, producing a higher infill splash percentage.

24.5 Test procedure

24.5.1 Test procedure for a single location

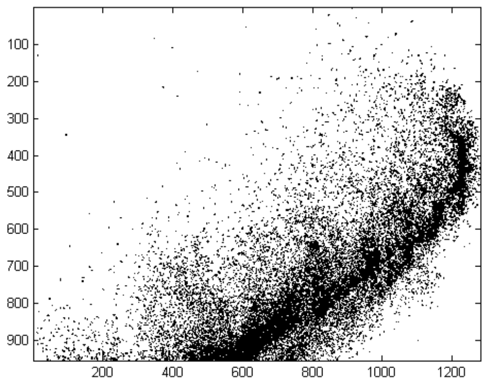
Figure 46: images recorded during splash test



The ball is projected onto the sample from the cannon and the impact on the surface is recorded using a high-speed camera. The full interaction from the point at which the ball impacts the surface is captured.

Figure 47: raw splash image

Figure 48: two-colour splash image



The frames are then transformed into two-colour black-and-white images (RGB 000 – red, green, blue colour model) and cropped to ensure that none of the yarn and undisturbed infill is included in the image. The percentage of black-to-white pixels in the image is calculated. The highest "splash percentage" is then recorded as the test result.

NB: The standard image size for analysis is 1280x1024px. The splash percentage should always be calculated using a frame size of 1280x1024px, even after cropping. This method assumes that any cropped area will automatically be white space.

24.5.2 Sample test location plan and test directions

Twelve test locations are spread over a total of two 1x1m samples to complete a test. The test must be carried out in two directions on the sample:

- Direction 1 – parallel and against the direction of tufting
- Direction 2 – perpendicular to the direction of tufting

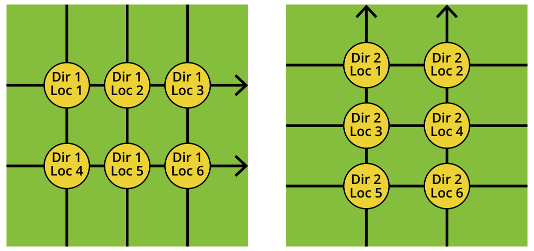
Six locations are tested for each direction, totalling 12 test locations overall.

Avoid impacting the same position and do not test any area that has acquired additional infill due to displacement during previous ball impacts.

An example of sample test locations is detailed below in Figure 49: example of test locations. A distance of at least 0.2m should be maintained between any test location centre and the edge of the sample. The impact crater of test locations must not overlap with other test locations. Careful attention must be given to deciding sample locations to ensure that any material dislodged from the sample cannot contaminate untested locations.

Figure 49: example of test locations

Sample 1 **Sample 2**



24.6 Calculation and expression of results of the infill splash

A simple percentage calculation is derived from the images to calculate the splash percentage in each frame:

$$\text{Splash percentage} = \frac{\text{No.of black pixels}}{\text{Resolution of the image in pixels}} \times 100 = \frac{\text{No.of black pixels}}{(1280\times1024)} \times 100$$

The highest splash percentage calculated from all captured frames is the splash percentage that is recorded for that location.

The six splash percentages are collected for direction 1 and then averaged to create an overall splash percentage for that direction. This process is repeated for direction 2, and then a final splash percentage is calculated from an average of all 12 results, with the intention of building an approximation of peak splash from the highest splash directions.

The splash test report should include the image from the highest density splash impact recorded during testing and must contain the following information:

- Test date
- Sample number

24.7 Calculation and expression of results of the angle ball rebound

Record the velocity of the ball immediately before and after impact with the surface. Calculate the angle ball rebound percentage using the following formula:

$$\text{Angle ball rebound (\%)} = \frac{S_2}{S_1} \times 100$$

Where:

S_2 = velocity immediately after rebound in km/h to the nearest 0.1km/h

S_1 = velocity immediately before rebound in km/h to the nearest 0.1km/h

Calculate the mean value of angle ball rebound from all tests for each direction of test.

Report the mean angle ball rebound as a percentage to the nearest whole number, e.g. 55%.

The angle ball rebound test report should include the image used for the calculation of S_2 and must contain the following information:

- Test date
- Sample number
- Calculated velocity: S_2

25 PROCEDURE FOR DIFFERENTIAL SCANNING CALORIMETRY (FIFA TEST METHOD 2024-15)

25.1 Scope

The test method for differential scanning calorimetry (DSC) on football turf yarns aims to determine the polymer composition of the yarn. DSC involves subjecting the yarn to controlled heating and cooling cycles while measuring the heat flow associated with changes in its thermal properties. By analysing the resulting thermograms, the polymer composition and the characteristics of the yarn can be identified and assessed. This procedure describes the test method to determine the melting point(s) of a fibre in the football turf and thereby determine the consistency of the polymers used to make the fibre(s).

25.2 References

ISO 11357-1:2023 Plastics – Differential Scanning Calorimetry (DSC)

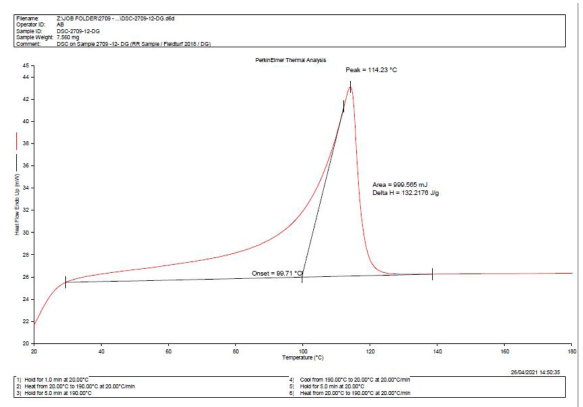
ISO 11357-1:2016 clause 5.2: Ventilated crucibles should preferably be used to avoid changes in pressure during the measurement run and to allow the exchange of gas with the surrounding atmosphere. For the accuracy of the enthalpy measurement, the heating must be performed at constant pressure.

NB:

1. The fibres used in third-generation surfaces are typically produced from either a single polymer or a blend of polymers. Single polymers generally show a specific relatively narrow melting peak, as in Figure 50: example of DSC curve with single melting peak.

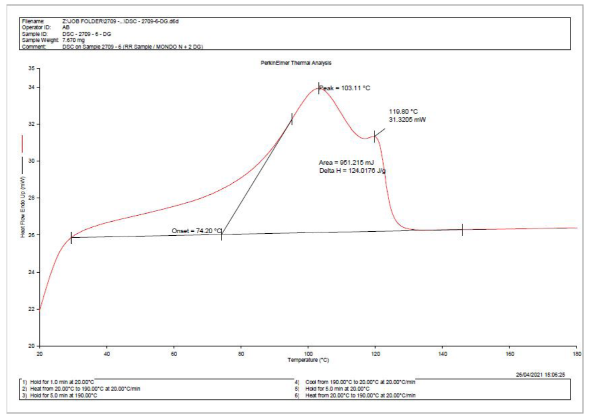
2. The sample size of the fibre should be 7.5±1.0mg.

Figure 50: example of DSC curve with single melting peak



Conversely, blends of polymers will show a broad range of melting. Each individual component of the blend will have its own melting peak. These individual melting peaks will superimpose upon the other melting peaks present, and where the melting peaks are close together, will appear as a broader more diffuse melting peak as in Figure 50: example of DSC curve with single melting peak. If the melting peaks of a blend of polymers are more separated, the peak will be broadened further, or the peaks will either appear separately or a "shoulder" will appear on the overall melting peak.

Figure 51: DSC curve representing melting behaviour of a fibre with a blend of polymers



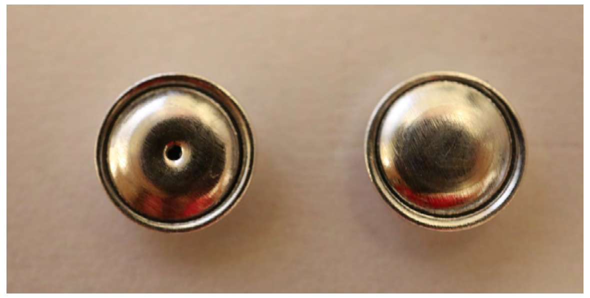
The peak is clearly broader in Figure 51: DSC curve representing melting behaviour of a fibre with a blend of polymers, and there is a shoulder at approximately around 120ºC.

The following temperature programme is to be used for the measurement:

- Equilibrate at 20.00°C
- Heat at 20.00°C/min to 190.00°C
- Isothermal for 5.00 minutes
- Cool down at 20.00°C/min to 20.00°C
- Isothermal for 5.00 minutes
- Heat up at 10.00°C/min to 190.00°C

To ensure the accuracy of enthalpy measurements and to prevent pressure fluctuations during the measurement process, it is advisable to use ventilated crucibles. These crucibles facilitate the exchange of gas with the surrounding atmosphere while minimising any changes in pressure. Additionally, it is essential to maintain a constant pressure while heating to ensure precise enthalpy measurements.

Figure 52: vented crucible (left) and unvented crucible (right)



25.3 Results

25.3.1 Graph requirements

The DSC graphs must meet the following criteria:

- The y-axis on a DSC graph represents the heat flow per unit of mass (mW/mg).
- The x-axis on a DSC graph represents the temperature in degrees Celsius (°C).
- The DSC heat flow curve, which represents the thermal energy absorbed or released by the sample during physical or chemical changes, must display heat absorption as positive upwards.

Melting peaks on a DSC graph represent the temperature range at which a sample undergoes a phase transition from a solid to a liquid state, absorbing thermal energy in an endothermic process, and they must be drawn on the upside.

25.3.2 Baseline, melting point(s), onset temperature and enthalpy (Delta H)

Begin drawing the baseline at 40°C and continue until the exothermic process stabilises. The baseline is formed by connecting the lowest points of the peaks and represents the heat flow in the absence of significant thermal events or transitions in the analysed sample.

The extrapolated onset temperature is determined by finding the intersection point between the extrapolated baseline and the inflectional tangent at the start of the melting or crystallisation peak. The baseline and inflectional tangent are calculated based on the temperature-dependent heat flow signal. Unlike the peak temperature, the onset temperature is less affected by the heating rate and sample mass, making it a more reliable indicator. By identifying the intersection point, this method provides a robust measure of the temperature at which the specific thermal event begins in the sample.

The enthalpy (Delta H) is calculated as the area enclosed by the baseline and the peak or shoulder related to the thermal event within the specified temperature range.

Record the melting point(s), the onset temperature and enthalpy (Delta H) of the peak(s) of the second heating cycle of the fibre. If a shoulder is present, its melting point should also be noted. It can be difficult to measure the precise point of the shoulder that corresponds to the associated melting point because of the diffuse shape of the shoulder. In such cases, second-order derivative analysis techniques should be used to define the melting point of the shoulder.

25.3.3 Test information

The DSC graphs must contain the following information:

- Test date
- Procedure
- Sample number
- Sample weight
- Onset temperature
- Melting point and enthalpy of the peaks
- Second derivative curve of the DSC curve

26 PROCEDURE FOR THERMOGRAVIMETRIC ANALYSIS (FIFA TEST METHOD 2024-16)

26.1 Scope

The test method for thermogravimetric analysis (TGA) on football turf infill materials aims to analyse and determine the ratio of organic to inorganic materials present in the synthetic infill. This test is divided into two procedures, depending on the specific type of infill used as performance infill. It is important to note that TGA testing is not required for organic (vegetal) infills.

26.2 Test apparatus

26.2.1 A thermogravimetric analyser with the following features:

- Heating rate up to 40°C/min
- Nitrogen purge gas with a flow rate in the range of 10-50ml/min
- The analyser should be maintained and calibrated in accordance with the manufacturer's instructions

An analytical balance capable of measuring to an accuracy of ±0.01mg

Nitrogen supply

26.3 Conditioning of samples

Ensure that the sample is dry before placing it in the apparatus. Switch the apparatus on and allow it to equilibrate for at least 30 minutes.

Use the same purge gas flow rate that was used to calibrate the instrument.

26.4 Test procedure

26.4.1 TGA of SBR (styrene-butadiene rubber) infill (from recycled tyres, coated or uncoated)

Nitrogen purge gas flow rate within the range of 10-50ml/min to be applied throughout the test

Sample weight should be between ≥25mg and ≤100mg

Heating programme:

- Heating from 50°C to 300°C with a heating rate of 15°C/min
- Maintain the sample at 300°C for eight minutes
- Heating from 300°C to 650°C at a heating rate of 15°C/min
- Heating from 650°C to 850°C at a heating rate of 25°C/min

26.4.2 TGA of EPDM (ethylene propylene diene terpolymer), TPE (thermoplastic elastomer) and other polymer infill types

Nitrogen purge gas flow rate within the range of 10-50ml/min to be applied throughout the test

Sample weight should be between ≥25mg and ≤100mg

Heating programme: 50°C to 850°C with a heating rate of 10°C/min

26.5 Assessment of test specimens

26.5.1 TGA on SBR infill

Measurement:

Organics: mass loss up to 650°C

Inorganics: 100% – % of organics

Elastomers: mass loss between 300°C (after being maintained for eight minutes) and 650°C

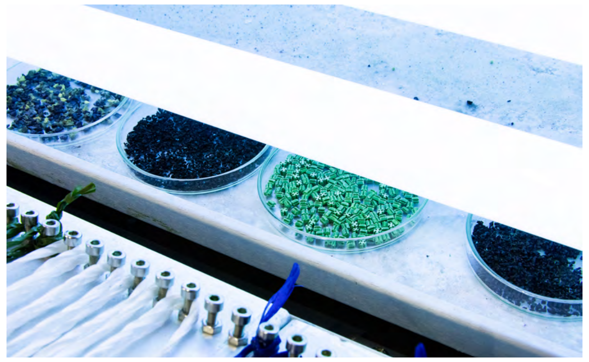
26.5.2 TGA on EPDM, TPE and other polymer infill types

Measurement:

Organics: mass loss up to 650°C

Inorganics: 100% – % of organics

Elastomers (for EPDM only): mass loss between beginning of second peak (usually around 400°C) and 650°C



27 DETERMINATION OF UV STABILISER CONTENT IN ARTIFICIAL-TURF YARN (FIFA TEST METHOD 2024-17)

27.1 Scope

The test method for UV stabiliser content in artificial-turf yarn on football turf involves subjecting test pieces of pile yarn to infrared light and measuring the change in absorbance. Samples collected from both laboratory and field tests are analysed using attenuated total reflectance/Fourier transform infrared reflection (FT-IR) to compare the levels of UV stabiliser between the original laboratory test products and on-site samples. The results of these samples should fall within an acceptable range of UV stabiliser values, ensuring consistency between the tested and the on-site products.

It is important to note that FT-IR analysis is conducted only if concerns arise regarding the UV stabiliser content, and if any significant discrepancy is found, FIFA reserves the right to revoke the certification.

27.2 Sample collection and storage

27.2.1 Taking the sample from the field

If there is an area that is affected, take a sample of yarn from this roll, however, include samples of yarn from different tuft lines within the same roll and from along the same tuft lines.

Note the position of the affected roll for comparison with the turf site plan.

If multiple areas are affected, samples must be taken from each of these rolls, including samples from different affected tuft lines.

Note the position of the affected rolls for comparison with the turf site plan.

27.2.2 Cleaning of field samples

Field samples contain traces of sand and rubber that need to be washed off.

The yarn that was protected by the sand layer on the field is cut from the rest of the sample.

These yarns are put in an Erlenmeyer flask with water. The Erlenmeyer flask is put in an ultrasonic bath for 15 minutes to be cleaned. After 15 minutes, samples are taken out of the water with a tweezer and wiped dry with soft tissue paper.

27.2.3 Product sample storage

For each product test, the FIFA-accredited laboratory test institute should collect and store a minimum of ten complete filaments of each fibre type from a minimum of three separate tuft lines in a cool, dark place with an appropriate label noting the date of collection and the relevant laboratory report number.

27.2.4 Field sample storage

During each field test, the FIFA-accredited field test institute should collect and store a minimum of ten complete filaments of each fibre type from a minimum of three separate tuft lines in a cool, dark place with an appropriate label noting the date of collection and the relevant field test report number.

27.3 Test apparatus

- FT-IR apparatus equipped with an ATR unit
- An air-circulating oven conforming to ISO 188
- An ultrasonic bath
- Demineralised water
- A climatic room of 23±2°C and 50±5% RH (relative humidity)

27.4 Conditioning of samples

If samples are taken from the field, they should be stabilised in a container in a climatic room to avoid exposure to UV light for a minimum of 11 days at 23+/-2°C and 50+/-5% RH.

27.5 Procedure

Clean the ATR crystal before every measurement according to the manufacturer's guidelines.

27.6 Procedure for laboratory samples

27.6.1 Identification of the UV stabiliser(s) peak(s)

A minimum of five monofilaments or tapes are put in an oven at 105+/-2°C for 4h+/-15 minutes. The samples are then cooled down in a desiccator for a minimum of two hours, allowing them to reach room temperature.

The "heat-aged" samples are put on the ATR crystal of the FT-IR apparatus for 32 scans. The spectra are taken at three different positions along the fibre. Ensure that the crystal is in full contact with the fibre and not sitting on the apex, for example, of a structured fibre.
A minimum of five original monofilaments or tapes are put on the ATR crystal for 32 scans and a minimum of three spectra are taken.

The averages of the peaks associated with the UV stabiliser are compared to each other. The heat treatment produces a shift in the UV stabilisers, and this will be reflected in a shift of the peak(s) of the UV stabilisers.

27.6.2 Quantification of the peak of the original sample

A minimum of five monofilaments or tapes from the same tuft line are put on the ATR crystal of the FT-IR apparatus.

Every measurement consists of 32 scans.

Eight different positions of the yarn are measured.

The spectrum must be normalised at the carbon peak located at 2950cm-1 for polyethylene and the baseline correction needs to be carried out.

The maximum height of the absorbance peak (determined in section 27.6.1: Identification of the UV stabiliser(s) peak(s)) is measured. This is defined as the absorbance of the sample, see section 27.8: Calculation of results.

If abnormally low values are obtained, check if the sample holder of the ATR is completely filled with material. If this is not the case, these measurements should be discarded.

The average of the eight different positions is calculated. If the coefficient of variation (ratio of the standard deviation to the mean) of these eight measurements is higher than 10%, eight additional samples are measured.

The measurements are performed on the same samples used for the UV test (section 21: Procedure for artificial weathering (FIFA Test Method 2024-11)).

27.7 Identification and quantification of peak(s) of the field sample

The measurement is performed in accordance with section 27.6.1: Identification of the UV stabiliser(s) peak(s).

27.8 Calculation of results

$$\text{\% original content of UV stabiliser} = \frac{\text{absorbance of the sample} \times 100}{\text{Absorbance of the samples submitted for UV}}$$

28 DETERMINATION OF PARTICLE SIZE DISTRIBUTION OF GRANULATED INFILL MATERIALS (FIFA TEST METHOD 2024-18)

28.1 Scope

The test method for the particle size distribution of granulated infill materials for football turf surfaces involves determining the consistency of samples and comparing them to the manufacturer's product declaration. This is achieved by passing the samples through different sieve sizes and obtaining a granulometric curve. The analysis allows for the determination of the particle sizes represented by D and d values, providing valuable information about the distribution of granules within the infill material.

28.2 Test procedure

Weigh a minimum of 300ml (0.3l) of the granulated infill material and place it on a clean tray in an oven at 45±5°C for two hours. Reweigh the sample. If the weight has reduced by more than 1.0±0.1g, return it to the oven for a further two hours. Reweigh the sample if the weight is consistent with the previous reading to within 1.0±0.1g and then remove it from the oven. If not, repeat this procedure until the weight is consistent to 1.0±0.1g. Remove the sample from the oven and allow it to cool to room temperature (minimum period: one hour).

For vegetal infill material, samples must be dried in an air-circulating oven for at least 48 hours at 45°C±5°C until the weight of the sample is constant, with no weight reduction of more than 1.0±0.1g (it is important not to subject the samples to high temperatures).

Determine the particle size distribution of the infill materials using the following sieves:

0.00mm, 200µm, 315µm, 0.5mm, 0.63mm, 0.80mm, 1.00mm, 1.25mm, 1.60mm, 2.00mm, 2.50mm, 3.15mm, and 4.00mm.

For coarser infill materials, the following sieves must be added:

4.50mm, 5.00mm, 5.60mm, 6.30mm, 6.70mm, 7.10mm, 8.00mm, 9.00mm, 9.50mm, 10.00mm, 11.20mm and 12.50mm.

Sieve size (mm)	Volume (mm³)	Sieve size (mm)	Volume (mm³)
0.2	0.004	4.50	47.713
0.315	0.016	5.00	65.450
0.5	0.065	5.60	91.952
0.63	0.131	6.30	130.924
0.8	0.268	6.70	157.479
1	0.524	7.10	187.402
1.25	1.023	8.00	268.083
1.6	2.145	9.00	381.704
2	4.189	9.50	448.920
2.5	8.181	10.00	523.599
3.15	16.366	11.20	735.619
4	33.510	12.50	1022.654

28.3 Calculation of results

d: starting from the smallest sieve, d_{test} is the largest sieve through which 10% or less of the sample passes (i.e. between 0% and 10% of the sample is smaller than the sieve designated "d").

D: starting from the biggest sieve, D_{test} is the smallest sieve on which 10% or less of the sample is retained (i.e. between 0% and 10% of the sample is bigger than the sieve designated "D").

Plot the results on a graph and determine the values of d_{test} and D_{test} for the sample.

Calculate the percentage mass of the sample falling between d_{test} and D_{test} when compared to the overall test sample mass.

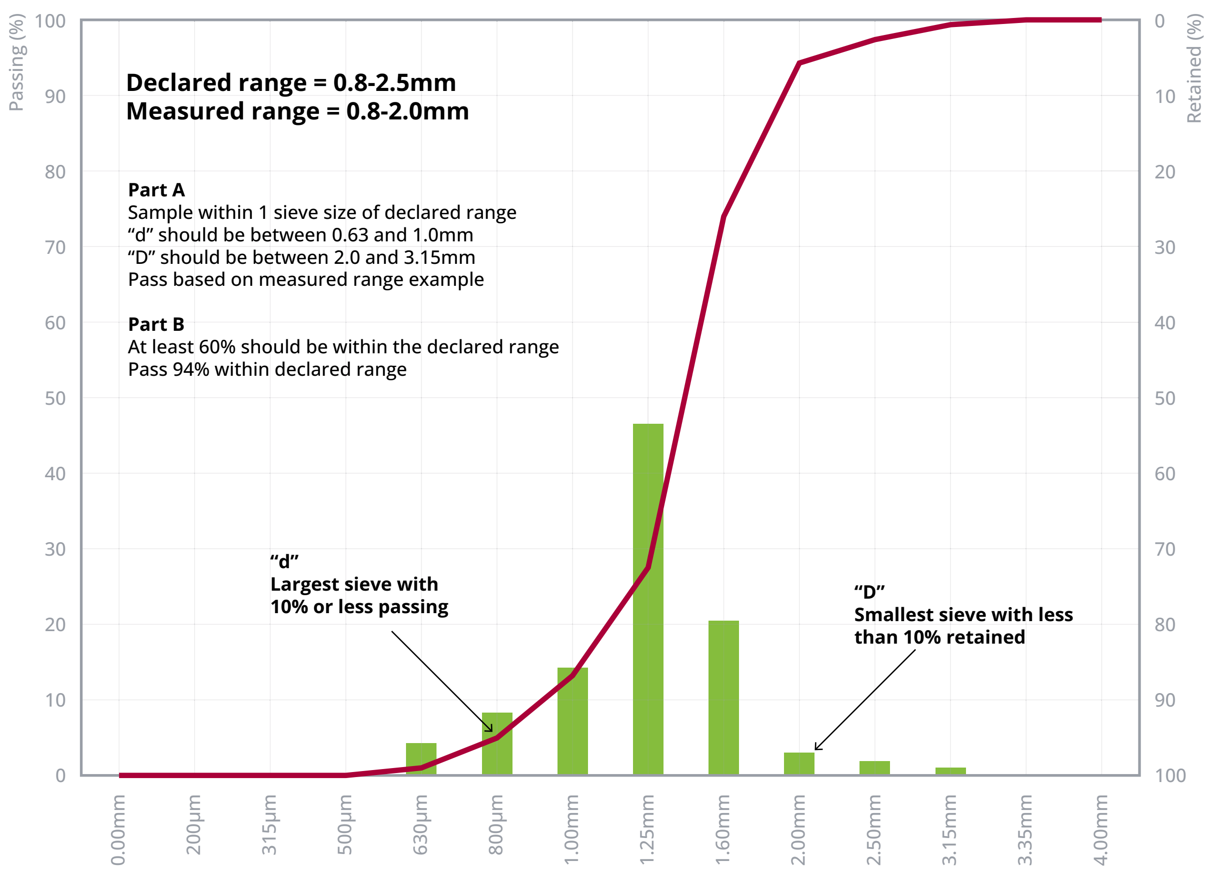
28.4 Analysis of results

Validation of the manufacturer's declaration – type approval laboratory tests

The manufacturer's declaration must define the range intended to be encompassed by d and D.

For a sample to comply with a manufacturer's declaration, the mesh size of the d_{test} and D_{test} sieves must be ± one sieve size, from the list given in 28.2 above, of the declared dm (the value for d declared by the manufacturer) and Dm (the value for D declared by the manufacturer) values and at least 60% of the total infill sample must be within the declared range, as illustrated below in Figure 53: example of particle distribution curve.

Figure 53: Example of particle distribution curve



29 DETERMINATION OF INFILL DEPTH (FIFA TEST METHOD 2024-19)

29.1 Scope

The test method for infill depth on football turf products is based on EN 1969 but includes modifications to accommodate the softer nature of the turf surface. The objective is to achieve consistent, reproducible and repeatable results when measuring the infill depth. The adapted apparatus ensures accurate and reliable assessments of the infill depth on football turf surfaces.

29.2 Test apparatus

The test apparatus comprises the following:

A depth-measuring probe, comprising a barrel with three flat-ended steel prongs, circular in section, approximately 2mm in diameter. These prongs are set in a triangular pattern with an approximate spacing of between 15mm and 20mm. The prongs must be sufficiently long so that when driven into a surface under test, the depth from the upper to the lower surface of the material under test (infill) can be measured by means of the calibrated, graduated barrel capable of reading between 0mm and 50mm in 1mm increments. The circular baseplate should be a minimum of 25mm in diameter to reduce the compression of the infill during measurement.

29.3 Test procedure

Place the depth gauge on the surface of the turf, ensuring that there are no extraneous items under the baseplate. Extend the prongs from the barrel; using hand pressure, push the plunger down into the infill materials whilst supporting the gauge upright with your other hand. Continue to push the prongs until resistance of the carpet backing material is felt, release the pressure on the plunger and check and slide the barrel gauge down onto the surface of the infill.

Read the depth of penetration directly from the graduated scale, and record this as the infill depth.

For field testing, the measurement must be carried out at the 19 test locations as set out in section 13.8.2: Procedure.

Figure 54: infill depth gauge

30 DETERMINATION OF INFILTRATION RATE OF ARTIFICIAL-TURF SYSTEMS (FIFA TEST METHOD 2024-20)

30.1 Scope

The test method for the infiltration rate of artificial-turf systems is based on EN 12616:2023, with adaptations made to cater to the specific needs of football turf. It aims to measure the permeability of the system, indicating the rate at which water can infiltrate through the surface. The results of this test are recorded in units of millimetres per hour (mm/h).

30.2 Definition

Permeability is defined as the infiltration rate when water is allowed to pass through the product due to gravity. It is calculated by measuring the time taken for the head of water to flow/pass a specified height between two vertical marks. This can be measured as a component of a system, e.g. a shockpad or a carpet only, or as a total system.

30.3 Test apparatus

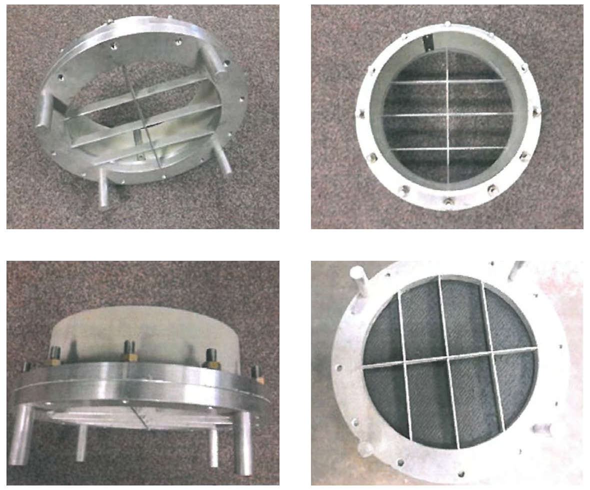
a. A ring of metallic or plastic material with an internal diameter of 300±2mm and a method of sealing the ring to the product to be tested (either mechanically with a clamp or by use of a sealant).

b. A support grid for underpinning the product to prevent it distorting when water is poured into the apparatus. The maximum deformation of the product must be 5mm from the outside of the ring to the centre once water has been added to the ring. Within the ring, there should be three parallel horizontal wires or bars and a central bar perpendicular to the other three. These should be 2.5+/-0.5mm in width to prevent obstruction of any porosity holes in the carpet.

c. Stopwatch (accurate to 0.1s)

d. Bubble/spirit level

Figure 55: example of apparatus for porosity testing



30.4 Sample preparation

Condition the test samples and any relevant infill in the laboratory at a temperature of 23±2°C for a minimum period of four hours.

Prepare a sample of shockpad and/or carpet, sealing it by either method in the ring; ensure that the minimum number of porosity holes in the carpet are visible within the 300mm ring area. Measure the diameter and location of the holes within the test piece and record/photograph for inclusion in the report.

Fill the carpet, if required, to the specified infill depths. Ensure that all fibres are visible and that there are no trapped fibres beneath the infill. Each layer should be compressed by placing a round disc with a mass of 5.00±0.25kg onto the turf. The disc should be rotated and counterrotated on the surface for a minimum of five full rotations to ensure compaction and levelling of any carpet infill. No additional pressure should be added to the disc.

If a mesh support is used, ensure that there is no sagging in the sample that would result in an uneven head of water over the sample.

Wetting of the test sample should be through the application of a minimum of five litres of water; the water should be applied through a disc of geotextile material of the same size as the diameter of the ring or through a similar size metal sieve with a mesh size no greater than 300 microns. Ensure that there is no leaking of water laterally out of the ring joints. If there is, reseal the sample to correct it. The sample should be left to drain for a minimum of 30 minutes.

30.5 Procedure

Ensure that the test rig is level prior to the start of the test.

Distribute water evenly to the consolidated samples through the mesh or geotextile. The head of water to be applied should be between 70mm and 90mm above the infill or backing of the sample, whichever is highest. Mark the ring at 10mm and 30mm above either the infill for filled systems, the shockpad (when testing the shockpad only) or the primary backing for non-filled systems or if measuring the turf without infill present. Time the fall in the head of water between the 30mm and 10mm markers above the infill or backing (i.e. a 20mm drop in head), record the time to the nearest 0.1 second, and ensure that any geotextile is removed prior to the start of the timer. If the infiltration rate is slow, stop the test at 30 minutes.

Repeat the test a further two times and average the last two results.

30.6 Calculation and expression of results

$$I_c = \frac{F_{wc}}{t_c}$$

Where:

- I_c = the infiltration rate in mm/h
- F_{wc} = the height the water has fallen, normally 20mm
- t_c = the time taken for the water level to fall in hours

If the result exceeds 2,000mm/h, denote ">2,000mm/h".

31 DETERMINATION OF YARN PROFILE (FIFA TEST METHOD 2024-21)

31.1 Scope

This method describes how to measure the thickness of a yarn, including the shape identification, through an image.

31.2 Test apparatus

31.2.1 General

A microscope with a magnification capability in the range of 200-250x and that is able to measure the dimensions.

31.3 Samples

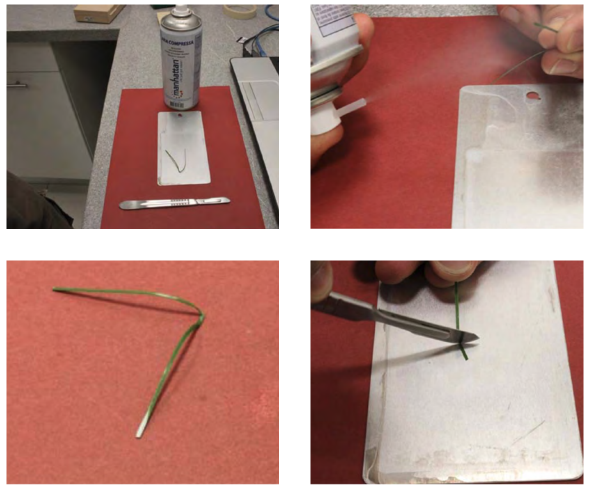
From a minimum of three different tuft lines, cut at least three fibres to be measured and photographed (three fibres to be measured in total). When sampling from a spool, three pieces of fibre must be measured and photographed at not less than five metres from each other.

31.4 Test procedure

Cut a piece of fibre around 50±10mm long from the available length from within the carpet or spool. Cool one end of the sample using an inverted compressed air bottle and accurately cut the end using a sharp blade (preferably a scalpel) against an aluminum plate.

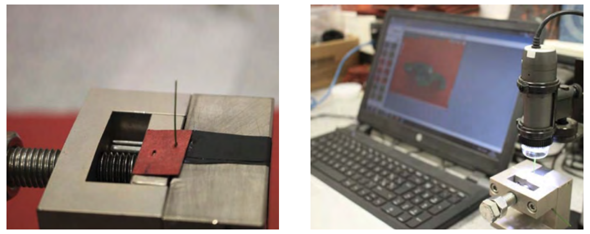
The sample obtained must have a clean cut without burrs or distortion of the fibre.

Figure 56: sample preparation procedure



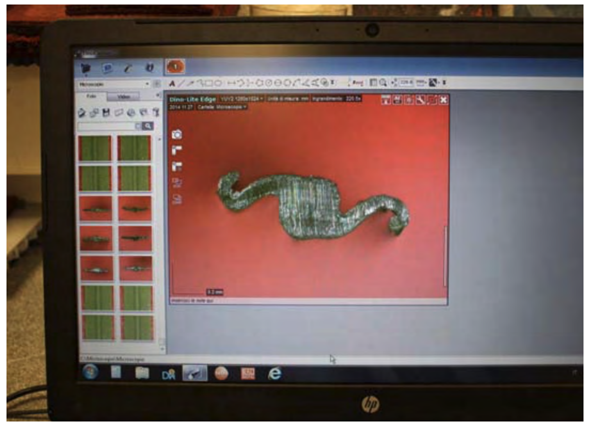
Using a support, holding the cut end in a vertical position perpendicular to the microscope, verify that the cut is clean, and if necessary, depending on the colour of the fibre, use an insert of a different coloured background to maximise the definition of the image.

Figure 57: placement under the microscope



Adjust the magnification of the microscope in the range of 200-250x and focus on the cross-sectional cut plane of the fibre. After making sure that they are in focus, take the picture.

Figure 58: screen view of the sample under the microscope



Proceed to the measurement of the following points, using the measurement function of the microscope (line):

1. Maximum width of the fibre
2. Maximum thickness (or depth) of the fibre, referred to as the perpendicular to its width
3. At least one intermediate reading between the centre and the extremity, on each side

Using the "circle" function of the microscope, inscribe where possible, in the areas of maximum thickness, the largest circle possible.

The picture obtained will be included in the FIFA laboratory report with the following details:

- Length: 15cm
- Width: 10cm
- The diameter of the largest circle
- Resolution: 100dpi

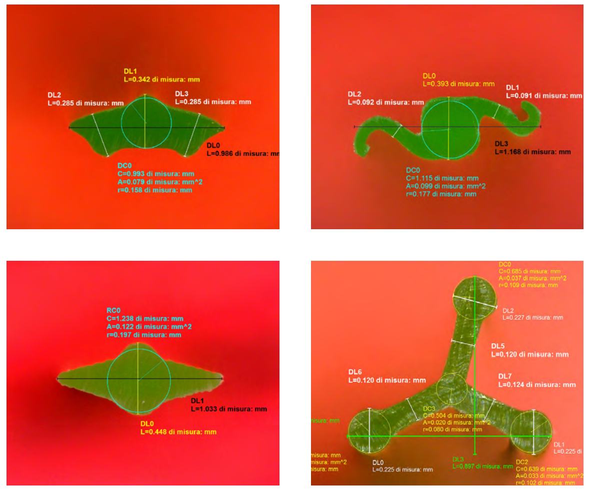
31.5 Calculation and expression of results

Record the dimensions of the yarn from a cross-sectional perspective, including all measurements.

The thickness of the fibre is defined as the diameter of the largest circle possible inserted in the core of the fibre.

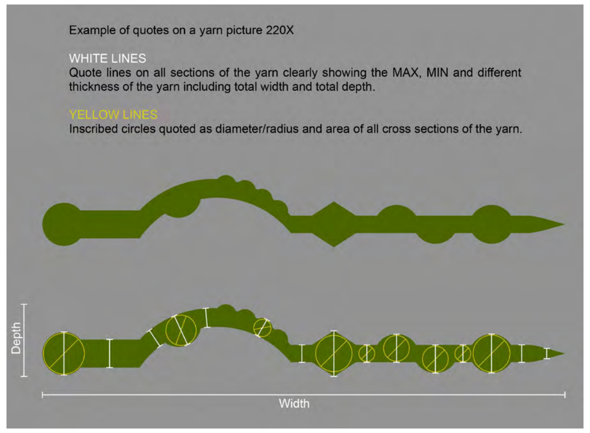
Typical examples of the most commonly used fibres are shown below:

Figure 59: typical common fibre shapes



If there are complex shapes, note the dimensions at several points as per the example below or consult the FIFA Quality Programme Workgroup for clarification.

Figure 60: sample of thickness measurements



32 DETERMINATION OF NON-ELONGATED FREE PILE HEIGHT (FIFA TEST METHOD 2024-22)

32.1 Scope

This method serves as a means of verification for both laboratory and on-site testing to ensure that the non-elongated free pile height is in accordance with the product declaration. If the non-elongated free pile height is correct, it infers that the sum of the two infills is also correct (not necessarily the ratio). It is also useful during retests to confirm whether the infill levels are consistent with previous testing.

32.2 Test apparatus

The test apparatus comprises the following:

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

32.3 Test procedure

Place the prism gauge on the infill of the synthetic turf surface for filled systems and on top of the primary backing for unfilled systems. Do not force the prism into the infill, rather place it onto the infill without exerting additional pressure. Ensure that the prism gauge is flat on the surface by using a bubble/spirit level. Record the length of the ten representative yarn fibres (ignore outliers); repeat this procedure at 90° to the first test (for measurements on-site, alternate between longitudinal and cross-pitch directions for each test position and calculate the median pile height in millimetres from the 10 representatives yarn fibres at each position). Calculate the median of the highest pile fibres in millimetres from the 20 representative yarn fibres.

The measurement must be carried out at the 19 test locations as described in section 13.8.2: Procedure for field tests and at three locations at least 100mm apart and a minimum of 100mm from the edge of an unconditioned sample.

33 DETERMINATION OF DECITEX OF YARNS (FIFA TEST METHOD 2024-23)

33.1 Scope

The test method for determining the decitex (dtex) of yarns involves analysing a yarn to measure its linear density. The dtex value provides information about the mass of the yarn per unit length.

33.2 Test apparatus

The test apparatus comprises the following:

- An analytical balance capable of measuring to an accuracy of ±1mg
- A gauge with a reading of 1mm
- An air-circulating oven conforming to ISO 188
- Tweezers

33.3 Conditioning of samples

If samples are from a field that is wet, they should be dried in an air-circulating oven at 70°C for 24 hours. After drying, they should be conditioned for a minimum of 24 hours at 23+/-2°C.

33.4 Test procedure

33.4.1 General method for assessing fibre dtex

Take 20 complete tufts with tweezers from the back of the carpet.

Scrape off any residue of latex (or coating) with the tweezers.

Remove any infill that may be “adhered” to the fibres.

Measure the length of each tuft to the nearest millimetre. Note down the sum of the lengths of the 20 tufts (L_{20}).

Weigh the 20 cleaned tufts (W_{20}) in grams.

33.4.2 Special cases

Where the coating or latex cannot be removed, proceed as follows: take three turf samples of a minimum of 200x200mm.

Shave off the pile of each piece and measure the length of the piles that have been shaved off up to the nearest millimetre (L_p).

Remove any infill that may be “adhered” to the fibres.

Measure the length of each tuft to the nearest millimetre.

Calculate the number of tufts according to ISO 1763 (N_t).

Weigh the piles that have been shaved off (W_p) in grams.

33.5 Calculation of results

33.5.1 General method for assessing fibre dtex

Calculate the total length of the 20 tufts as follows:

$$\text{dtex} = \frac{W_{20} \times 10^7}{L_{20}}$$

Special method

$$\text{dtex} = \frac{W_p \times 10^7}{N_t \times 2 \times L_p}$$

33.6 Expression of results

The results should detail the dtex of each type of fibril per tuft and the number of fibrils of each type per tuft.

(a)dtex x (b)

Where (a) corresponds to the linear mass (g) of the fibril per 10,000m, “x” is the multiplication sign, and (b) the number of fibrils per tuft.

Linear mass of yarn: dtex x number of yarns

For example: 1,900 dtex x 8

When a tuft is composed of different fibrils, the sign “+” is inserted and the combined dtex result is shown between parentheses.

(Linear mass of fibril 1 dtex x number of fibrils 1 + linear mass fibril 2 dtex x number of fibrils 2)

For example: (1,900 dtex x 8 + 2,200 detex x 2)

In the eventuality of a different yarn composition between tufting lines, the tufting lines need to be identified.

For example: line 1 (1,900 dtex x 8 + 2,200 detex x 2); line 2 (1,900 dtex x 6)

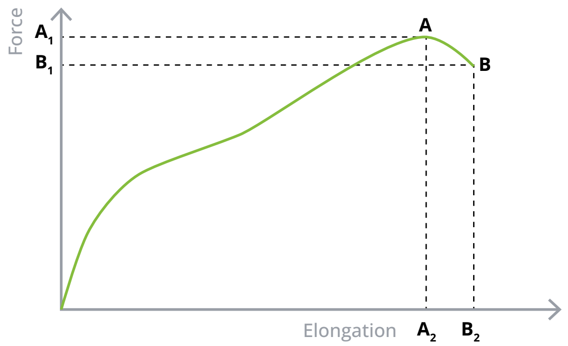
34 DETERMINATION OF PEAK FORCE, YARN BRITTLENESS AND YARN TENACITY (FIFA TEST METHOD 2024-24)

34.1 Scope

The test method principle for peak force, yarn brittleness and yarn tenacity involves subjecting materials to a tensile test to measure their behaviour under stress and strain. The stress-strain curve provides insights into the stiffness, elastic limit, yield point and deformation characteristics of the materials.

The peak force represents the highest amount of force (marked as A1 in figure 61 below) exerted on a specimen to cause its failure during a tensile test conducted under specific conditions.

Figure 61: force-elongation graph from a tensile test



Yarn brittleness reflects the yarn's ability to absorb energy, which is determined by the area beneath the force-extension curve generated during testing. The impact of artificial weathering on yarn samples, leading to yarn degradation, is assessed through changes in this energy absorption capacity.

Figure 62: principal of yarn brittleness

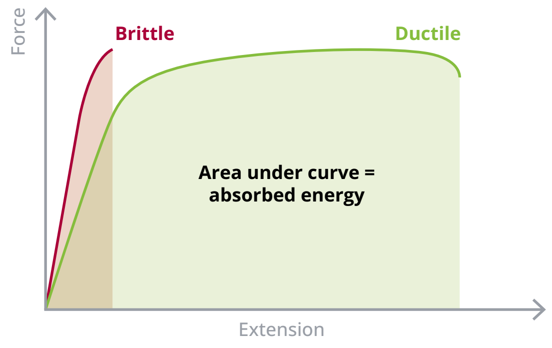
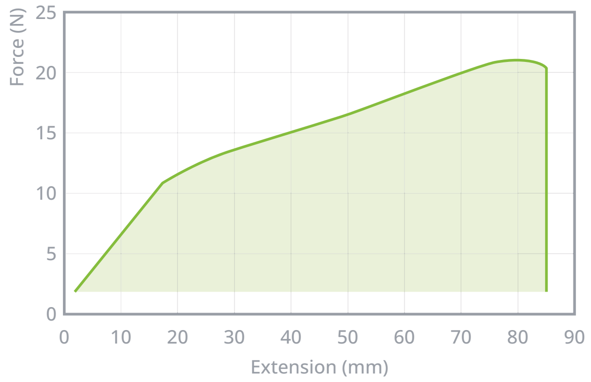


Figure 63: typical extension – force plot from yarn test. The area under the curve is the yarn energy absorption



The area under the stress-strain curve represents the energy absorbed by the material before failure, allowing for a comparison between ductile and brittle materials. In the context of synthetic turf, a ductile yarn is considered to be more resilient than a brittle yarn based on their respective behaviours and energy absorption capabilities.

Yarn tenacity is the ratio of the peak breaking force of a fibre to its linear mass.

34.2 Test apparatus

The test apparatus comprises the following:

- A tensile testing apparatus with a load cell over the testing range of 1N to 40N
- Tensile test machine with accuracy in accordance with ISO 5893
- Clamps to secure the yarn sample
- A computer or software for data recording and analysis

34.3 Conditioning of samples

Samples should be conditioned for a minimum of 24 hours at 23+/-2°C.Tests should be performed at 23+/-2°C.

34.4 Test specimens

Existing results for a particular family of yarns can be carried forward, provided the following conditions are met:

1. When tested in accordance with ISO 11357-3, the DSC trace of the yarn shows the same profile. The main points of reference when comparing yarns must be obtained from the second heating of the polymer sample and comprise the peak temperature, peak area and overall curve shape, all of which should be similar (peak temperature ± 3°),
2. The thickness of the yarn must be at least 90% of the previously tested yarn.The shape of the yarn is the same.

34.5 Test procedure

Testing should be conducted on newly produced yarn samples that have not been exposed to outdoor environments and on samples that have undergone artificial weathering following EN 14836 Method 2.

The tensile behaviour of materials is measured using tensile test machines. This procedure applies to both unexposed fibres and UV-exposed fibres.

1. A fibre length of 100±2mm is clamped at both ends.
2. The fibre must be positioned in the axis of the tensile machine and laid flat.
3. Start by attaching the fibre to the top grip.
4. Set the load/force to zero (tare the load sensor).
5. Attach the fibre to the bottom grip, ensuring that no load/force is applied to the fibre.
6. Apply displacement at a predetermined strain rate. The strain rate is equal to 50% of the fibre length per minute. For example, for a fibre of 100mm in length, the strain rate would be 50mm/min.
7. Ensure that the fibre does not slip between the grips during the test by marking the fibre at the contact points with the grips. If the fibre slips during the test, the results of the test should not be considered.
8. Results should not be considered if failure occurs in contact with the grips.

A minimum of ten representative tests per fibre type should be conducted. Exclude any obvious outliers before calculating the average results for repeat tests.

34.6 Calculation of results
34.6.1 Data processing and analysis:

The data from each test must be processed as follows to create an extension-force curve plot:

1. All data corresponding to a force measurement of <1N must be excluded.
2. Raw force data must be smoothed using a five-point moving average filter.
3. Raw extension data must be smoothed using a five-point moving average filter.
4. Extension data must be set at 0mm at 1N.
5. All data beyond the point of maximum force (peak force) must be excluded.

34.6.2 Report the following me asurements for each yarn sample:

1. Peak force in N (refers to the maximum force required to break a strand of yarn). See value on the curve.
2. Failure extension:

Failure extension = Δl / lo x 100

Where:

Failure extension expressed as a percentage,
Δl = the length variation between the length of the fibre at peak force and lo in mm,
lo is the reference length in mm.

Yarn tenacity in cN/tex is calculated by dividing the peak breakage force (in cN) by the linear density (in tex).

Change in energy absorption

The energy absorbed by the yarn prior to failure (brittleness) is determined by calculating the integral under the extension-force plot by using the trapezoidal method. The trapezoid step length should be at least 100 times smaller than the yarn extension failure length. The integral is calculated up to the point of maximum force (peak breakage force), and all data beyond this point is excluded. The minimum force taken into account is 1N (as shown in figure 63).

Calculate the mean value of energy absorption for both the new and the aged yarns. From the two mean values, calculate the percentage change in yarn energy absorption as follows:

$$\text{Change in energy absorption} = \left(\frac{E_{aged} - E_{new}}{E_{new}} \right) * 100\%$$

Where:

E_{aged} = mean yarn energy absorption of samples subjected to artificial weathering,

E_{new} = mean yarn energy absorption of unexposed samples.

Stiffness (gradient of the second order polynomial function at 5mm extension)

- Fit a second-order polynomial function to the first 10mm of extension using Gauss's method of least squares.
- Calculate the gradient (in N/mm) of the polynomial function at an extension of 5mm to determine yarn stiffness.

35 DETERMINATION OF TUFT WITHDRAWAL FORCE (FIFA TEST METHOD 2024-25)

35.1 Scope
The test method for tuft withdrawal force is based on ISO 4919 (2012) and has been adapted to ensure consistency when testing football turf. It quantifies the force required to extract a half tuft from an artificial-turf carpet. By measuring this force, the test provides an indication of the tuft retention strength.

35.2 Test apparatus
The test apparatus comprises the following:

- A tensile testing apparatus with a load cell that is accurate to ±5% over the 10-250N testing range.
- Surgical forceps.
- A baseplate with a minimum dimension of 60x60mm with a circular hole, of a minimum radius of 12mm, cut out. The cut-out may have a throat to facilitate the positioning of the tufts to be withdrawn.

35.3 Conditioning of samples
Take a sample with a minimum dimension of 200x200mm from the carpet to be tested.

If samples are from a (wet) field, they should be first dried in an oven at 70°C for 24 hours. Afterwards, they should be conditioned for a further minimum of 24 hours at 23+/-2°C.

Tests should be performed at 23+/-2°C.

35.4 Test procedure
Install the baseplate so that it is flat, on a plane perpendicular to the direction of the tuft withdrawal.

Select one end of one whole tuft and attach it into the surgical forceps.

Clamp the carpet on the baseplate and ensure that the tuft is located in the cut-out of the baseplate.

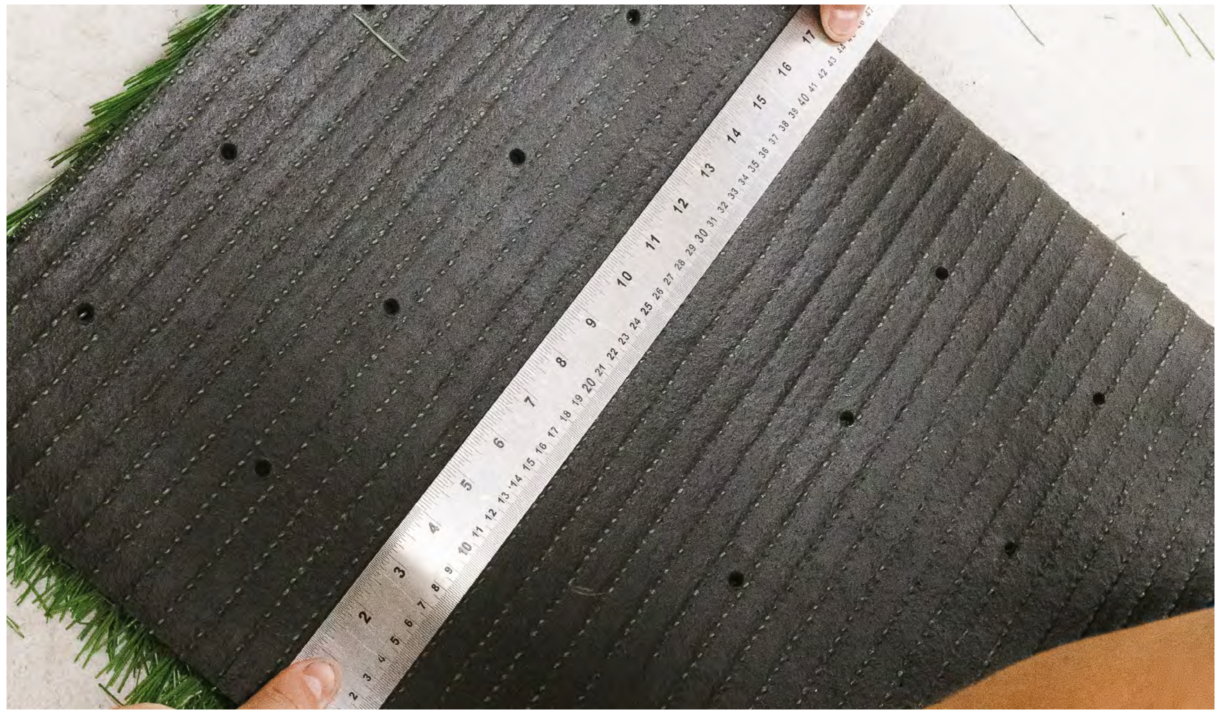
Set the tensile testing machine in motion with a constant speed of 100mm/min and completely withdraw the tuft along a path that is essentially perpendicular to that of the carpet specimen.

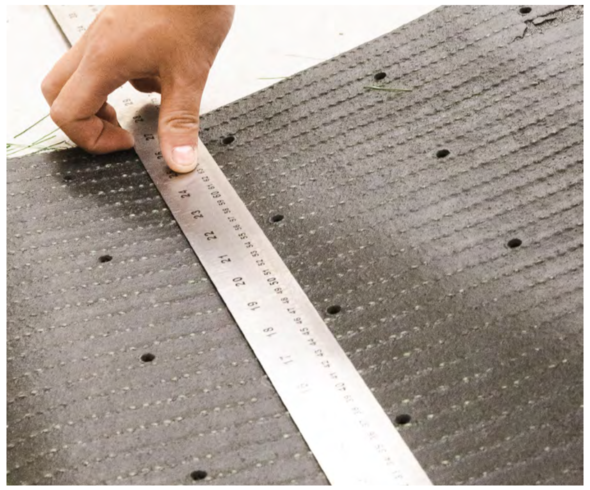
Verify that only one tuft was withdrawn and register the maximum force recorded by the tensile machine.

If additional fibres from another tuft were inadvertently gripped or if only part of the tuft was withdrawn, ignore the result.

Repeat the procedure for a minimum of 20 tufts, spread over the sample. The minimum distance between each withdrawn tuft is at least 25mm.

35.5 Calculation and expression of results
Calculate the mean tuft withdrawal force in newtons and note the value to one decimal place, along with the standard deviation for the 20 tufts.





36 DETERMINATION OF NUMBER OF TUFTS PER UNIT LENGTH AND GAUGE, AND TUFTS PER UNIT AREA (FIFA TEST METHOD 2024-26)

36.1 Scope

The test method for tufts per unit length and gauge, and tufts per unit area in football turf involves determining the number of tufts present in a given length, as well as the spacing between tufts, both in the laboratory and on-site. The procedure provides a standardised method to quantify the density and arrangement of tufts within the football turf system. This allows for consistent comparisons between different turf samples and ensures accurate assessments of the tufting characteristics.

36.2 Test apparatus

A device capable of measuring accurately over a minimum length of 500mm. The apparatus must have an accuracy of a minimum of 1.0mm.

36.3 Normative references

ISO 2424 Textile floor coverings – Vocabulary

36.4 Test procedure

36.4.1 Conditioning of samples

When testing in the laboratory, samples must be stored in a climatic room for a minimum of 24 hours at 23+/-2°C and assessed under these conditions.

36.4.2 Sampling – taking the sample from the field

If representative samples of the tufted turf installed of a minimum size of 500x500mm are available, these should be used for analysis. Where possible, more than one sample should be obtained. If the location of the roll of turf from which the sample was cut is known, this information should be recorded.

If only one sample is available, raise one corner of the turf and undertake the measurements on the reverse side of the turf. Raise a second corner of a separate roll of turf and undertake the measurements on the reverse side of the turf.

36.4.3 Sampling – taking a sample from a roll of turf or from a sample sent to the laboratory for assessment

Cut representative samples of the tufted turf to be evaluated of a minimum size 500x500mm. Individual samples should be from separate manufactured rolls of turf. Ensure that any sample cut is a minimum of one tuft line from the selvedge of the turf roll.

36.4.4 Measurement directly from the installed field

If a sample is not available to be removed from site and taken back to the laboratory for assessment, an alternative assessment must be conducted.

If it is possible to fold over the corners of the as-laid turf, the following procedure must be used. If the infill levels inhibit the folding over, the infill must be removed from the corners and reinstated after the procedure has been completed. Finally, if the border of the turf has been mechanically fixed or adhered, permission must be obtained from the facility owner/operator to reopen the fixed edges. Stretching of the carpet must be avoided.

At least two measurements from different rolls must be performed.

36.5 Procedure for measuring the number of tufts

36.5.1 Procedure for measuring the number of tufts linearly along the direction of production

Place the sample on a flat surface (only if tested in the laboratory). Lay the measuring device along the side of a row of tufts in the direction of manufacture, approximately 50mm from the edge of the turf. Place the point zero directly against a tuft as it projects through the primary backing. Count the maximum number of whole tufts over a distance of at least 400mm. Take note of the number of tufts (N_t) and the distance (L_t).

Repeat the procedure at approximately 150mm, 250mm, 350mm and 450mm from the edge.

36.5.2 Procedure for measuring the number of tufts perpendicular to the direction of production between each tufting needle, generally referred to as the machine gauge

Place the sample on a flat surface (only if tested in the laboratory). Lay the measuring device along the side of a row of tufts perpendicular to the direction of manufacture, approximately 50mm from the edge of the turf. Align the measuring device along a series of adjacent tufts. Place the point zero directly against the right-hand side (when measuring right to left) or the left-hand side (when measuring left to right) of a row of tufts as it projects through the primary backing. Count the number of tuft lines over a distance of at least 400mm. Take note of the number of tufts lines (N_g) and the distance (L_g).

Repeat the procedure at approximately 150mm, 250mm, 350mm and 450mm from the edge.

36.6 Calculation and expression of results

36.6.1 Calculation for measuring the number of tufts linearly along the direction of production

For each set of values, calculate the individual values using the following equation:

$$\text{Number of tufts per 100mm} = \frac{N_t}{L_t} \times 100$$

Calculate the average of the five sets of values and record it. Express the results in tufts/100mm to one decimal place.

36.6.2 Calculation for measuring the number of tufts perpendicular to the direction of production between each tufting needle, generally referred to as the machine gauge

For each set of values, calculate the individual values using the following equation:

$$\text{Gauge} = \frac{N_g}{L_g}$$

Calculate the average of the five sets of values and record it. Express the results in millimetres to two decimal places. For information, the whole fractional imperial value (e.g. 5/8, ½, ¾, etc.) in inches can be indicated in parentheses.

36.6.3 Calculation of the total number of tufts per square metre

$$\text{Number of tufts per m}^2 = \frac{1000 \times N_t}{L_t} \times \frac{1000}{\text{gauge}}$$

Express the results in tufts per square metre to the nearest whole number.

37 DETERMINATION OF PILE LENGTH ABOVE BACKING (FIFA TEST METHOD 2024-27)

37.1 Scope

The test method for pile length above the backing involves determining the length of the pile fibres above the primary backing in a football turf sample. This procedure provides a standardised method to measure and compare the pile height across different samples. It ensures the accurate and consistent assessment of the pile length, which is an important property of a turf system.

37.2 Test apparatus

A device capable of measuring accurately to a minimum of 1.0mm, e.g. a steel ruler.

37.3 Test procedure

37.3.1 Conditioning of samples

When testing in the laboratory, samples must be stored in a climatic room for a minimum of 24 hours at 23+/-2°C and assessed under these conditions.

If samples are taken from the field, they should be stored in a climatic room for a minimum of 24 hours at 23±2°C.

37.3.2 Sampling – taking the sample from the field

If representative samples of the tufted turf installed of a minimum size of 500x500mm are available, these should be used for analysis. Where possible, more than one sample should be obtained. If the location of the roll of turf from which the sample was cut from is known, this information should be recorded.

If only one sample is available, raise one corner of the turf and undertake the measurements on the reverse side of the turf. Raise a second corner of a separate roll of turf and undertake the measurements on the reverse side of the turf.

37.3.3 Sampling – taking a sample from a roll of turf or from a sample sent to the laboratory for assessment

Cut representative samples of the tufted turf to be evaluated of a minimum size 500x500 mm. Individual samples should be from separate manufactured rolls of turf. Ensure that any sample cut is a minimum of one tuft line from the selvedge of the turf roll.

37.3.4 Measurement directly from the installed field

If a sample is not available to be removed from site and taken back to the laboratory for assessment, an alternative assessment must be conducted.

If it is possible to fold over the corners of the as-laid turf, the following procedure must be used. If the infill levels inhibit the folding over, the infill must be removed from the corners and reinstated after the procedure has been completed. Finally, if the border of the turf has been mechanically fixed or adhered, permission must be obtained from the facility owner to reopen the fixed edges. Stretching of the carpet must be avoided.

At least two measurements from different rolls must be performed.

37.3.5 Procedure for measuring the pile length above backing

Place the sample on a flat surface (only if tested in the laboratory) with the fibres upright so that the direction of manufacture of the football turf is leading directly away from the technician.

Choose a tuft line that is approximately 100mm from the selvedge of the sample and approximately 100mm from the nearest edge of the sample. Hold the measuring device upright, perpendicular to the table on top of the primary backing immediately adjacent to a tuft. If the tuft is composed of a single fibrillated yarn, measure the height of the whole fibre. If, however, the tuft is composed of several fibrils, these should be measured individually.

For fibrils on the outer side of the U-shaped tuft, hold the measuring device on the outer side of the bundle of fibrils in the tuft. If, however, the fibril is located on the inner side of the bundle, place the measuring device in the centre of the U-shaped loop. Pull the fibre taut against the face of the measuring device and note the length of the fibre/fibril to the nearest millimetre.

For texturised fibres, do not pull the fibre taut, but hold the fibre against the face of the measuring device, avoiding bending the fibre in such a manner as to increase the effective overall pile height. Note the length of the fibre/fibril to the nearest millimetre.

Record the mean pile height of the measured tuft.

Repeat the procedure to obtain ten tuft pile height measurements in total.

37.4 Calculation and expression of results
Calculate the average of the ten measurement values and record it. Express the results in millimetres to one decimal place.

38 DETERMINATION OF MASS PER UNIT AREA (FIFA TEST METHOD 2024-28)

38.1 Scope
The test method to determine the mass per unit area involves measuring the weight of a football turf sample and dividing it by the corresponding surface area. Accurately determining the mass per unit area allows for consistent comparisons to be made between different turf samples and the manufacturer's specifications.

38.2 Test apparatus
The test apparatus comprises the following:

A device capable of measuring accurately over a minimum length of 500mm. The apparatus must have an accuracy of a minimum of 1.0mm.

An analytical balance with an accuracy of ±0.1g.

38.3 Test procedure

38.3.1 Conditioning of samples
If samples are taken from the field, they should be stored in a climatic room for a minimum of 24 hours at 23+/-2°C.

38.3.2 Sampling – taking the sample from the field
If representative samples of the tufted turf installed of a minimum size of 500x500mm are available, these should be used for analysis. Where possible, more than one sample should be obtained. If the location of the roll of turf from which the sample was cut is known, this information should be recorded.

If only one sample is available, raise one corner of the turf and undertake the measurements on the reverse side of the turf. Raise a second corner of a separate roll of turf and undertake the measurements on the reverse side of the turf.

38.3.3 Sampling – taking a sample from a roll of turf or from a sample sent to the laboratory for evaluation
Cut representative samples of the tufted turf to be evaluated of a minimum size 500x500mm. Individual samples should be from separate manufactured rolls of turf. Ensure that any sample cut is a minimum of one tuft line from the selvedge of the turf roll.

38.3.4 Procedure for measuring the mass per unit area
To ensure accuracy and repeatability, it is important that, whenever the sample is being prepared, the edges are cut through the backing material with a minimum of fraying and avoiding cutting through tufts.

Place the sample on a flat surface. Lay the measuring device along the side of a row of tufts perpendicular to the direction of manufacture, approximately 50mm from the edge of the turf. Align the measuring device along a series of adjacent tufts.

In the machine direction, cut two parallel lines of at least 400mm in length. Both the left-hand side and right-hand side cuts should be between tuft lines and not across a tuft line.

Perpendicular to the machine direction, cut a further two parallel lines of approximately the same length as the machine direction cut. Both lines should be cut between the tufts, avoiding cutting through a tuft.

NB: If, due to the number of tufts along the length of the sample, this is difficult to achieve, remove the tufts immediately above point zero and immediately below the cut length. This should make it possible to cut cleanly through the backing, avoiding cutting through the tufts.

Measure the width and length of the turf in millimetres to an accuracy of 1mm. Five readings of the width should be taken at approximately equal distance apart along the length. Five readings of the length should be taken at approximately equal distance along the width. Take the average of the five width measurements (w) and the average of the five length measurements (l).

Measure the mass (m) of the turf sample in grams to an accuracy of 0.1g.

38.4 Calculation and expression of results
For each set of values, calculate the individual values using the following equation:

$$\text{Mass per unit area } (g.m^2) = \frac{m \times 1000 \times 1000}{w \times l}$$

Calculate the value for each sample assessed and record it. Express the results to one decimal place.

39 DETERMINATION OF POLYCYCLIC AROMATIC HYDROCARBONS CONTENT FOR POLYMERIC INFILL MATERIALS (FIFA TEST METHOD 2024-29)

Polycyclic aromatic hydrocarbons (PAHs) are a widely occurring group of chemicals present in natural and man-made materials, including some rubbers and plastics used to make infills for synthetic turf sports surfaces. Prolonged exposure to unacceptably high concentrations of PAHs can be harmful to human health, and it is therefore important that any polymeric infill does not have unacceptable amounts of PAHs.

To ensure that players and match officials, installation contractors and maintenance contractors are adequately protected, the European Union and other countries are establishing legislation that will limit the PAH content of infill materials. As these will be legal requirements, compliance will be mandatory in the regions in which they apply.

In countries where there are no legal restrictions, FIFA recommends that the European Union's limits, detailed below, are applied to all new FIFA fields containing polymeric infills.

For the avoidance of doubt, if the national regulation prohibits the sale of non-compliant infill products (PAH (8) content >20mg/kg), the PAH content test is not recommended.

When fields containing polymeric infills are first tested (see NB 3 below) for FIFA field certification, it is recommended that the field test also include a test to verify that the infill installed complies with these requirements. If verification testing is requested, it should be undertaken as follows:

Sampling of the infill to be undertaken in accordance with EN 17409 (Surfaces for sports areas – Code of practice for the sampling of performance infills used within synthetic turf surfaces), including preparation of the samples in accordance with clause 9 and Appendix A.

The PAH content of the samples must be determined using the method prescribed by the national regulations. If no national regulation exists, one of the following methods should be used:

- AfPS 2019:01 PAK, published by the German Federal Institute for Occupational Safety and Health (this is prescribed within the EU)
- ASTM F3496
- Any other method that has been shown to provide equivalent results to those above

European Union REACH Regulation requirements The sum of the content of the eight PAHs listed below must be ≤20.0mg/kg			
PAH	CAS registry number	PAH	CAS registry number
Benzo[a]pyrene (BaP)	50-32-8	Benzo[b]fluoranthene (BbFA)	205-99-2
Benzo[e]pyrene (BeP) C	192-97-2	Benzo[j]fluoranthene (BjFA)	205-82-3
Benzo[a]anthracene (BaA)	56-55-3	Benzo[k]fluoranthene (BkFA)	207-08-9
Chrysen (CHR)	218-01-9	Dibenzo [a, h] anthracene (DBAhA)	53-70-3

NB:

1. Testing to demonstrate compliance with this requirement should be undertaken by an independent test laboratory accredited to ISO 17025 for the specified procedure.
2. Compliance with this requirement demonstrates that the PAH content of the polymeric infill used when the football turf surface was installed was in accordance with the threshold limits stipulated by the European Chemical Agency. These requirements are intended to protect players and match officials from exposure to materials containing unacceptably high levels of PAHs.
3. During the lifetime of the playing surface, top dressing with additional infill will be required. In many cases, this will not be supplied by the company that built the pitch. Additionally, the field may be exposed to localised contaminates (atmospheric pollution, etc.) that may change the PAH content of the infill layer. Therefore, the field owner/operator should conduct periodic checks to ensure that the PAH content of the infill on the field does not exceed the recommended limits.

40 DETERMINATION OF POTENTIAL MIGRATION OF CHEMICAL ELEMENTS – EN 71-3 (FIFA TEST METHOD 2024-30)

When fields containing infills are first tested for FIFA field certification, it is recommended that the field test also include a test to verify the possible migration of chemical elements. If verification testing is requested, it should be undertaken as follows:

Sampling of the infill to be undertaken in accordance with EN 17409 (Surfaces for sports areas – Code of practice for the sampling of performance infills used within synthetic turf surfaces), including preparation of the samples in accordance with clause 9 and Appendix A.

The migration of certain infill elements of the samples must be determined using the method prescribed by national regulations. If no national regulation exists, FIFA recommends using the future prEN15330-5 standard, which refers to EN71-3: Safety of toys – Part 3: Migration of certain elements.

In countries in which there are no legal restrictions, FIFA recommends that the category 3 limits of the EN71-3 standard, detailed below, be adhered to.

Element	Migration limit		
	Category I (mg/kg)	Category 2 (mg/kg)	Category 3 (mg/kg)
Aluminium	5 625	1 406	70 000
Antimony	5	11,3	560
Arsenic	3,8	0,9	47
Barium	1 500	375	18 750
Boron	1 200	300	15 000
Cadmium	1,3	0,3	17
Chromium (III)	37,5	9,4	460
Chromium (VI)	0,02	0,005	0,2
Cobalt	10,5	2,6	130
Copper	622,5	156	7 700
Lead	13,5	3,4	160
Manganese	1 200	300	15 000
Mercury	7,5	1,9	94
Nickel	75	18,8	930
Selenium	37,5	9,4	460
Strontium	4 500	1 125	56 000
Tin	15 000	3 750	180 000
Organic tin	0,9	0,2	12
Zinc	3 750	938	46 000

41 MINIMISING INFILL MIGRATION INTO THE ENVIRONMENT – FIELD DESIGN (FIFA TEST METHOD 31)

The polymeric infills used within many synthetic-turf sports surfaces have been identified as a source of potential environmental contamination if they are allowed to migrate from the field into the surrounding land. It is therefore important that the design of any football turf field that has such infills incorporate features that will minimise the risk of this occurring.

Based on the recommendations of the draft CEN (European Committee for Standardization) Technical Report: Surfaces for Sports Areas — Synthetic Turf Sports Surfaces: Controlling Infill Migration to help Minimize Environmental Contamination, all football turf fields incorporating polymeric infills should consider the following design features.

41.1 Drainage filters

To minimise the risk of infill being transported by storm water into the aquatic environment, all drains around or near the synthetic-turf field must include silt traps to capture any infill being washed into the drainage system. These should typically comprise a filter bucket offering primary filtration (removing the heavier silts) and a secondary fine microfilter that captures any remaining small particles. Both the filter bucket and secondary fine microfilter should be easily removable for cleaning/replacement.

41.2 Perimeter fencing/edge margin containment barriers

See Figure 64: fencing panels used when the synthetic-turf surface is laid up to a fence and Figure 65: raised edging options and paved zone to separate synthetic-turf surface from perimeter boundary for typical examples of the fencing and details described below.

If a field is enclosed by a non-solid (e.g. mesh) fence, it must incorporate some form of physical barrier to prevent infill leaving the field.

A number of different edge barriers have proven to be successful, including the following:

- Panels of 0.5m or higher. These may be formed from brickwork, timber, rigid plastic extrusions, metal work or other materials.

- A combination of a paved area and 200mm of timber or plastic boards, mounted to the fencing system so that they sit flush with the ground and do not allow infill to migrate under them.

If tanalised timber boards are used, it is recommended that they be vacuum pressure impregnated softwood timber, in accordance with class 4 of EN 335.

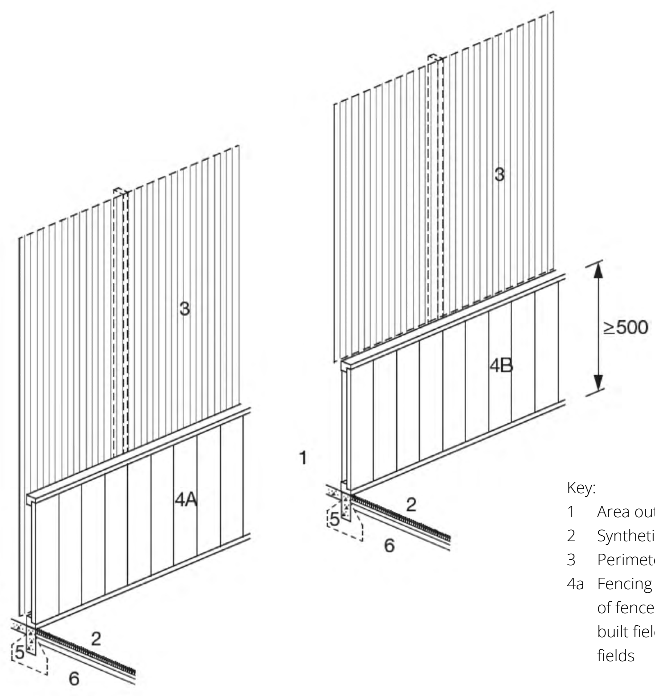
- Raised precast concrete edgings or kerbs (minimum 200mm high) located inside and adjacent to the fence line.

- Cast concrete plinth/kerb (minimum 200mm high) on which the perimeter fencing is flush-mounted.

If the perimeter edge detail is less than 500mm high, there is a possibility of infill being lifted over the edge detail during routine play and maintenance. To minimise the risk of this occurring, a paved (asphalt, concrete, paving slabs, etc.) margin (minimum 500mm wide) should be positioned between the synthetic turf surfacing and the fence line. This should be designed to allow ground staff to collect any dispersed infill that has worked its way to the sides of the field and put it back onto the playing area before it leaves the facility. It must be designed to avoid construction joints and other features where the infill can accumulate.

If a slot or gully drain are required to capture water falling on the paved margin, they should be fitted with silt traps to capture infill being washed into the drainage system.

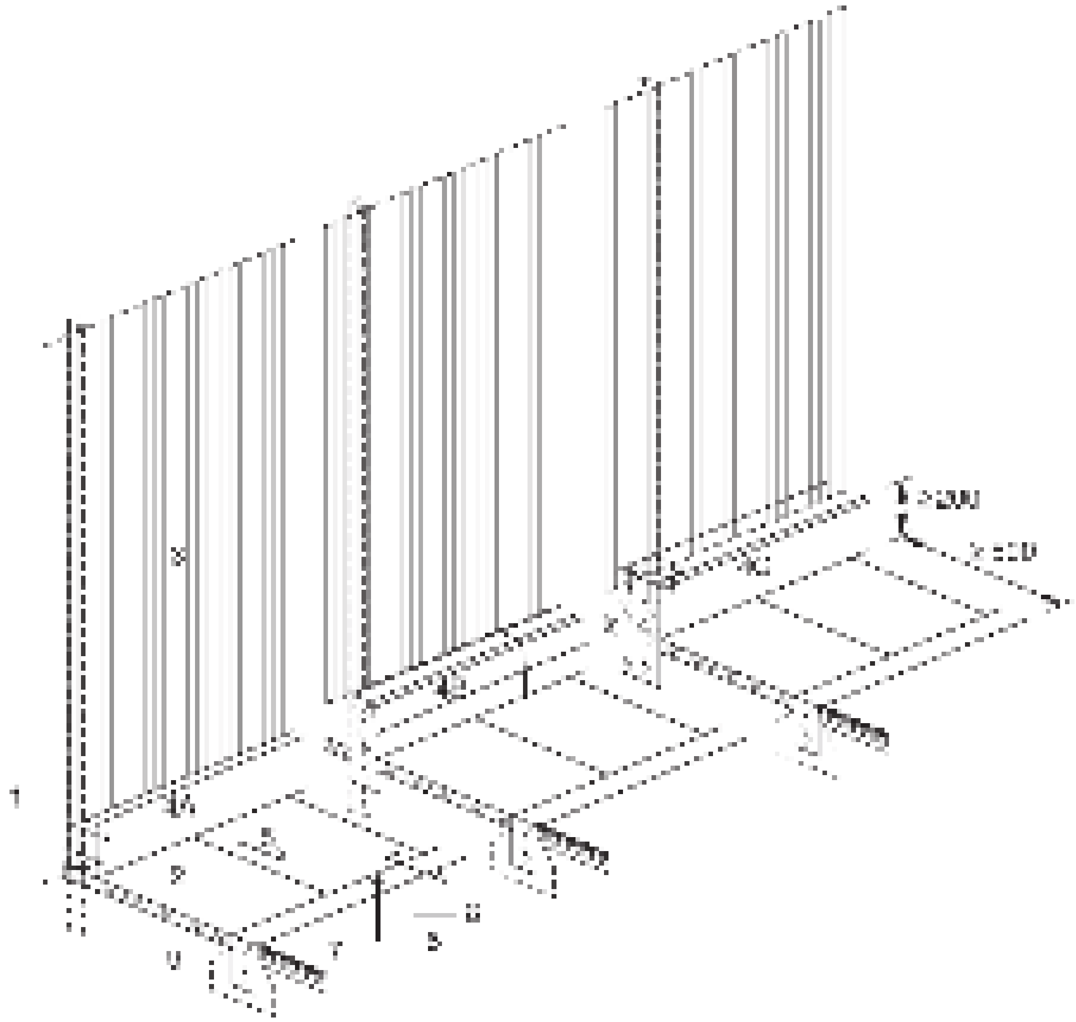
Figure 64: fencing panels used when the synthetic-turf surface is laid up to a fence



Key:
1 Area outside field
2 Synthetic-turf surfacing
3 Perimeter fencing
4a Fencing boards mounted in front of fence. May be used on newly built fields or be fitted to existing fields
4b Fencing mounted above boards – most suited to new fields and fencing
5 Field-edge detail/kerb
6 Synthetic-turf field base

All dimensions are in millimetres.

Figure 65: raised edging options and paved zone to separate synthetic-turf surface from perimeter boundary



Key:
1 Area outside field
2 Field side of fence
3 Perimeter fencing
4a Timber or plastic board
4b Precast concrete kerb with fence mounted behind
4c Cast concrete edging with fence mounted above
5 Hard paved zone between synthetic turf and fence
6 Field edging/kerb
7 Synthetic-turf surfacing
8 Flush edge detail to avoid trip hazard
9 Synthetic-turf field base

All dimensions are in millimetres.

41.3 Access points

Boot-cleaning grates/scraper mats should be installed at all (single and double) entrances to the field. They may comprise:

- smooth bar industrial decontamination grates;
- heavy-duty rubber scraper mats; or
- heavy-duty honeycomb profile mats.

The cleaning grates/scraper mats must be the full width of the entrance gate and at least 1.5m in length so that people cannot step over them. They should be positioned immediately adjacent to entrance gates, either internally, when located in a paved surround/spectator area, or externally, when the synthetic-turf surfacing is laid to the perimeter fence.

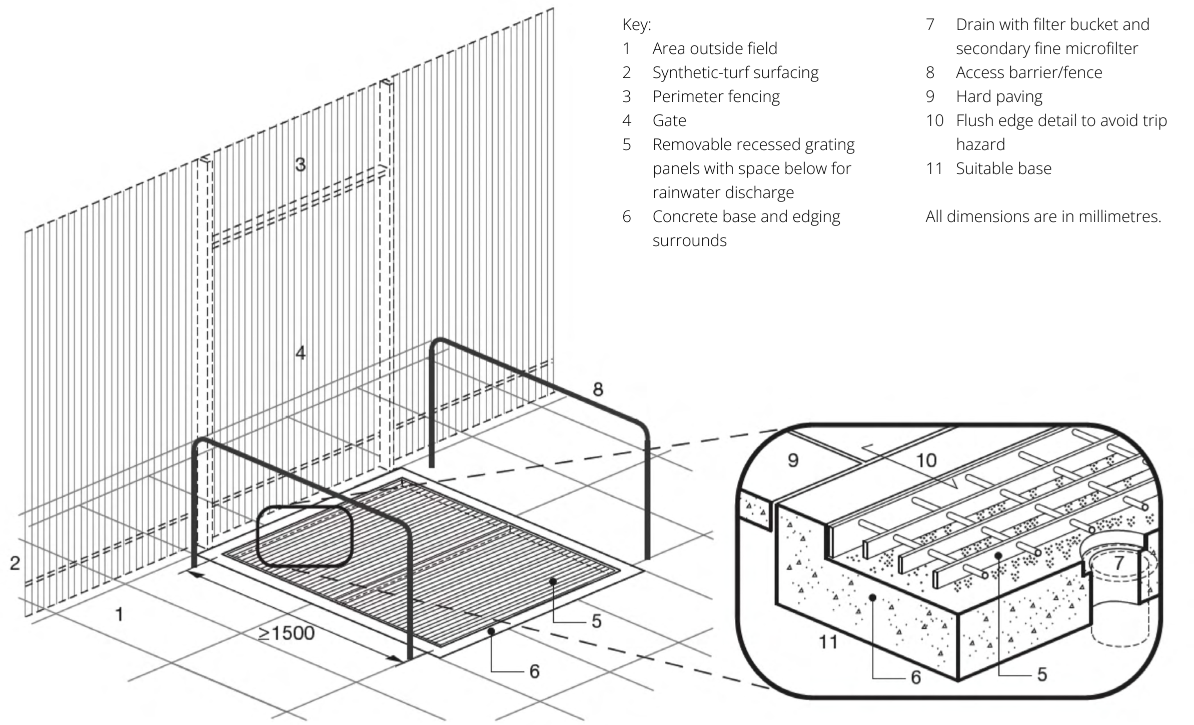
The mats should be set in recessed concrete bases that will contain any infill or other detritus being taken off the field by players' and match officials' footwear or maintenance equipment, etc. To prevent the bases filling with water, they should contain a suitably designed drain fitted with a silt trap to capture infill.

All metalwork must be hot-dip galvanised in accordance with EN ISO 1461, and care should be taken to ensure that no sharp edges are left after galvanising.

Typical examples of decontamination/boot-cleaning grate

Figure 66: decontamination/boot-cleaning grate (located outside all entrances) and Figure 67: decontamination grate/boot cleaning – alternative configuration show typical examples of cleaning grates/scraper mats.

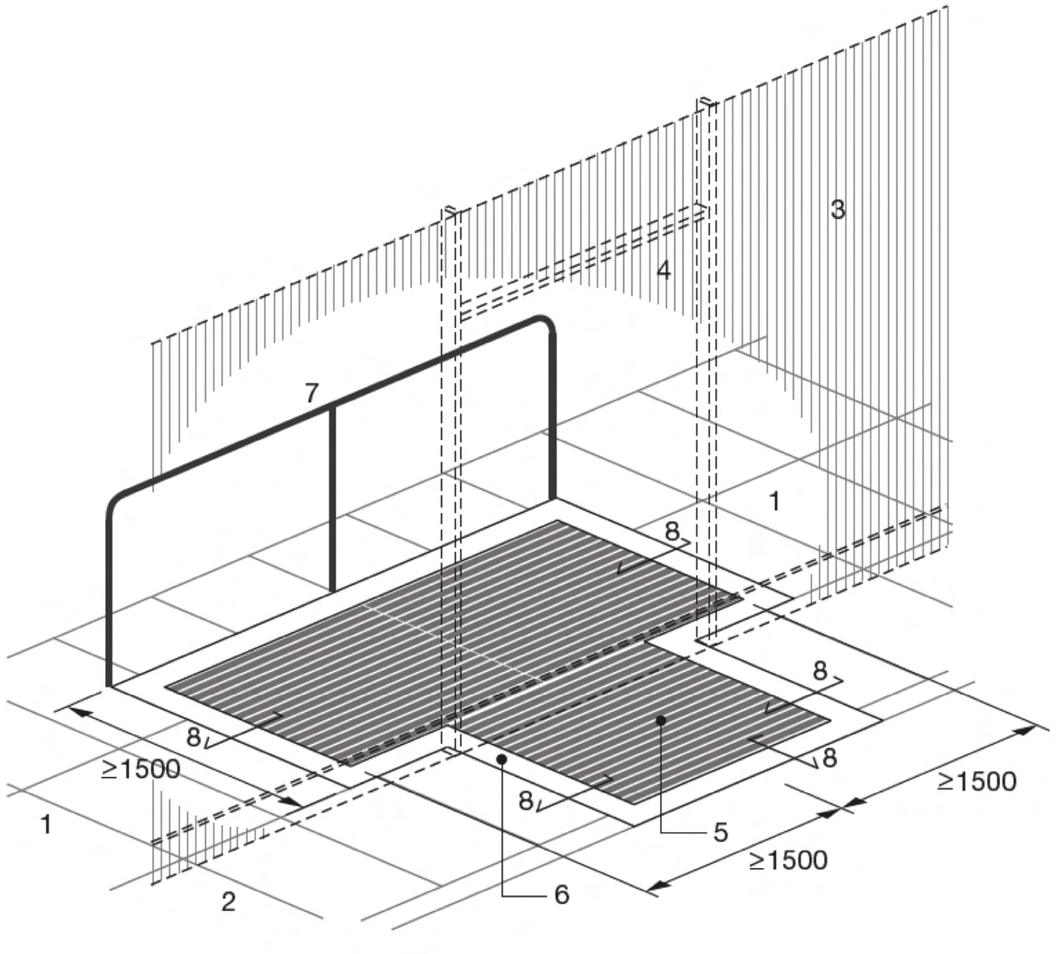
Figure 66: decontamination/boot-cleaning grate (located outside all entrances)



Key:
1 Area outside field
2 Synthetic-turf surfacing
3 Perimeter fencing
4 Gate
5 Removable recessed grating panels with space below for rainwater discharge
6 Concrete base and edging surrounds
7 Drain with filter bucket and secondary fine microfilter
8 Access barrier/fence
9 Hard paving
10 Flush edge detail to avoid trip hazard
11 Suitable base

All dimensions are in millimetres.

Figure 67: decontamination grate/boot cleaning – alternative configuration



Key:
1 Area outside field
2 Synthetic-turf field
3 Perimeter fencing
4 Gate
5 Heavy-duty rubber scraper mats
Heavy-duty honeycomb profile mats
Smooth bar industrial decontamination grates
6 Concrete base with drain and silt trap
7 Control barrier/fence
8 Paved footpath, flush to grate to avoid trip hazards

All dimensions are in millimetres.

41.4 Boot-cleaning stations

Multiperson boot-cleaning stations, with suitable signage encouraging players and match officials to use them, should be located at the main points of egress from the field.

If mounted outside the synthetic-turf field, the boot-cleaning station should be positioned over a hard paved area that has a suitable design to contain dislodged infill and drains in accordance with 41.2: Perimeter fencing/edge margin containment barriers.

41.5 Snow clearance

In climates where heavy snowfall can be encountered, the field should contain a hard paved or extended synthetic-turf area that is designed to ensure that melted snow drains back onto the main field, or to suitably designed drains that have appropriate silt traps to capture any infill being washed away.

Figure 68: boot-cleaning station

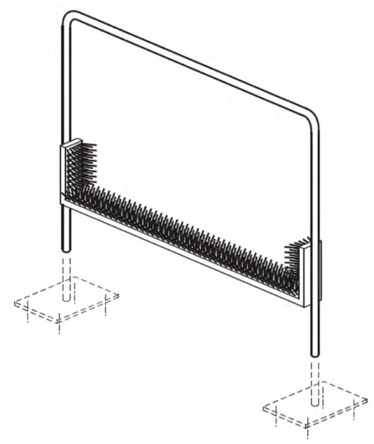
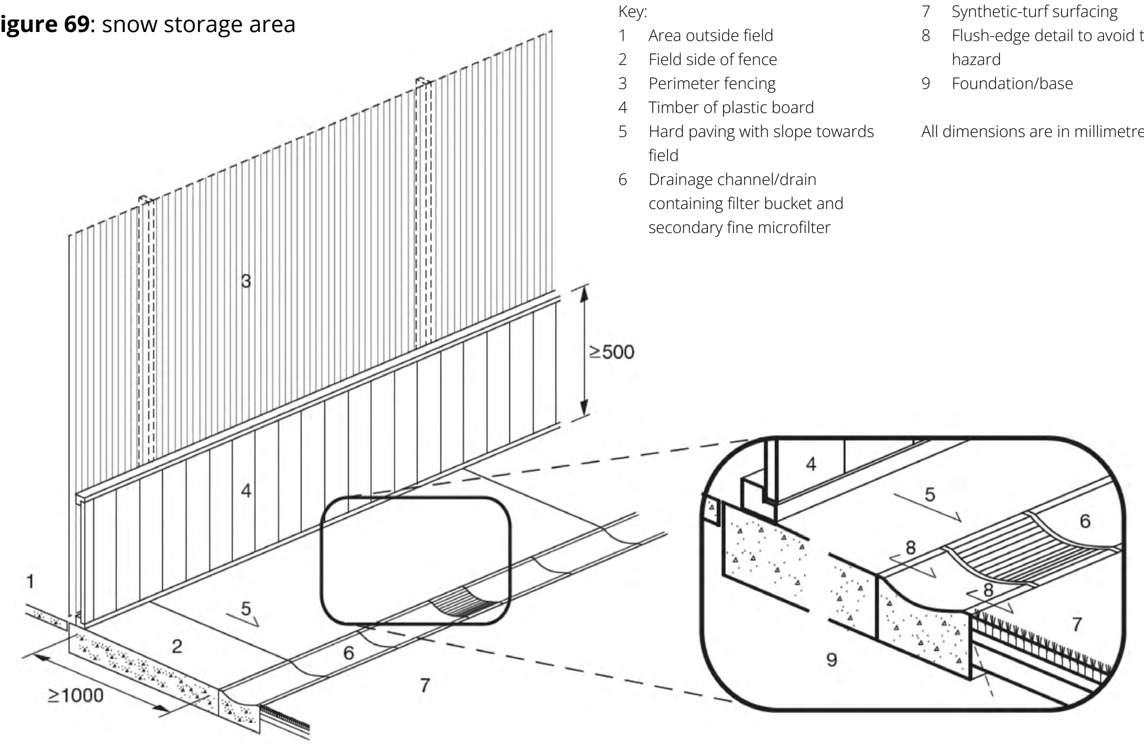
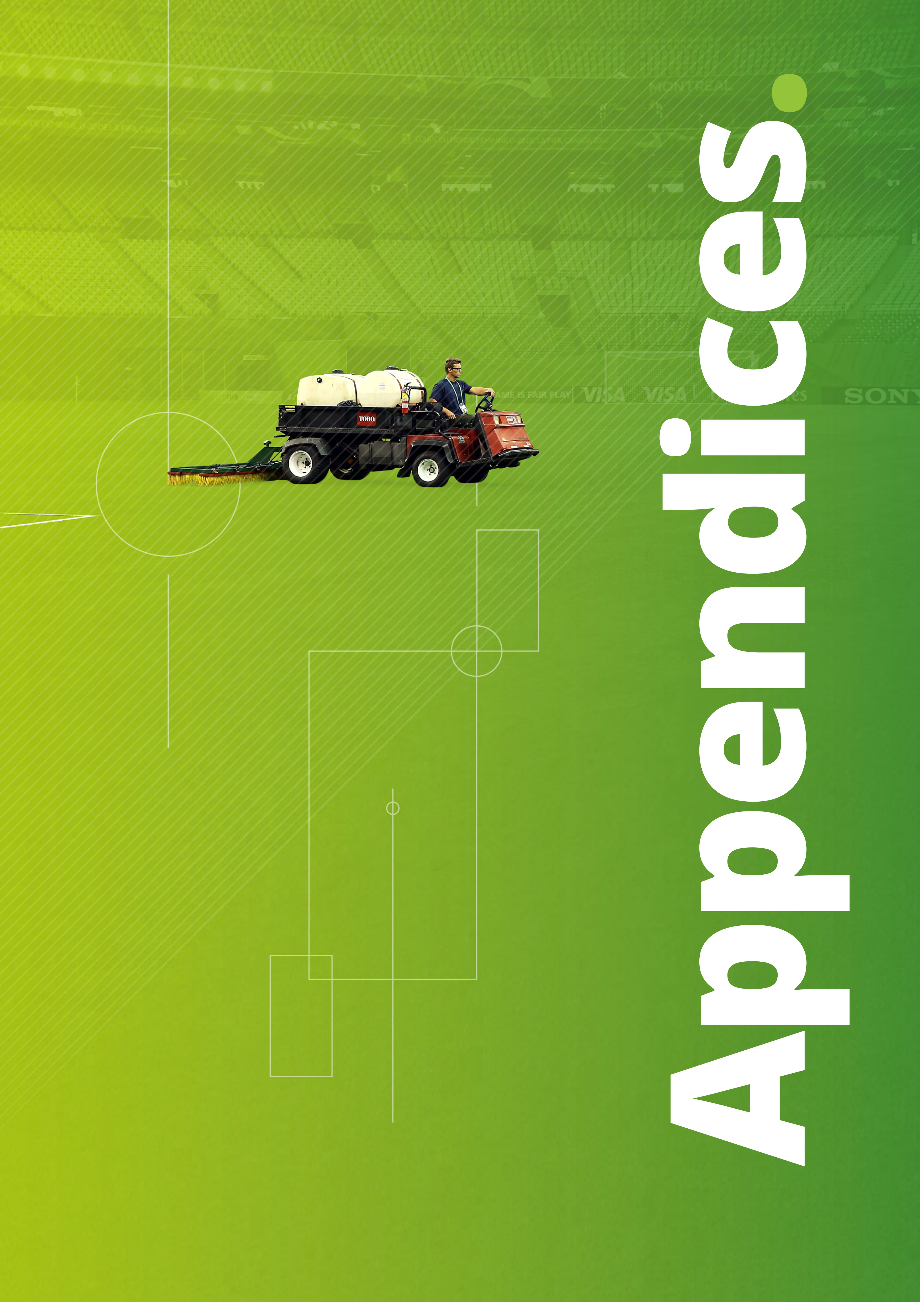


Figure 69: snow storage area



Key:
1 Area outside field
2 Field side of fence
3 Perimeter fencing
4 Timber of plastic board
5 Hard paving with slope towards field
6 Drainage channel/drain containing filter bucket and secondary fine microfilter
7 Synthetic-turf surfacing
8 Flush-edge detail to avoid trip hazard
9 Foundation/base

All dimensions are in millimetres.



APPENDIX I: LISPORT XL – SAMPLE PREPARATION PROCEDURE

The following procedure describes how a football turf sample needs to be prepared when it is exposed to the Lisport XL:

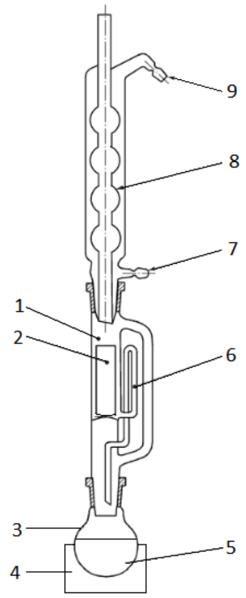
1. Rake the sample against the direction of tufting to lift the fibres using a hard rake.
2. Disperse the sand evenly with a spreader:
   a. Fine-tune the sand distribution with a rigid rake.
   b. Ensure an even distribution by measuring the infill depth using a depth probe (forceful penetration).
3. Add the performance infill (with the spreader):
   a. Fine-tune the infill distribution with either a rigid or soft rake.
   b. Ensure an even distribution (within 10% of the product declaration) by measuring the infill depth using a depth probe (soft penetration) and a prism (three readings per square metre).
4. Ball rebound
   a. Take five measurements diagonally across the sample.
5. Run five conditioning cycles in the Lisport XL.
6. Ball rebound
   a. Take five measurements diagonally across the sample.
7. Lisport XL: 3,000 or 6,000 cycles
   a. Maintenance after every 500 cycles (250 cycles for vegetal infill materials)
      i. Deconsolidate the performance infill by using a hard rake (do not deconsolidate the sand infill).
      ii. Add displaced performance infill and redistribute evenly on the sample by using a spreader.
      iii. Use a hard rake to distribute the infill evenly and finish off with a brush.
      iv. Ensure an even distribution (within 10% of the product declaration) by measuring the infill depth using a depth probe (soft penetration) and a prism (three readings per square metre).
   b. Maintenance after 3,000/6,000 cycles
      i. Deconsolidate the performance infill by using a hard rake (do not deconsolidate the sand infill).
      ii. Add displaced performance infill and redistribute evenly on the sample by using a spreader.
      iii. Use a hard rake to distribute the infill evenly and finish off with a brush.
      iv. Ensure an even distribution (within 10% of the product declaration) by measuring the infill depth using a depth probe (soft penetration) and a prism (three readings per square metre).
8. Run five conditioning cycles in the Lisport XL.
9. Perform required testing after Lisport XL (reduced ball roll (dry/wet), ball rebound, advanced artificial athlete, rotational resistance, surface friction and abrasion and any other required test).

APPENDIX II: DETERMINATION OF EXCESS SPIN OIL ON SYNTHETIC GRASS FIBRES (NOT MANDATORY)

41.6 Scope
This method describes how to determine the presence of excess spin oil, also referred to as spin finish, on synthetic grass fibres.

41.7 Test apparatus
41.7.1 General
Soxhlet extraction apparatus

Figure 1: Soxhlet extractor



Key:
1. A Soxhlet extractor with a volume of 150ml
2. Cellulose Soxhlet extraction thimbles
3. A round-bottomed flask with a minimum capacity of 200ml
4. A heating device
5. Isopropanol p.a.
6. A syphon
7. Cold water intake of the condenser
8. A condenser
9. Outlet of condenser
10. A ventilated oven
11. An analytical balance capable of weighing to the nearest 1mg
12. Arotavapor with heating bath
13. A desiccator with silica gel
14. Weighing flasks

NB: An automated system for Soxhlet extraction can be used as an alternative.

41.8 Test procedure
Dry the round-bottomed flask for a minimum of four hours in an oven at 105±3°C. Let it cool down in a desiccator for two hours.

Weigh it on the analytical balance, this is m_2.

Transfer approximately 5g of fibre into the extraction thimble and place this in the Soxhlet extractor, as shown in Figure 1.

Fill the round-bottomed flask with isopropanol and connect it to the Soxhlet extractor. Attach the condenser to the Soxhlet extractor and turn on the water flowing into the intake (position 7).

Regulate the temperature of the extraction apparatus to achieve two extraction cycles of ten minutes.

NB: It is recommended that a pretest be carried out to determine the heating temperature of the heating device to achieve this number of extraction cycles.

Reflux the solvent through the sample for 20 minutes, which is two extraction cycles.

Remove the extraction thimble with the yarn from the apparatus.

Allow most of the solvent to evaporate and evaporate the remainder of the solvent in a rotavapor.

Dry the round-bottomed flask in an oven at 105±3°C for one hour. Let it cool down for at least one hour in a desiccator.

Weigh the dried and cool round-bottomed flask on an analytical balance (m_3).

Remove the yarn from the extraction thimble and put it in a weighing flask. Let it dry in an oven for at least four hours and for no more than 16 hours at 105±3°C. Let it cool down in a desiccator for a minimum of two hours.

Weigh them on the analytical balance, this is m_d.

41.9 Calculation of results
The percentage of spin oil on the yarn is given by:

$$\frac{m_3 - m_2}{m_d} \times 100\%$$

Where:

m_2 = mass of the empty round-bottomed flask in grams

m_3 = mass of the round-bottomed flask with residue in grams

m_d = dry mass of the yarn after solvent extraction in grams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