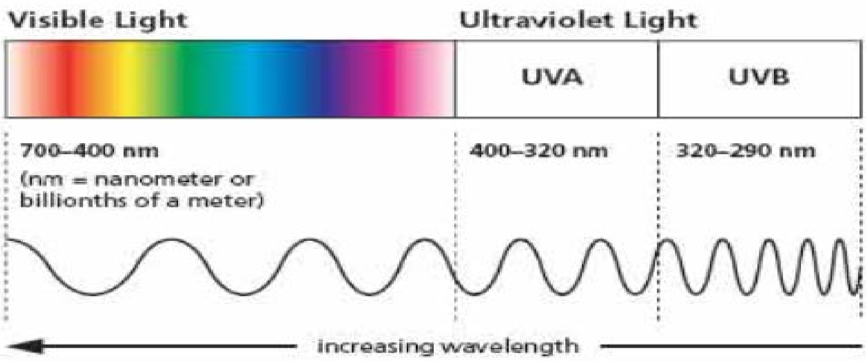
ESTO Yarn Working Group

Proposal to enhance and standardise the Resistance to Artificial Weathering testing requirements for synthetic turf pile yarns

Introduction and background

Synthetic turf sports surfaces are used throughout the world and one of the biggest reasons for their appeal is their ability to provide high quality sports facilities in regions where growing natural grass is not possible due to high ambient temperatures and/or a lack of water. These climatic factors that create the demand for synthetic turf surfaces also, however, expose the playing surface to high levels of harmful UV radiation from the sunlight that can significantly weaken the life of the synthetic turf playing surface.

UV radiation is part of the electromagnetic (light) spectrum that reaches the earth from the sun. It has wavelengths shorter than visible light, making it invisible to the naked eye. These wavelengths are classified as UVA, UVB, or UVC, with UVA the longest of the three at 320-400 nanometers. UVB ranges from 290 to 320 nm and the even shorter rays, designated as UVC (which are absorbed by the ozone layer and does not reach the earth).



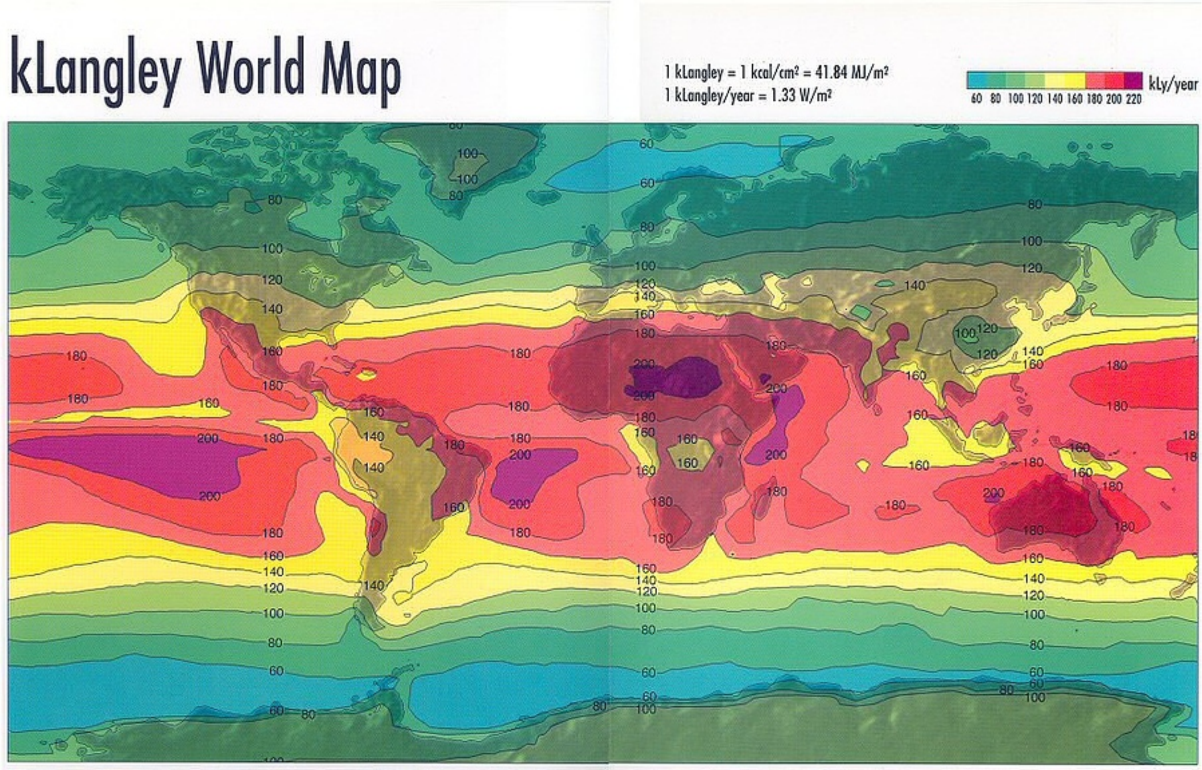
Synthetic turf pile yarns are manufactured from polymers such as polyethylene, polypropylene and nylon. These polymers consist of long molecular chains that can vary in length, complexity and orientation. When exposed to UV radiation the molecular chain structures interact photo-chemically to form free radicals, which then react with oxygen in the atmosphere causing the exposed surfaces of the polymer to discolour, weaken and crack. It is therefore essential that a polymer's formation includes a means of protecting it from such attack. To achieve this, UV stabilisers are added to the polymer formulation.

In the case of the polymers used to produce synthetic turf pile yarns Hindered Amine Light Stabilizers (HALS) are most commonly used (other ways of preventing the formation of harmful free radicals, such as hydroperoxide decomposers, may also be used). HALS protect the polymer from the detrimental effects of free radicals by neutralizing them and hindering chemical degradation.

To verify appropriate UV stabilisation components have been incorporated into the polymer master-batch from which a synthetic turf pile yarns is extruded, it is necessary to test the yarn's ability to resist artificial weathering using a standardised test procedure. Whilst there are many artificial weathering methods available, the synthetic turf sports surfacing market, led by the Standards issued by the international sports federations and the European Standards EN 14836 and EN 15330 has adopted an approach based on using fluorescent tubes that expose samples of synthetic turf pile yarn to a defined amount of UV radiation plus controlled levels of heat and moisture.

The majority of the Standards require a total amount of emitted specific energy of 4896 KJ/m^2, but certain markets require more severe weathering. The Australian Football League (AFL), mindful of the high UV levels much of Australia is subjected to, has adopted the principals specified in EN 14836 but extended the period of simulated exposure to be more representative of their conditions. In France, with particular focus on its overseas territories in regions of the world subjected to high UV radiation, and Italy (via its national amateur football federation the Lega Nazionale Dilettanti (LND) the principals of EN 14836 have been amended to also use UVB radiation as a means of subjecting synthetic turf pile yarns to a more onerous test.

The diagram below shows typical total yearly radiation exposure levels (full sunlight spectrum) for the world in kilo Langley. It also illustrates the radiation energy levels in many regions where synthetic turf markets are growing rapidly.



With such data being available it might be considered quite simple to select an artificial weathering programme that replicates the real world situation for the markets you wish to sell into. Unfortunately there is no simple answer and it is theoretically impossible to have a single conversion factor that you can multiply an artificial weathering programme by to calculate a certain number years of outdoor exposure in any specific location, because it runs counter to the most basic principles of accelerated weathering. Therefore an artificial weathering programme is at best a comparative means of ranking similar products.

Whilst the current testing protocols have proved to be adequate for many traditional markets for synthetic turf, premature yarn failures in more extreme markets do occur. Having reviewed the comparative performance and real life failures of yarns meeting the current international Standards the ESTO Yarn Working Group has concluded a more robust testing protocol is desirable and should be adopted globally to provide greater protection for consumers irrespective of where they are based, whilst at the same time removing the need for localised national standards or regulations that increase the complexities of product development/certification and entry to a market.

Proposed harmonisation of artificial weathering procedures

Whilst recognising the limitations of simulating artificial weathering by the use of fluorescent tube expose, the ESTO Yarn Working Group has concluded that as this approach is the one most commonly used and readily available, it should be retained.

Although the French / Italian approach of using UVB fluorescent tube radiation has some appeal in that it provides a harsher test in the same time period as the standard UVA test, the increased energy levels generated by UVB radiation can result in kinetics that can initiate chemical reactions that would not be possible under natural conditions and this can result in poor correlation between UVB artificial weathering and real life experiences, meaning it is not an approach many specialists advocate.

The ESTO Yarn Group therefore proposes the existing UVA test procedure should be modified to double the radiation exposure to 9600 kJ/m^2/nm (taking approximately 5000 hours).

A fully defined revised test protocol is given in Appendix A for consideration by the international sports federations, CEN, etc.

Proposed specification requirements

At present most international standards specify the maximum change in strength of a pile yarn should not reduce by more than 50% of the original value. Whilst many yarns now easily achieve this requirement the 50% value is well established requirement for various forms of Artificial Weathering testing (not just synthetic turf surfaces) so it is considered appropriate to retain this requirement.

The ESTO Yarn Working Group proposes, however, that the 50% requirement should apply to the breaking tenacity (ration of the yarn's breaking strength to its linear density) and the Elongation at Break of the yarn at the maximum breaking force.

In addition to changes in tensile properties following artificial weathering most international standards also specify the change in colour as a result of weathering should be Gray Scale 3 or greater. The ESTO Yarn Working Group believes this requirement is appropriate and does not need revision.

Family groups of yarns

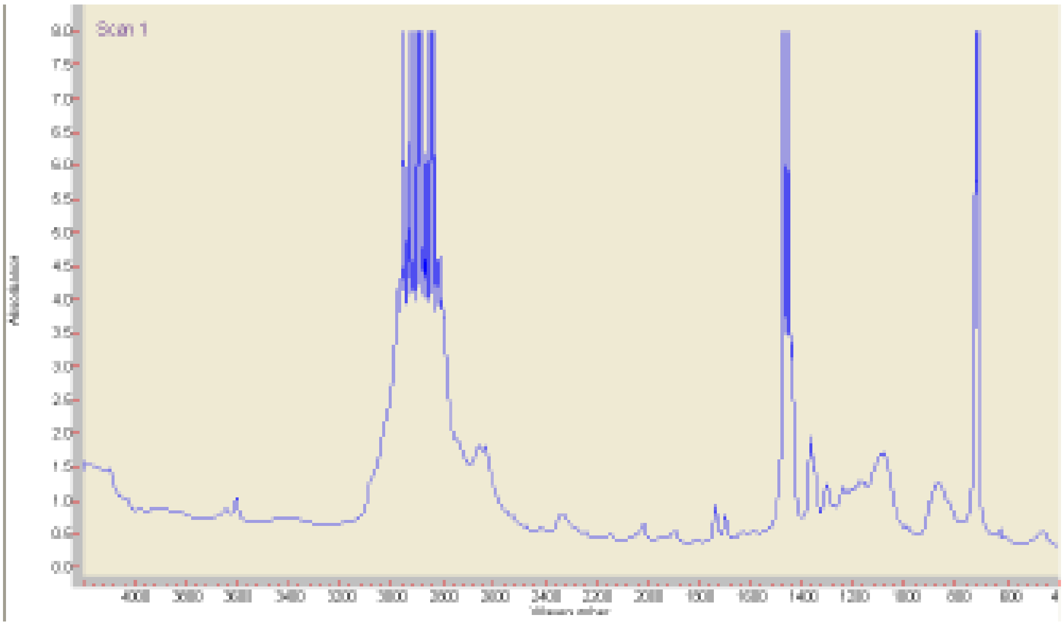
It is quite common for a synthetic turf pile yarn to be produced in a number of different thicknesses (e.g. 100, 150, 300 microns, etc.). The yarns are of the same polymer formulations, have the same shape etc, the only difference being their thickness. At present, most Standards require every yarn thickness to be tested. Whilst the concept of testing each master-batch formulation and colour is fully supported, the ESTO Yarn Working Group consider the need to test thicker versions of a yarn from the same 'family' as excessive and unnecessary. As described previously UV, degradation causes the exposed surfaces of the yarn to discolour, weaken and crack. The effects of UV degradation are assessed by measuring changes in the tensile properties of a yarn as a result of exposure. If two samples of the same formulation/construction, but with differing thicknesses are tested the thicker sample should require more force to cause it to fail.

The ESTO Yarn Working Group also therefore propose that a Resistance to Artificial Weathering result obtained on one yarn type be considered valid for all thicker (≥ 90%) versions of the same yarn (note a 90% value is considered appropriate when the reproducibility of measuring the thickness of the yarn is taken into account).

To validate a yarn is from the same family as a product tested previously the ESTO Yarn Working Group proposes the characteristics of the yarn should be identified as follows:

1. Differential Scanning Calorimetry in accordance with ISO EN ISO 11357-3. The main points of references to be used when comparing products should 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 ± 3º).

2 Fourier Transform Infrared Spectroscopy (FTIR). The main points of references to be used when comparing products shall be the peak locations and peak heights.



3 Thickness – measured in a standardised method as already specified by the FIH and AFL.

4 Shape – recorded photographically.

Consultation

It is proposed the ESTO Yarn Group's proposals will be submitted to the following organisations for consideration:

AFL
FIFA
FIH
World Rugby
One Turf concept
CEN TC 217

STC (for information)

Appendix A – ESTO Yarn Group - Proposed method for the Artificial Weathering of synthetic turf pile yarns

1 Principle

Specimens of synthetic turf pile yarn are identified and exposed to ultra-violet (UV) radiation under controlled environmental conditions. Changes in the tensile properties of the yarn are measured before and after exposure.

2. Yarn polymer identification

The pile yarn shall be characterised as follows:

a. Differential Scanning Calorimetry undertaken in accordance with ISO 11357-3: 2011 – second heating of sample

b. Fourier Transform Infrared Spectroscopy

c. Thickness of the yarn as follows:

C.1 Apparatus

C.1.1 Microscope

Microscope having x230 magnification.

In cases where the yarn exceeds the monitoring area of the microscope a lower but maximum magnification must be used to reduce calculation errors. The microscope must have the possibility to measure the sample in real time and to record the measurement as a digital file.

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

C.1.2 Freezing system

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

C.1.3 Reference square

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

C.1.4 Cutting blade

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

C.1.5 Small clamp

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

C.2 Samples

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

C.3 Procedure

Cut with scissors a yarn from the synthetic turf carpet at the bottom side without applying a tensile force. Repeat the procedure in other two points that shall not be in the same tufting line. Cool ('freeze') the yarn until frost forms on the surface of the yarn. Immediately cut the yarn as perpendicular as possible to the cross section using the reference square.

Position the yarn perpendicularly by the mean of a small vice under the optic of the microscope. Select the X230 magnification or the most appropriate in cases where the yarn exceeds the monitor area of the microscope. Focus the cross section of the yarn. Using the measuring tool determine the maximum thickness of the yarn.

C.4 Results

The average yarn thickness of the three samples shall be recorded and visual images saved. Results obtained must be within 10% of the manufacturer's declaration.

d. Shape of the yarn to be recorded photographically under x230 magnification.

e. RAL Design Colour ccoordinates of the yarn.

3 Tensile properties of yarn sample

Determine the tenacity and elongation of break of the unexposed specimens of the yarn in accordance with EN 13846.

4 Artificial Weathering

4.1 Apparatus

Artificial weathering cabinet using fluorescent UV lamps and environmental controls having the following features:

a. UVA-340 nm lamps (Type 1A), in accordance with EN ISO 4892-3:2006 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 0.80 W/m^2/nm at 340 nm.

b. 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.

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

For the humidity-condensing mechanism, the water vapour shall be generated by heating water in a container located beneath and extending across the whole area occupied by the test pieces. Racks (completely filled with test pieces) shall constitute the sidewall of the exposure chamber, so that the backs of the test pieces are exposed to the cooling effect of the ambient air of the exposure chamber or ambient room air. The water being used for condensing or spraying shall conform to EN ISO 4892-3:2006.

In apparatus designed to wet the exposed faces of the specimens by means of a humidity-condensing mechanism, the water vapour shall be generated by heating water in a container located beneath and extending across the whole area occupied by the specimens. Specimen holders (completely filled with specimens) shall 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 shall conform to EN ISO 4892- 2:1999,

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

e. Black-panel thermometer, conforming to EN ISO 4892-1:2000.

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

4.2 Procedure

Wrap, without strain, a specimen of the yarn around the specimen holders so that the exposed stands do not overlap and mount in the test cabinet with the 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 shall comprise (240 ± 4) min of dry UV exposure at a black-panel temperature of (55 ± 3) °C, followed by (120 ± 2) min of condensation exposure, without radiation, at a black-panel temperature of (45 ± 3) °C. If sample wetting is by condensation, allow at least 120 min per interval to ensure attainment of equilibrium. This time does not form part of the exposure cycle. After an exposure of (9,600 ± 125) kJ/m^2/340nm, carefully remove the specimen from the exposure cabinet and test as required by the product specification.

NOTE An exposure of (9600 ± 125) kJ/m^2/340nm will require approximately 5000 h with cycling to complete to moisture cycling.

5 Measurements and calculations after Artificial Weathering

5.1 Colour change

Assess any change in colour of the pile yarn resulting from the Artificial Weathering in accordance with ISO EN 20105- AO2.

5.2 Loss of tensile properties

Determine the tenacity and elongation of break of the artificially weathered yarn in accordance with EN 13846: 2004.

Calculate the percentage difference in the tenacity and elongation of break between the unexposed test specimens and artificially weathered test specimens.

6 Report

Report the following:

a. Reference to this test method

b. Manufacturer of the pile yarn

c. Product name of the pile yarn

d. DSC trace for the pile yarn

e. FTIR trace for the pile yarn

f. Thickness of the pile yarn

g. Cross sectional shape of the pile yarn

h. RAL Design colour coordinates for the pile yarn

i. Tenacity of the unexposed pile yarn

j. Elongation of break of the unexposed pile yarn

k. Tenacity of the artificially weathered pile yarn

l. Elongation of Break of the artificially weathered pile yarn

m. Percentage change in Tenacity of the pile yarn after artificial weathering

n. Percentage change in the Elongation of Break of the pile yarn after artificial weathering

7 Requirements

7.1 Colour change

The contrast in colour between new unexposed specimens and specimens subjected to artificial weathering shall be no less than Gray Scale 3.

7.2 Tensile properties

The percentage difference in the values of Tenacity and Elongation at Break when comparing new unexposed specimens and specimens subjected to artificial weathering shall be 50% or less.

7.3 Family grouping of pile yarns

Any pile yarn tested in accordance with this test procedure may be considered a *Family Reference* for other pile yarns within the same family group providing the following conditions are satisfied:

a. The DSC trace for a family member is the same as the *Family Reference*. For a trace to be considered the same the peak temperature ± 3º, the peak area and overall curve shape should be similar.

b. The FTIR trace for a family member is the same as the *Family Reference.* For a trace to be considered the same the peak locations and peak heights should be similar.

c. The thickness of the family member should be at least 90% of the *Family Reference.*

d. The Cross sectional shape of the family member should be the same profile as the *Family Reference.*

e. The RAL Design colour coordinates for the family member should be the same as the *Family Reference.*