

„Artificial Turf Surfaces for Soccer“

What Owners of Soccer Pitches should know about Artificial Turf^{1 2 3}

Hans J. Kolitzus

IST Switzerland, United States Sports Surfacing Laboratory USSL

www.iss.de/ist-ch

1. Scope

The objective of this study was the development of a reference source addressing artificial turf surfaces for soccer pitches (also called Football Turf). It is intended for use as an aid to owners who are installing new or updated pitches. The focus is not on the products but on characteristics of the surface systems that are relevant to the owner and players. The study is limited to surfaces that are currently considered “state-of-the-art”. For this purpose, it shall be assumed that the synthetic turf surfaces of today’s design are regarded as principally suitable, thus, it is not necessary to explain the differences between natural turf and early sand-filled artificial turf systems with their pros and cons. The advantages of today’s systems are not addressed, but may be studied elsewhere (orientation documents of Swiss Football Association SFV, Swiss Ministry of Sport BASPO, and German Football League DFB).

The following aspects will be dealt with:

- Classification acc. design
- Assessment by players
(managed by the Zürich Football Association)
- Sport Performance acc. technical tests
- Assessment acc. FIFA-, EN- and SFV criteria
- Compatibility with Environment
- Long-term behavior (maintenance/preservation of usage condition under wear and UV exposure)
- Maintenance

Regarding the economy of artificial turf pitches the study published in the FIFA Turf Roots Magazine 01 is recommended⁴

¹ See additional document with pictures

² Thanks to Kathleen Smith for her assistance in the review of this English version.

³ This document reflects the situation of June 2007 as known to the author

⁴ <http://www.fifa.com/aboutfifa/developing/pitchequipment/footballturf/development.html>

2. Design of Artificial Turf Surfaces for Soccer

History

The first artificial turf product (non-filled) was installed in the AstroDome at Houston in 1966 (hence the name Astroturf). In the following years this type of product was accepted more and more, mainly in the US for American football.

In Europe, the sport of Field Hockey was the driving force for the installation of non-filled surfaces. In Switzerland, the first soccer/hockey pitch with artificial turf was installed in 1974 at Heerenschürli. This type of surface was used in the 1976 Olympic Games for the first time (hockey).

Beginning in the 1980's, the bulk of the installations were sand-filled surfaces, which were often installed with unsuitable sand and not properly maintained. Because they did not meet the main sports functional requirements for soccer, the official soccer world did not accept them as an alternative to natural turf. Thus, sand-filled surface pitches were used mainly for winter training and school or leisure sports as a substitute for non-existing, unavailable or non-feasible natural turf pitches.

The development of modern artificial turf surfaces began in 1997/98 when the Fieldturf Company patented a new technology of a rubber-sand infill instead of pure sand.

Parallel to this, artificial turf systems without any infill were created which reproduce the structural characteristics of natural turf more realistically (Astroplay, Greenfields, XLturf, Sportisca). A very noticeable change is the lack of granular displacement and jumping around when shoes or balls impact the surface.

Acceptance and Function

Artificial turf surfaces are accepted today by the soccer players because they allow bare skin to slide without the risk of carpet burns (formerly a common complaint) and because these surfaces have a noticeable resilience.

The more comfortable sliding behavior is caused by a reduction of the pile fiber density compared with the former "hockey" type surfaces (i.e. lower number of tufts and pile fibers). Conversely, the characteristics of the pile fibers provide less sliding resistance and more softness due to their greater length (up to 70mm). An additional

method used to reduce sliding resistance is to cover the pile fibers with a wax-like coating (LSR fibers). Non-filled surfaces sometimes still have a hard time with sliding behavior. Although much improvement has been achieved, such surface systems should be installed along with a sprinkler system.

The resilience of the filled systems is the result of a suitable combination of rubber granules in the pile layer and the effect of the elastic layer below the turf. Non-filled surfaces produce additional resilience through the elastic effect of the pile fibers. This is achieved through the combination of two types of pile fibers: textured and long, with the textured fibers located between the long, mostly straight fibers. The textured fibers are not visible at the surface and serve as “support” fibers whereas the long fibers are the “play” fibers.

The sand infill is needed to put a load on the turf carpet to stabilize it against horizontal stress.

The issue for artificial turf surfaces in respect to sports function is controlling the various performance characteristics – ball roll behavior, ball rebound, resilience, sliding behavior, traction/foot safety, and abrasiveness – so that they correspond as much as possible with the structural model of natural turf surfaces. This is described in terms of testing characteristics by the requirements of FIFA or EN 15330.

The technical challenge is to preserve the characteristics for as many years as possible when exposed to elements such as high stress and UV radiation.

An important structural point is water permeability. Its importance depends of the volume of precipitation in the area of the respective sports facilities. Permeability is achieved using design details such as holes or perforations in the backing of the surface, combined with adequate permeability of the substructure and slope/gradient (see comments below). However, very quick drainage is not optimal since it is advantageous for a certain amount of moisture to remain (be retained) in the pile layer as long as possible (reduction of electro static charges, improvement of sliding behavior).

Electrostatic charges mainly occur in dry conditions (avoided by wetting the pile fibers).

Finally, compatibility with the environment is an important factor (applies mainly to elastomeric/rubber infill) both when the surface is in use as well as at the end of its lifecycle or its replacement.

The views of relevant sports associations can be seen in publications of UEFA ¹, FIFA ^{2 3} (and); the Deutscher Fussball-Bund (DFB German Soccer Association)⁴ or the FIFA Turf Roots Magazine 01 ⁵.

It is inevitable that the playing technique on these new surfaces– despite of all resemblance with natural turf – must be adjusted. However, this adjustment by the players is actually no more severe than when playing on different natural grass pitches (seasonal variations, different maintenance conditions, different cut and grass hardness in various countries such as Norway or Spain, dry – wet). Sports experts consider these problems a transitory phenomenon which is mainly of psychological nature. An important role in this is held by the selection of properly designed football shoes (see contribution of the shoe expert below).

Constructional Aspects

Artificial turf surfaces are commonly delivered in rolls 3 to 5 meters wide.

The surface may be installed on an elastic layer consisting of PUR bound rubber granules or PUR bound rubber granules mixed with stones. Another group of artificial turf surfaces is designed for direct placement on mineral or asphalt substrate (i.e. without elastic layer).

While turf surfaces with infill are typically installed loose-laid, surfaces with no infill normally have adherence to the substrate in order to avoid formation of wrinkles caused by heat expansion or extreme use (stop and turning exercise of players in line). If there is sufficient stiffness to the backing this adhesion is not needed (backing may be furnished with up to 4 fabric layers).

Surfaces without infill should not be stretched but only fixed at the periphery of the pitches. If an artificial turf surface is glued to the elastic layer, renovation of the turf

¹ <http://www.uefa.com/newsfiles/38018.pdf>

² http://www.fifa.com/mm/document/afdeveloping/pitchequip/fqc_requirements_manual_march_2006_326.pdf

³ <http://www.fifa.com/aboutfifa/developing/pitchequipment/index.html>

⁴ <http://www.dfb.de/index.php?id=145>

⁵ <http://www.fifa.com/aboutfifa/developing/pitchequipment/footballturf/development.html>

pitch will be more costly since not only the turf layer but also the elastic layer must be replaced.

The surface rolls must be connected with each other. With filled surfaces this is typically performed with seam tape (non-woven Polyester or Polyamide) which is glued with a PUR coating. It is important to note that good continuous contact of the edges of the turf rolls with the tape during the curing of the adhesive is critical with 2-component Polyurethane adhesives. In this application the 1-component PUR adhesives are more ideal.

Non-filled surfaces may be connected in the same way. However, it is technically more elegant and safer to use the sewing method. A sewing machine runs over the seam and connects the adjacent rims/edges in a zigzag stitch pattern. The sewing thread is secured with PUR binder underneath the backing so that the joint cannot come open even if the sewing thread is mechanically damaged (UV and abrasion resistant PES). At this time, the sewing technique is restricted to non-filled surface systems.

Another surface type with a non-filled pile layer is the panel design (about 2x1m). In this method, the turf layer is glued to a relatively stiff panel-like elastic layer which the turf overlaps on all 4 sides by about 4cm. Elastic layer strips, about 8cm wide, are then placed between the surface panels. The connection is made using the Velcro technique. Here, the “hook” part of the Velcro is under the backing of the projecting turf layer while the elastic strips are equipped with the “loop” part. The connection can/may be detached at any time. Therefore, this surface type is considered to be a mobile system.

Field lines or stripes are produced in 2 basic ways: either by tufting them in during construction using colored pile fibers or by cutting the primary turf and gluing in sections of colored turf. Non-filled surfaces are often marked by using paint spray.

Water permeability is normally achieved by the perforation of the turf backing. The perforation process creates holes (about 4mm diameter) in a grid pattern about 10 to 15cm. This procedure occurs at the end of the manufacturing process.

Percolation of water through the turf begins as the water is first absorbed by the pile layer (including the infill). As the water exceeds what can be held in the pile and infill,

it drains through the perforations into the supporting layer. Since unbound/mineral supporting layers often exhibit a specific permeability of about 0.01 cm/s only water also 'sheets' or drains horizontally to the sides of the pitch. To accommodate this type of common water movement pitches should always be designed with a slope of about 0.5 -1.0% and with a drainage system along the sides of the pitch (e.g. drain trench with pipe Ø 150mm min.).

Components of Artificial Turf Systems:

- Pile fibers of PE, PP or PA
- Infill = mixture or layers of sand and elastomeric granules (SBR, EPDM etc.)
- Pile layer consists of pile fibers and infill
- Backing fabric of PES; partly double to 4 times with glass fiber reinforcement
- Backing coating of Latex or PUR
- Elastic layer of synthetic foam or PUR bound rubber granules
- Elastic supporting layer of PUR bound mixture of mineral and rubber granules
- Asphalt supporting layer (bound supporting layer)
- Mineral supporting layer (unbound supporting layer)

The surfaces which are regarded suitable for soccer can be divided in 4 basic types:

- Non-filled with elastic layer
- Filled without elastic layer (ES) or elastic supporting layer (ET)
- Filled with ES or ET with low thickness of pile layer
- Filled with ES or ET with thick pile layer

Pile Fibers

Pile fibers are normally made of Polyethylene (PE), Polypropylene (PP) and PP-copolymers or Polyamide (PA). Two types of yarns are to be distinguished: fibrillated fibers and monofilaments.

- For production of fibrillated fibers thin films (slit film) are extruded which contain parallel splits or "points of fracture by design". The final properties are created by subsequent treatment such as stretching and heat (→ curled structure). Up to 12 such fibers are combined to form the individual carpet tufts.
- The characteristic of fibrillated fibers is their softness which severely limits skin burn injuries that occur when sliding over the surface with uncovered/unprotected skin (sliding skin burns, rug burns). This is especially true for the fibers termed LSR fibers (LSR = low sliding resistance). However, fibril-

lated fibers still experience issues with the longevity of the elastic behavior and their form stability (splitting and felting). A further design consequence is that these fibers snap off right above the pile infill after a rather short time which negatively changes the ball and sliding behavior. The LSR technique is also applied to monofilament fibers.

- Today, artificial turf surfaces are mainly manufactured with monofilament fibers which are extruded as individual fibers. This allows the design of the cross section and thickness of the fibers (bent, imprinted with grooves, profiled) to be specified. Their thickness varies between 90 and 200 μm (0.200mm) and they can be manufactured from harder or softer material which allows for more or less flexibility according to the type of cross section. Monofilaments are also subject to subsequent treatment, especially to produce a curled structure.

Today, fibrillated fibers are used mainly in combination with monofilament fibers only.

The stabilization of the pile fibers against UV light and heat is crucial to the aging behavior. Since the stabilization is costly special attention must be paid to it. Unfortunately, the effect of the stabilization cannot be controlled with simple and immediate tests and visually it is not detectable as all artificial turf carpets are green when new. Therefore, a diligent process of quality determination is vital (identity of the fiber; manufacturer of the fiber; reference installations, certificates of long-term ageing).

The pile fibers are tufted into a primary backing fabric. Several pile fibers are combined per tuft. The distance of the tufts varies both parallel and across the axis of the carpet rolls.

Experience has shown that the tips of the pile fibers must stand above the infill by about 15 to 20mm in order to control the ball roll behavior according to the requirements of the sport. This exposed fiber also creates the look of natural grass that is desired.

The pile fibers can be a problem for the player even if the technical requirements have been met. For example, when non-filled surfaces exhibit a relatively thick pile layer made of relatively stiff pile fibers, the resilience is initially caused by the fibers laying over instead of vertically compressing which is the desired action (i.e. the foot

is constantly deflected to the side by up to 25mm; → uncertain footing). More important is the fact that this is connected with increased abrasiveness.

Another problem exists with (mainly) non-filled surfaces in the form of electrostatic charges. This is especially true with surfaces on top of PE or EPP foam elastic layers. This phenomenon is observed on dry surfaces only. A solution to this problem has been found by adding conductive fibers to the pile layer. However, the charges must also be conducted through the elastic layer into the substrate (design task).

Abrasiveness is not limited to unfilled pile layers, it can also be a problem with filled surfaces. Essentially it is caused by the density of the pile layer (number of pile fibers and tufts per m²), structure, shape and hardness/stiffness of the (monofilament) fibers. Abrasiveness manifests itself with skin burn injuries and abrasions when players slide over the surface with uncovered/unprotected skin. Abrasiveness is especially noted with Polyamide fibers. Therefore, these fibers are used as supporting fibers only. In this application they are very effective because they exhibit – different from PE fibers – very good deformation recovery. Instead of the Nylon 6.6 fibers which were used in the beginning, only Nylon6 fibers are used today.

In order to avoid the problem of abrasiveness, non-filled artificial turf surfaces should always be installed with a sprinkler system. Different from irrigation of natural grass pitches, irrigation in this case serves to moisten the pile layer only (therefore less water consumption). It is important to use water which does not have too much carbonate, manganese or iron since these elements can accelerate weathering and hence discolor the fibers or form a crust on the pile.

Infill

The infill is applied in several layers: normally it begins with a layer of sand to act as a ballast layer to stabilize the surface by its weight, followed by a layer of elastomeric granules made of:

- SBR/NR (recycled tire granulates, black),
- PUR coated SBR,
- EPDM (pigmented special granules) of various density and hardness
- TPE

There are also surface systems in which a mix of mineral and elastomeric granules is applied between the 1st and the 2nd layer of infill.

In respect to function and monetary concerns, so-called SBR granules are by far the most advantageous infill. Although this provides a second use for the rubber from recycled car tires, there is a public concern on this regarding health and the environment. It is possible that its black color is viewed as visually unpleasant or, in indoor applications, the transient strong rubber smell is distasteful. This is hard to say as color is assessed differently by different people and the smell can be greatly reduced if the facility is well ventilated (inflated roof, windows or forced-air ventilation system). The experimental study under way in Switzerland (BASPO) as well as research in Spain and Norway (see ISSS Seminar 2006) revealed that the health and environmental concerns are not founded, but rise from unsubstantiated rumor or sales oriented disinformation.

A few years ago, it was observed that pile fibers of artificial turf surfaces filled with SBR granules “changed color” from the original green to grey-green within 3 to 6 months. From the industry it is reported that this was due to an incompatibility of the fiber stabilizers and components within the SBR. This problem was resolved by an adjustment to the stabilization process of the pile fibers.

SBR granules can be improved in both color and ecological respect if they are covered with pigmented PUR binder (e.g. Stade de Swiss / Wankdorfstadion Bern). However, the effect of this improvement is gradual and reasonable progress towards the environmental aspects is questionable.

In addition to recycled tire material EPDM recyclate is also offered in the color black or grey. These granules are made of scrap which is collected from the production of gasket material (technical scrap). Although these materials are primarily of good quality, the addition of inferior waste must be factored in if considering their environmental compatibility. If such products are used, the origin of the granules must be investigated and evidence of impeccable quality determined.

With newly manufactured EPDM granules, the color appearance of the artificial turf surface is improved; however the monetary cost is significant. Since these granules are manufactured directly for the infill of pile layers – not a recycled product – the properties of the granules can be specifically and uniformly designed according to the

application. EPDM-granules are fully cross linked materials which can be either sulphur or peroxide cured. Sulphur cured materials are in use since the 1980's in artificial track surfaces and have been proven to be weather stable. Peroxide cured materials are a relatively new development. Even with virgin EPDM products failures were observed: lumping or hardening of granules (reason: use of off-spec components instead of prime quality).

Granules made from thermoplastic elastomers are relatively new in sport surface construction (about 2 years). The materials used in sport surfaces are divided in TPE-V and TPE-S. TPE-V materials are blends of EPDM and a thermoplastic polyolefin, which are partially cross linked. Here, the stabilization and cross linking method strongly influences the weatherability of the product and it's elasticity. Also, the only advantage over fully cross linked EPDM materials is recyclability. TPE-S materials are a blend of a styrene copolymer and a thermoplastic polyolefin. These materials are physically cross linked, no chemical reaction is needed. The weatherability is especially good, if SEBS is used as base polymer. .Since there are many options in the design of the granules great care in finding the optimal system is needed. Also, many materials are labeled TPE only, thus special consideration and a thorough assessment of their quality is required.

Occasionally, the production technique of rubber granules is discussed: crushing of raw material at normal temperature or in deep frozen condition (cryogenic granules). The advantage of cryogenic granules is viewed as their better size definition (i.e. very little dust). However, with modern production techniques normally milled granules do not fall behind in this respect.

It is difficult to control the precise amount of infill during installation of filled turf layers. This is crucial though as the performance of the surface depends greatly on the thickness of the layer. This layer-depth characteristic cannot easily be determined since the surface of the infill layers are below the pile layer surface (not possible visually; with caliper by point only). Thus, a situation often occurs when too much sand is initially applied that the required amount of rubber granules cannot be applied (pile layer too full; min. 15mm free fiber length must stand out from the infill). Therefore, special attention must be paid to the application of the sand. To do this, the pouring-in process must be performed with specially designed sand spreaders which control the amount of infill and brush the sand / granules into the pile layer. It is especially impor-

tant to fill in the sand in multiple passes in order to prevent pile fibers being bent and totally covered by sand.

Backing

The majority of the fabrics used as a base for the turf layer are made of Polyester or Polypropylene. The fabric is partly reinforced by glass fibers in order to improve the form stability when exposed to heat. In some systems multiple fabric layers (2, 3 or even 4) are used for further improvement of stiffness. The backing helps to avoid formation of wrinkles caused by the stress of sports play.

The inserted tufts of pile fibers are held in place (fixed) by the secondary backing. Latex and PUR are the commonly used materials. While Latex needs a specific stabilization process in order to be resistant to water, Polyurethane often has a problem with insufficient adhesion to the seam tape used to join the rolls of turf (problem of 2-component adhesives; improvement is noted with 1-component PUR adhesives).

As previously stated, water permeability is created with all tufted artificial turf surfaces through the perforation of the backing with 4mm holes which are drilled / burned in a grid pattern with a typical spacing being 10 to 15cm. Panel like surfaces allow effective drainage through the joint connection (which is – of course – effective if the supporting layer is permeable enough).

Elastic Layer

The resilience of the artificial turf system is controlled through a combination of type of material, thickness of layers and length of pile fibers, together with the resilience of the elastic layer (ES or ET respectively.).

Elastic layers are installed from prefabricated rolls or panels (PUR compound foam, PE foam rolls or rubber compound mats) or they are paved on-site. Prefabricated elastic layers are prone to dimensional changes. This means that movement of the elastic layer elements (rolls or panels) and formation of wrinkles caused by exposure to heat or sports stress must be avoided. This is done by gluing the turf carpet to the elastic layer or connecting the panels with comb-and-groove technique, Velcro or a textile joint tape.

Elastic layers are highly recommended since they provide a reasonable part of the available resilience and do not require maintenance. Furthermore, elastic layers will outlast several installations of turf.

Elastic layers cannot compensate for or replace insufficient supporting capability or evenness of the subbase / subconstruction. Too much unevenness of the sub construction leads to a non-uniform thickness of the elastic layer and thus to varying resilience of the surfaces system.

The drainage capability of elastic layers is predominantly vertical and very limited in respect to horizontal water movement. To aid with this the supporting layer must have drainage slits with maximum spacing of 1m.

Supporting Layer - Subsoil

The supporting layer must provide the stability of the surface system (permanent evenness even with acceptable loads) and water drainage. The design must follow the established rules of sports surface construction (e.g. DIN 18035-6 or -7 respectively). Mineral supporting layers must be fully resistant to frost (freeze-thaw heave). The top supporting layer should always be a bound supporting layer (e.g. drain asphalt).

It is important to understand that pure vertical drainage occurs during medium rain only. With heavy rain also superficial drainage to the sides of the pitch takes place. It is necessary to provide drainage trenches with enough drainage capacity.

Direct installation of artificial turf surfaces on top of unbound (mineral / gravel) supporting layers is problematic. This is especially true in Switzerland since stable mineral materials are not always available due to lack of crushed stone. Unstable mineral materials are sensitive to deformation and shifting by stepping on the turf surface and in the long run lead to unevenness which will be duplicated on the turf surface. The stability is also important during the installation of the turf layer when vehicles transport the heavy turf rolls and the infill in order to keep the surface even.

The stepping stability must be assessed in water saturated condition (when stepping no separation of fines of the supporting layer material must occur). Suitable materials

are typically made of crushed stones of sufficient strength with a max. particle size of min. 24mm and a low content of fines.

3. Assessment of Football Players

The surface-test matches held by the Football Association of the Township of Zürich revealed that filled as well as non-filled surface systems are fully accepted from the players' point of view.

Evaluation of the questionnaires comparing different artificial turf products:

By Urs Egger, President of Stadtzürcher Fussballverband

During January and February 2007, the main teams of the FC Seefeld (1st League) and the FC Oerlikon-Police (2nd Regional League) tested the following pitches with training and friendly games:

FIFA Home (filled):	Freundschaftsspiel (at beginning snow fall) on top of elastic layer
Neudorf Oerlikon (non-filled):	2-3 times training per week pre-fabricated turf panels w/o infill
GC Campus Niederhasli: Main Pitch; (non-filled)	FC Seefeld Freundschaftsspiel non-filled turf on elastic layer (PUR bound. rubber granules; special design)
GC Campus Niederhasli: 2nd pitch; (non-filled)	FC Oerlikon-Polizei Training prefabricated panels with velcro connection
Juchhof (non-filled):	FC Oerlikon-Polizei Freundschaftsspiel prefabricated panels with velcro connection
Regensdorf (non-filled):	FC Seefeld Freundschaftsspiel non-filled turf on top of PE elastic layer
Dietikon (filled, no elastic layer)	Trainingsspiel

The questionnaires were evaluated in the following way. After play the players filled in the questionnaires. There were 4 levels of assessment ranging from 4 for „very good“ down to 1 for not satisfactory“. The sum per criterion was calculated and divided by the number of players. This resulted in a rating of the average quality. Of course, the individual criteria must also be regarded which ends up with a more detailed analysis. It should be considered whether specific weight should be assigned to the various criteria, however, according to a German study this seems to be unnecessary.

Pitch	FC Seefeld	FC Oerlikon-Police	Rank
FIFA Home	3.20	3.11	2
Neudorf	2.94	2.14 D = 2.67	5
GC Campus: Main	3.37		1
GC Campus: 2nd		2.67	
Juchhof "2007"		2.34	6
Regensdorf	2.96		4
Dietikon	3.12		3

The considerable difference in the assessment of the Neudorf pitch by the two teams is noticeable. The FIFA pitch is rated 'good' despite the snow coverage right after the GC Campus pitch.

Zürich, March 1, 2007

4. Technical Testing

Today, technical testing is performed according to the FIFA Quality Concept (FQC) ¹ which refers to EN Standards as far as those are available. However, it also contains several deviations and additional test procedures. However, several test procedures are under revision or have been revised already (contact football.turf@fifa.org for information).

The technical testing procedures accomplish two different purposes:

- Determination and Distinction of the sports technical performance of the surface systems (player/surface and ball/surface)
- Description of physical condition and identity of surface systems: i-data

It is acknowledged that technical test procedures designed to cover sport performance cannot accurately imitate actual sports movement and interaction. Their imitation capability must inevitably be limited to essential aspects. The procedures must then be designed to deliver results with quantitatively acceptable accuracy with the most critical point being that the results determined by different labs with their own equipment and personal comply to an acceptable degree. The accuracy of the tests performed with artificial turf is somewhat limited. This is not so much the fault of the test procedures as such, but by the variability of the surface systems when installed (reproduction of pile infill is difficult).

The technical tests (the application of test procedures and comparison with limits and requirements) provide the data which may be used with a high degree of likelihood, to evaluate the suitability of surface systems prior to new their being installed on a full-size pitches. Even with testing it is neither an absolute that a surface which has been successfully tested in the lab will satisfy players nor is it guaranteed that surfaces which fail in the lab testing are not suitable.

The following performance parameters can be determined:

- | | |
|------------------------------------|-----------|
| • Force Reduction/Shock Absorption | EN 14 808 |
| • (Standard) Deformation | EN 14 809 |
| • (Vertical) Ball Rebound | EN 12 235 |
| • Angled Ball Behavior (Ball Pace) | FIFA |
| • Rotational Resistance | EN 15 301 |
| • Ball Roll Distance | EN 12 234 |

¹ <http://www.fifa.com/en/development/pitchsection/0,1245,5,00.html>

- Linear Friction FIFA
- Skin Friction / Abrasion FIFA

The effect of mechanical stress exerted by the sports activities (wear) is studied within the lab testing using the Lisport Device (EN 15306). With this device cleat-studded cylinders are rolled over the surface 5000 times in a shifting pattern which incorporates a type of skidding. The above listed tests are repeated after this wear treatment.

The test method for determination of the resistance to UV radiation has not been delineated – at least on the international level. A recommendation has been proposed for use of the Austrian procedure (OISS Regulation Artificial Turf 2006) in which the pile fibers are exposed individually to a defined UV radiation (EN 14836) for 5 months and then retested for tensile strength. The decrease of tensile strength is used to assess the UV stability. The advantage of the procedure is that it can be applied to fibers taken from ready made surfaces.

The procedures for description of the physical and constructive condition are used to determine the identity of the surfaces and their components (i-data). This is a mandatory part of lab testing. This information is necessary to establish the compliance of an installed surface with the offered product. There are no requirements which apply to all surfaces or for specific types only. However, there are limits for deviation of the i-data determined with the installed surface from the i-data provided by the manufacturer for the product (see FIFA).

I-data: parameters / characteristics:

Artificial Turf Layer

- Weight per unit area
- Number of Tufts per unit area
- Pile Height in mm
- Total Pile Layer Weight in g/m^2
- Pile Layer Weight above Backing in g/m^2
- Type of Construction
- Orientation of Pile Fibers

Pile Fibers

- Type of Material
- Type

- Weight per Length in dtex
- Length above Backing in mm
- Thickness in μm
- Width in mm
- Form
- Structure
- DSC – On-set + Peak Temperature

Backing

- Backing Fabric – Type
- Weight in g/m^2
- Coating – Type
- Coating – Application Rate in g/m^2

Elastic Layer

- Type of Material
- Type (style / form)
- Force Reduction / Shock Absorption
- (Standard) Deformation
- Thickness
- Density
- Tensile Strength

The technical tests are tools which, in the hands of the design professionals, enable them to describe / specify the required condition of the surfaces and to control them after installation.

For the investigation of installed surface systems all sport performance tests procedures can be used. The i-data can be confirmed with reference samples of each installation. Therefore, it is important to secure several reference samples of the supplied / delivered surface rolls and to test their identity prior to installation or at least before the handing over of the job.

Test reports of lab or field tests are usable only if they reflect all relevant characteristics (see attached classic examples).

The following constructional tests are important:

- Evenness
- Slope
- Strength
- Water Permeability
- If applicable: Force Reduction of Elastic Layer

These tests must be performed on the elastic layer and the supporting layer prior to installation of the artificial turf layer.

All parts of the artificial turf systems should be subject to continuous supervision prior, during and after installation. While the FIFA and EN 15330 concepts require at least visual verification / acceptance of the sport performance characteristics of the completed turf system, they do not cover the elastic layer.

When using DIN 18035-7 it must be notified that leading members of the DIN committee state that strength and resilience of installed layers can be determined, however the results of such tests must not be used for assessment of the site work since DIN requirements allegedly refer to samples produced under lab conditions only. Samples taken on site were felt to have been disturbed / unregulated and therefore could not be used. If this were true, the goal of the standard would be questionable as it would not be possible to confirm the field installed materials against those offered. Of course, it is undisputed that specific circumstances of the field testing and probable disturbance of materials in the field sampling process occur and must be taken into account appropriately.

5. Assessment according to FIFA, EN and SFV Criteria

There are several assessment systems of artificial turf systems the most prominent being the FIFA Quality Concept (FQC)¹. This predominantly cites the appropriate EN standards for the test procedures. FIFA developed two requirement systems: FIFA 1-star and FIFA 2-star (EN 15330 standard resembles FIFA 1-star). The FIFA 2-star has already been accepted for play-offs of World Cup and European Competitions under UEFA control. Following the European Championship in 2008, subsequent finals of these events may also be held on artificial turf surfaces (provided that they meet FIFA 2-star requirements).

¹ <http://www.fifa.com/en/development/pitchsection/0,1245,5,00.html>

The difference between FIFA 1-star and FIFA 2-star surfaces is that for FIFA 1-star surface systems more liberal requirements are applied (no skin friction/abrasion testing; no tests in wet condition) and the repeat of the field tests is requested after 3 years instead every year. Bearing this in mind, the use of FIFA 1-star surface systems is aimed at community and club level pitches (i.e. use in FIFA or UEFA events is unlikely).

The installation of a FIFA 2-star pitch proves the appropriate sport performance condition of the surface at the time of the field testing. To maintain this condition is the task of the maintenance activities. If a field does not meet the 2-star criteria at the time of field re-testing (12 month after initial field testing) despite of repeated maintenance the field will be down-graded to 1-star status or lose its FIFA RECOMMENDED certificate at all. FIFA only issues certificates to pitches with their complete artificial turf systems but not to components of the turf systems and not to the turf system after successfully passing the lab testing. FIFA 2-star certificates expire exactly 12 month after the initial field testing took place unless a successful re-testing has been performed.

Aside of the FIFA system, artificial turf systems may be tested in the lab and in the field according to the FIFA or EN 15330 test methods and requirements by qualified test labs having ISO 17025 Accreditation for these test procedures. This meets the needs of community and club level pitches if the testing program is as complete as the FIFA concept (see attached proposal).

The requirements of the FQC are rather s restrictive. They were specified for top playing / performance level. Thus, for community level pitches playability is given even though some of the FIFA or EN requirements may be exceeded. However, such deviations must be specified in the tender documents.

The use of artificial turf surfaces on national level is left to the discretion of the national soccer associations. The Swiss Football Association (SFV) decided that as of July 1st 2006 all matches held in the Association Championship, from Super Leagues down to the lowest amateur classes, must comply with the FIFA or EN requirements¹. This means that all artificial turf pitches used for these activities are subject to con-

¹ <http://www.football.ch/sfv/de/Dokumentationen.aspx?vNews=1&newsID=8>

tinuous control by the SFV which includes the requirement that all pitches be tested prior to homologation and at least every 3 years after installation.

In the past, the German standard, DIN 18035-7, was used for assessment of artificial turf systems in the German speaking countries. Meanwhile, the movement toward international standardization has left the German standard behind so that the only parts of DIN 18035-7 that are still relevant are those which deal with the subbase / subconstruction (note: DIN 18035-7 must be withdrawn by the end of 2007 due to the publication of EN 15330). Originally progressive, over the years the German standard has lost credibility / reputation through multiple changes and amendments.

Attached to this study is a comparative overview of the requirements of the various Specification Systems.

6. Environmental and Health Compatibility

The environmental compatibility of synthetic sports surfaces has been discussed since the early 80's. Observations and studies by the Department of Water Protection for the State of Zürich lead to the ban and elimination of Lead, Mercury, Chromate and Cadmium in these systems. Determination of those heavy metal pollutants was established through the use of an elution in water test method. That basic idea was picked up by the Swiss Federal Committee „Environmental Compatibility of Elastic Synthetic Surfaces on Sports Grounds“ (published as ESSM 105:1997) and then further spread through the DIN 18035-6 Standard. While the basic idea was sound, these efforts were largely based on armchair decisions and the risk level was over-emphasized.

Thus, the requirement for DOC value (DOC = Diluted Organic Carbon) was set near the lowest threshold value which can be determined accurately (although the DOC value can be caused by harmless substances such as sugar) and the content of the heavy metal Zinc was highly restricted. In addition, it was rather deliberately introduced that the water used for the elution was CO₂ saturated (i.e. without theoretical and practical foundation “since today's rain water is acid ...”) which wrongly lead to very high Zinc level results in the elution test. Finally, the relatively unknown testing procedure for nitrification inhibition was added.

The orienting values for the assessment of environmental compatibility were set based on data provided by Germany. These values reflected the typical range of content of substances in common synthetic surface products. The working premise was that with these values as the baseline, those products meeting these ranges through elution testing were thought to be environmentally compatible. Products exceeding these ranges were to require additional scrutiny. In the course of time, the “orienting values” became “limiting values” and finally “requirements” with alleged legal status (Waste Water Regulation in Switzerland; Soil Protection Regulation in Germany). The metamorphosis of the environment documents occurred almost unnoticed. Fortunately, no great harm ensued since synthetic surfaces were in compliance with these requirements.

When artificial turf surfaces came into play the ESSM 105 and DIN 18035-6 environment documents were applied to turf surfaces once again in a process without scrutiny. This had negative consequences for surfaces filled with rubber granules. Here, the rubber granules are, different from synthetic surfaces, not covered by Polyurethane so much more zinc was found in the test water due to the larger exposed surface of the rubber granules so the orienting values were noticeably exceeded. Based on this result and instead of reconsidering the matter, zinc was declared a pollutant despite its rating in water by the World Health Organization (WHO) as organoleptic only (i.e. effecting taste). Also not factored in was that the zinc release of artificial turf pitches is much, much lower (actually non-comparable) than the level produced by car tires in traffic.

Finally, on the issue of the pH of the elution water, the argument was made that rain water loses its acidity as soon as it touches the surface. This was accepted only in Austria. Further research has found that the Zinc problem actually disappears with elution in pH neutral water.

This situation was recognized by the Swiss Ministry of Sports (BASPO) which setup a new committee to scrutinize the question of the environmental compatibility of sports facility surfacings. As a first step, the ESSM 105 regulation was withdrawn since it is regarded as professionally outdated and more current research is underway. Since 2006, a field-study has been ongoing to investigate the actual release of heavy metals and potential organic pollutants from various turf systems. To date, the results show that there is no reason to ban black SBR rubber granules provided that these are from recycled car tires as the composition of car tires is well known and unlike

technical rubber scrap, which cannot be controlled, no contamination through the addition of other dangerous substances is expected. The study is expected to be completed by the end of 2007. The Swiss Ministry of Health (2006) has also published a statement denying a health risk caused by rubber granules in artificial turf surfaces (risk due to PAH) ¹.

As a public service, the ISSS (International Association for Sports Surface Sciences²) presented a Technical Symposium in October 2006, at which the results of studies conducted in various countries were presented in English for the first time. The presenters have graciously allowed this very informative research to be made available through the ISSS website³. This research took health as well as environmental risks into account. Some of the studies were on-going, however no risks were reported which required specific action - most notably in respect to the need for exclusion of certain materials such as SBR granules made of old car tires.

Part of the environmental compatibility problems is the question of the future disposal of artificial turf surfaces. With well-known products there should be no general problem since they do not contain hazardous components in relevant quantities. However, in individual cases local conditions for disposal (combustion, landfill) must be checked. It is important to differentiate between the turf carpet, the infill and the elastic layer since the infill is normally re-used and elastic layers may last minimum three times a turf carpet.

7. Long Term Behavior

It is estimated that surfaces of today's provenance can be played on for 10 to 15 years. This means that wear of the pile layer does not occur to the same degree as was observed with sand filled surfaces in the past where silica sand acted like sandpaper between pile fibers. Also the resistance to damage from UV radiation is no longer a critical issue as pile fibers produced by reliable manufacturers with proven quality are used. A crucial factor in longevity is, of course, appropriate maintenance.

However, it is not only playability / usability in its basic sense which matters but also long term compliance with the requirements of FIFA or EN. Unfortunately, reliable

¹ <http://www.bag.admin.ch/themen/chemikalien/00228/03458/index.html?lang=fr>

² www.sportsurfacescience.org

³ <http://www.iss.de/conferences/Dresden%202006/Technical/index.htm>

evidence is not yet available on this issue. The lab test with the Lisport device may give a clue towards this but no certainty.

8. Maintenance

Different methods are applied to filled and non-filled artificial turf surfaces.

- The installer must provide the owner with a precise maintenance manual spelling out all details and timeframes of the required procedures.
- The manufacturer of the surface should also supply the necessary maintenance equipment and provide practical training.
- The owner must appoint a responsible person for the maintenance task.

Non-filled surfaces need little maintenance other than keeping them clean. Soiling of pile fibers by air pollution is usually rinsed off by rain water.

In order to maintain or revitalize the playing characteristics (ball roll etc.) these surfaces must be brushed from time to time (i.e. 1x weekly with heavy usage up to 1x monthly with medium usage). The suitable devices must be specified by the manufacturer of the installed turf layer.

The granular infill is crucial for optimal playability of filled surfaces. During use the granules shift and a non-uniform distribution of granules occurs especially in the intensively played areas such as penalty areas, goal lines and corners. According to the intensity of usage, these areas must be brushed regularly and re-dressed with granules as necessary. As a general rule, it is important that the pile fibers uniformly extend above the infill layer by about 15 to 20 mm.

In order to achieve uniform playability throughout the field, the pitch must be treated with a tractor-mounted framed-brush in at least two directions (especially against the inclination of the pile fibers).

The bristles of the brush should be made of Polyester with a diameter of around 1.2mm. The bristles must be regularly examined and replaced when they are bent due to repeated use. The procedure must be repeated more often with intensive usage such as tournaments or other big sporting events.

FIFA is going to require continuous maintenance, mainly brushing, in order to keep the sport performance on FIFA 2-star level. For this, facility managers must regularly apply the ball roll test to control the actual condition of the surface.

Cleanliness: Leaves, branches and other organic deposits must be removed regularly. Moss seizure is an indicator of partial water non-permeability. This can be fixed by using a long pin to penetrate the surface down to the sub base several times (min. 15cm deep). The moss must be removed mechanically and granules must be added accordingly. Chemical weed killers or other types of chemicals must not be used.

Snow does not have direct influence on quality and longevity of the artificial turf surface. Melting water is drained off by the water permeability as long as the sub construction is not frozen. For effective snow removal a working plan should be prepared in order to avoid compaction of the snow by working vehicles.

Snow layers up to 2-3cm are removed best with a front-mounted revolving brush 1 meter in width. The vehicle must not exceed the specified axle load. It is important that the revolving brush is supported by wheels and that the tips of the pile fibers are not touched. Revolving brushes without supporting wheels must not be used. All motorized vehicles must be equipped with low pressure tires. To avoid damage to the turf layer, don't use any devices with studs or chains or park devices on the turf for longer periods of time. Avoid tight turns with moving devices. Rule: the higher the snow layer the more difficult the snow removal.

Snow layers above 5-6cm must be removed with of a snow rotary hoe. The removed snow should be moved onto a dumper driving at the side of the rotary hoe. The same rules apply as for the revolving broom. The safety distance of the rotating milling blades from the pile fibers should be min. 2-3cm. The final cleaning after the rough snow removal must be done with a front-mounted revolving brush only. If using a shovel loader the shovels or shields must not have sharp edges.

If ice has formed on the top of the artificial turf system, extra caution must be applied. Ice and pile fibers may have been locked together so that a mechanical action will damage the turf surface. A word of caution: damage caused by unprofessional ice and snow removal are not typically covered by the warranty / guarantee of the turf manufacturer or installer.

Don't use chemicals for ice removal. Many chemicals leave colored residues on the turf which are not usually removable. Common Salt, Calcium Chloride, Ammonium Chloride or other corrosive or irritating chemicals may have negative influence on users, devices and the artificial turf components.

Suitable and recommended maintenance devices must be equipped with broad or balloon tires (low pressure tires). The driving speed must not exceed walking speed. Sharp turns and abrupt braking or turning on the spot must be avoided. Vehicles must not produce bow waves with their wheels since this will cause irreversible distortion of the turf (e.g. crooked or shifted lines). If the equipment is as specified and has been handled correctly, bow waves may be indicators of poorly manufactured or installed synthetic turf layers.

Maintenance vehicles must be inspected regularly in order to avoid oil, gasoline, or grease contamination of the surface. In the event that this happens, consult the maintenance manual or contact the manufacturer of the turf carpet for cleaning instructions.

Plan of Maintenance Activities:

- Weekly inspection – brushing of intensively used areas such as penalty area, goal line or corners.
- Monthly inspection – inspection of whole pitch, application of rubber granules as necessary
- Annually cleaning of whole pitch with special maintenance device

Recommendations for Usage

It is important to control the following:

- Don't allow shoes with long metal studs/cleats
- Don't allow smoking or any tobacco products on the pitch
- Protect the turf surface from fireworks and their falling debris
- Do not allow animals on the turf surface
- Ban the use of chewing gum / sunflower seeds on the turf surface
- Prohibit glass from the turf surface
- Prohibit heavy items with sharp-edged footings, stakes or the like on the turf surface
- Require shoes be cleaned prior to stepping on the turf surface
- Keep the areas in front of the turf pitch clean

- Brush the dry artificial turf regularly
- Place sufficient trash cans around the pitch.

9. Economical Aspects

See information provided in the FIFA Turf Roots Magazine 01.

10. Burning Behavior

The burning behavior is an important aspect as far as safety and also damage from vandals. A UEFA video was produced in cooperation with the fire brigade of Zürich showing the situation in a very convincing and dramatic way. On one hand, all artificial turf surfaces burn if ignited (at least in dry condition) and the surfaces are locally damaged to a great degree. On the other hand, there is no tendency for spread of fire, thus only the cost for repairing the surface is an issue. Even incendiary devices (also Magnesium fireworks up to 2000°C) represent no increased safety risk. Since fireworks attacks occur during matches, safety personnel can take control of such items quickly before noticeable smoke forms which might be unpleasant. As far as testing for the burning behavior of turf, a suitable test procedure has been developed by the Austrian Research Institute (OFI)¹.

11. Summary

As a criterion of a turf systems overall suitability the requirements of FIFA or EN 15330 may be used. However, the requirements of FIFA allow for a wide spectrum of playability and what is right for one area may not be right for another, therefore, owners and clubs should go and see for themselves the playing characteristics of the intended surface products at reference installations. Ideally, purchase orders should always be awarded based on existing and accepted pitches. Additionally, the identity of the products must be proven through a test report which complies with the FIFA program.

It is a common sales technique to refer to individual characteristics of the represented product only: for instance form and thickness of pile fibers. However, this is not a sufficient criterion in itself for the assessment of a better or lesser functional quality. For

¹ <http://www.iss.de/conferences/Vienna2004/Technical/Flammability.htm>

assessment the total system must always be taken into account (i.e. turf layer + infill + elastic layer).

When selecting an artificial turf surface be always aware of the requirements of the national football association, FIFA, UEFA or the like.

The players' assessment of playability of non-filled compared with filled surfaces is not final yet. However, it must be emphasized that players in Switzerland like to play on both surfaces (see player inquiry of Zürich) and that non-filled surface products have been considerably improved. The cost and maintenance issue may be the decisive factor in many cases where FIFA 2-star level is not required (there are no non-filled surface systems with FIFA 2-star certification yet).

Non-filled surfaces have a clear advantage with their independence to weather during installation. Since these seams are normally sewn not glued and neither rubber granules nor sand must be added (application is limited to almost dry conditions only to achieve the trickling capacity) there are no weather-related installation delays.

There are also situations where non-filled surfaces are preferred.

- In areas where the pitches are exposed to heavy storms (e.g. tropical areas). Under these conditions the granules are simply blown away.
- In Nordic countries where snow removal is often necessary, non-filled surfaces have an advantage since snow removal is easier and there are no complaints due to visual contamination of the removed snow with black rubber granules.
- In Nordic countries artificial turf is used also in field houses where rubber granules may produce unpleasant smell. This may be solved by using TPE materials.
- Whenever excessive requirements due to environmental conditions (water supply areas) must be met.
- Furthermore, less maintenance expenditure is a reasonable factor.

Controversial views still exist regarding the question whether an elastic layer is advantageous / necessary or not. For surface systems without elastic layer the argument is that the resilience (protection function) must completely provided within the pile layer and the pile layer resulting in more elastomeric infill in order to secure the protection function. The pile layer also contains less sand than filled surfaces on elas-

tic layers. The crucial advantage is that in winter when humid sand in-fills freeze the resilience of the elastic layer is not effective any more. A disadvantage is a possible loss of performance over time. The assessment of these arguments is a matter of personal opinion.

If the intended sport is Field Hockey or any other sport which requires non-filled turfs to be wetted, the issue of water usage, supply and cost may be considered a drawback especially in areas where clean water is scarce or the supply unstable.

Finally, the importance of maintenance is to be taken into account when assessing filled and non-filled surfaces.

The manufacturers must combine the various factors in such a way that functional surface systems result. Restriction of the assessment for instance to fiber shape, thickness, and/or structure is a common tool in the market place to exclude competitors' products. These individual aspects are very important, however their influence on the playability can be assessed based on practical experience only (→ reference installations).

Assessment criteria of the various artificial turf pitches:

Name of pitch:

Name of player:

Date:

Criteria	Very good	good	satisfactory	Non satisfactory	remarks
Traction					
Suitability for sudden starts					
Suitability for ball stopping					
Suitability for Dribbling					
Hardness of the turf					
Promoting stumbling					
Injury Risk					
Stress of joints					
Suitability of straddling					
Injury risk at sudden falls					
Injury risk at continuous sliding					
Suitability at turns on one leg					
Ball movement					
Angle of ball rebound					
Ball calculable ?					
Suitability for short passes					
Technique					
Suitability for kicks from stand					
Suitability for kicks from rotation					
Evenness of turf surface					
Remarks					