Study on UV Ageing of Artificial Turf

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The aim of my presentation is to introduce for discussion our experience and studies on experimental UV ageing. I mean the comparison between laboratory testing and on site behaviour of artificial turf and yarns.

There are so many ways to assess ageing, different for each industry: apparatus, protocols, lamps, number of cycles … that we could debate the whole day. That is the reason why I prefer to report our experience from site, in order to get a correlation if possible.
We think that, as each industry, surfaces and products are different, the most important thing is to correlate with the behaviour on site and to have both approaches: physical and chemical.
We learnt a lot from damages in French Islands, it is why we decided to set up an experimental station in the Caribbean islands.

Each product, I mean component has its own coefficient of extinction: it is why it is so difficult to simulate reality but our responsibility, as a testing house to control durability, is to avoid the majority of the problems which could occur.

The presentation has 3 parts and summarizes several studies:

- CEN work and Labosport proposals
- Damages observed from site and 2003 study
- Last comparison between site and Q UV lamps A and B in 2008.

1. CEN standardization

Work on artificial surfaces (tracks and turfs) began around 1998 with a First Labosport proposal in 1999 based on the ISO 4665; approved in Brussels (1999). CEN drafts were written from 2002 for an approval in October 2003 and a CEN enquiry in February 2004. The EN 14836 was published in 2004.

The only difference with our proposal was based on the use of UV A lamp (340 nm) instead of UV B lamp (313 nm). UV B lamps seemed too different from the UV solar spectrum by several experts.

In the mean time several damages occurred over the World which brought us to do more testing. The first pitches with the new generation of turf were installed in 1999 in France and 2001 and 2002 in La Réunion.
The pitches from La Réunion were damaged between one year and half and two years after their installation (whitening, breaking).

We did a study during 6 months in 2003 to analyse the problems, which were also detected in France in our exposition area in Le Mans after two years of exposure for rubbers from tyre and 3-4 years of exposure for EPDM crumbs.

For our First studies we took the UV B lamps due to the experience in synthetic tracks and assessment of rubber ageing (mainly in the Caribbean) and also due to comparisons between site and lab.

We had a physical approach (colour and tensile strength characterization) and a chemical approach with DSC (Differential scanning calorimetry) to assess the melting point.

			Traction		Calorimetry	
	Study number	Appearance	Break (N)	Losses (%)	Melting point (°C)	Area (mJ)
Polyethylen	1	Fibrillated	53,2	-27,6	-0,3	100,3
	2	Fibrillated	42,0	-32,7	0,9	-145,2
	3	Fibrillated	26,3	-25,6	0,0	-115,6
	4	Fibrillated	34,1	-29,4	0,8	-27,0
	6	Fibrillated	26,6	-24,3	0,2	51,6
	9b	Fibrillated	7,3	-17,3	-0,4	-3,0
	9a	Monofilament	6,0	-43,9	-0,9	-60,7
Copolymer	5	Monofilament	13,8	-58,1	2,7	10,5
	7	Monofilament	11,1	-57,1	2,8	-46,1
	8	Monofilament	13,9	-72,6	4,5	-355,5
	10	Monofilament	16,4	-75,8	4,2	35,8

Fibers after ageing (UV B lamps) 2500 hours

Agreement	**losses mark " - "**
	gains mark " + "

Diff = After-before

The ageing lasted 2 500 hours (cycles of 4 hours UV at 55°C - lamps 313nm and 2 hours black with only humidity at 45°C) : it is now 3000 hours.
Tensile strength according to NF EN 13864
Colour change according to EN ISO 20105-A02

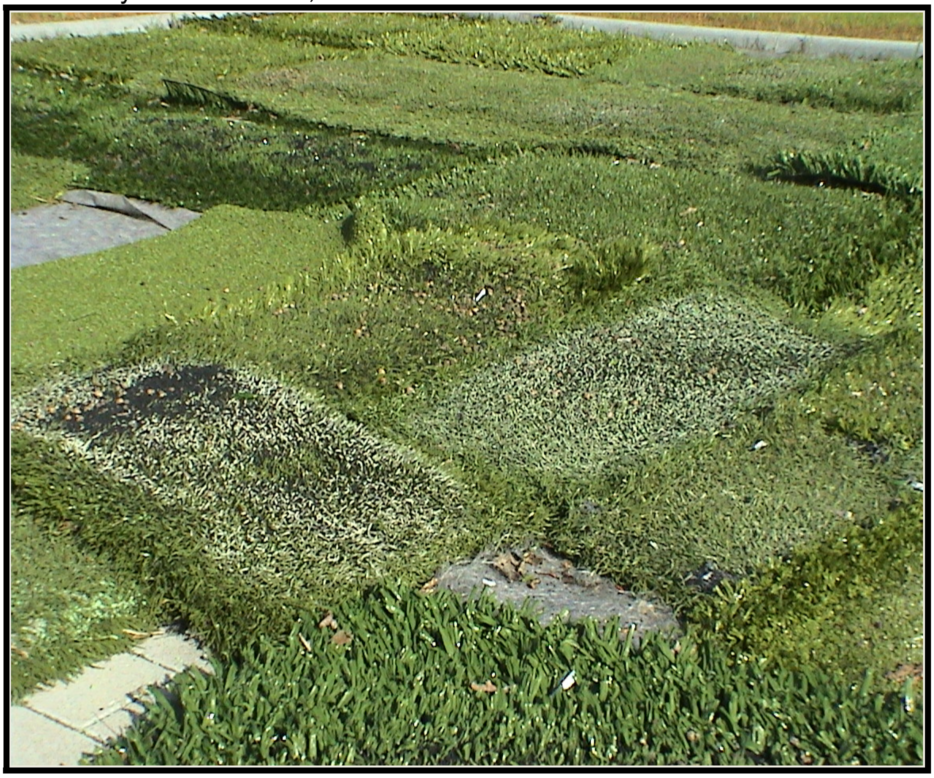
CONCLUSION

- **PP and PP based Copolymers lost more 50 % tensile strength after 2500 hours of exposure**
- **There is a correlation between change in the melting point and loss of tensile properties**

Labosport proposal was not accepted by CEN and the UV A lamps were adopted (with 3000 hours), nevertheless we kept in France UV B for French Islands. Italy did the same.

2. Damages

- ✓ Beginning of site exposure in Le Mans: 2001 (beginning of FIFA FQC). Whitening after 2 years for Tyre rubber and 4 years for EPDM, double time than French Islands.



Between laboratory testing, yarns from site and yarns not exposed we noticed a loss in tensile properties and loss of abrasion resistance but also a loss in the melting point.
We did the same for several damages and always found a correlation between site and lab exposure.
I also noticed that good yarns never failed in the QUV, lamps B.

- ✓ **After 2003, many problems appeared on site on the new generation of turf :**

. Martinique 2001 (PA) : 2 years aged
. La Reunion 1 2003 (PP) : 2 years aged
.La Reunion 2 2004 (CP) : 2 years aged

3. Labosport study : 2003

<u>Example from La Martinique PA</u> : Basse Gondeau (2003 study)

	Study in 2003		
	Resistance to wear (g)	**Tensile strength (N)**	**Melting point (°C)**
New	0,56	13,3	259,36
Basse Gondeau (BG)	No more fiber after 2/3 years	5,5	253,08
Artificial weathering (UVB)	5,34	-	251,03
	Loss between new and BG	-7,8 (59%)	-6,28
	Loss between new and UVB	-	-8,33

- ✓ HALS are attacked by elements from SBR, created from the Sulphur (SO2)
- ✓ UV B reproduces this attack
- ✓ UV B is a protection for the municipalities from problems which are not expected due to new system

CONCLUSION

Good simulation in lab to reproduce the problems with QUV B

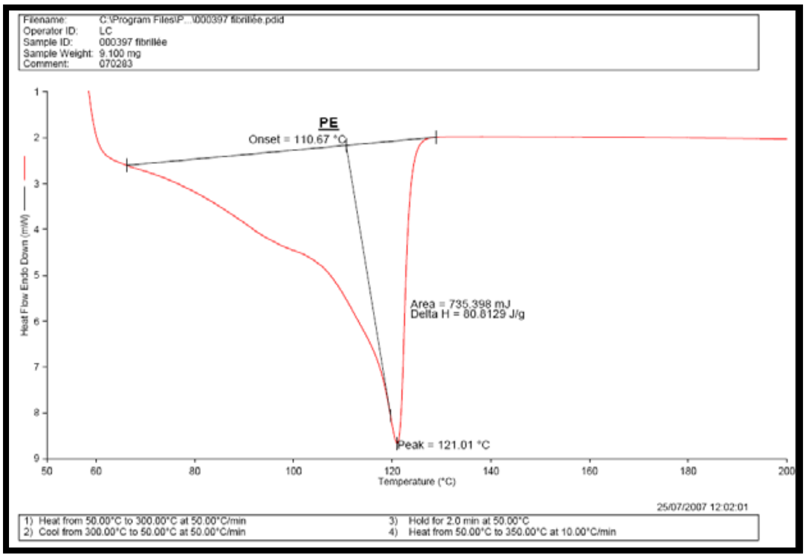
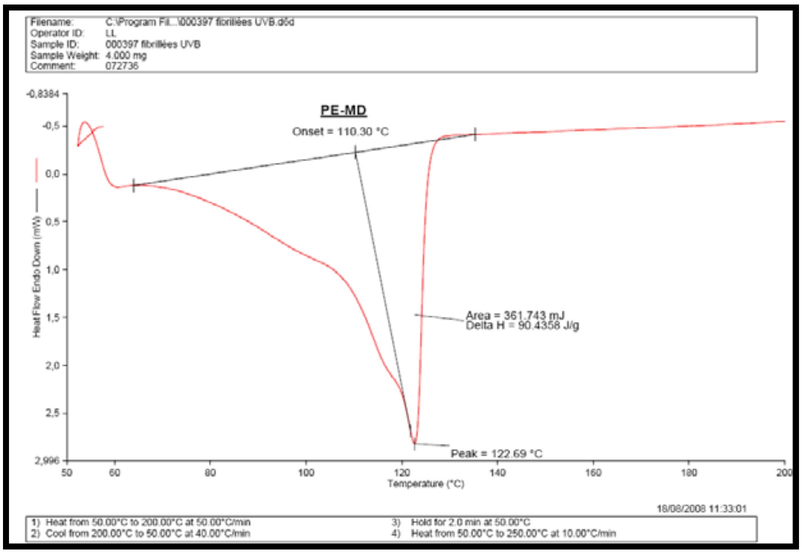
- **Tensile strength**
- **Melting point**
- **Colour**

We formalized the method in France in 2004 (XP P90-112 - November 2004).

4. Study from 2008

10 months in La Martinique due to the target date of a FIFA meeting, UVA and UVB, 3000hours (2000 hours of UV) for lab testing

- ✓ Experimental testing from turf with rubber
  - Problems to carry out tensile strength
- ✓ Experimental testing on yarns
  - Good correlation between site exposure and QUV testing with UV B. 10 months in La Martinique involve a tensile strength result between QUV A and QUV B, it means QUV give more ageing, as there is no rubber which can bring an additional destruction of protecting agent, UV B is more convenient.

DSC on new fiber	
DSC on aged fiber (UVB)	

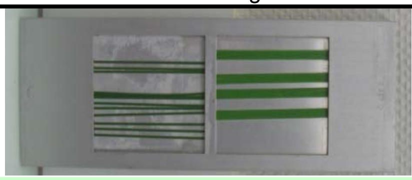
Synthetic turf 001644

PE-LD et PE-MD	DSC	
H	peak (°C)	peak (°C)
3000 hrs UVA	=	=
3000 hrs UVB	↓↓	↓↓
10 months in carribbean island	=	=
S	peak (°C)	peak (°C)
3000 hrs UVA	↓↓	↓↓
3000 hrs UVB	↓↓	↓↓
10 months in carribbean island	=	=

Synthetic turf 001647

PE-LD et PE-MD	DSC	
H	peak (°C)	peak (°C)
3000 hrs UVA	↓↓	↓↓
3000 hrs UVB	↓↓	↓↓
10 months in carribbean island	=	=
S	peak (°C)	peak (°C)
3000 hrs UVA	↓↓	↓↓
3000 hrs UVB	↓↓	↓↓
10 months in carribbean island	=	=

↑↑↑↑	Very important positive variation
↑↑↑	Important positive variation
↑↑	medium positive variation
↑	small positive variation
=	No variation
↓↓↓↓	Very important negative variation
↓↓↓	Important negative variation
↓↓	Medium negative variation
↓	Small negative variation



2 fibers: Monofilament PE-LD and PE-MD; Fibrillated PE-MD (000397)

	DSC		Tensile strength (N)		Identification	
fibrillated PE-MD fiber	PE-LD peak (°C)		Maximum force (N)	Variation (%)	Pile weight (dtex)	Colour
new	121,01		44,41		5800	
3000 hrs UVA	121,55		44,35			5
3000 hrs UVB	122,69		32,13		5665	4/5
Variation between aged and unaged after UVA	0,54		-0,06	0		
Variation between aged and unaged after UVB	1,68		-12,28	-28		
10 months in carribbean island	123,16		36,18		6130	4
Variation between aged and unaged after UV in caribbean	2,15		-8,23	-19		
monofilament PE-LD and PE-MD	PE-LD peak (°C)	PE-MD peak (°C)	Maximum force (N)	Variation (%)	Pile weight (dtex)	Colour
new	106,22	123,05	14,26		2000	
3000 hrs UVA	105,75	122,79	14,69			5
3000 hrs UVB	107,80	124,88	12,47		2028	5
Variation between aged and unaged after UVA	-0,47	-0,26	0,43	3		
Variation between aged and unaged after UVB	1,58	1,83	-1,79	-13		
10 months in caribbean island	108,13	124,98	13,32		2039	4/5
Variation between aged and unaged after UV in caribbean	1,91	1,93	-0,94	-7		

2 fibers: PE-LD and PE-MD (000554)

	DSC		Tensile strength (N)		Identification	
H monofilament	**PE-LD peak (°C)**	**PE-MD peak (°C)**	**Maximum force (N)**	**Variation (%)**	**Pile weight (dtex)**	**Colour**
new	105,34	122,47	14,95			
3000 hrs UVA	105,68	122,47	14,39			5
3000 hrs UVB	105,39	122,13	13,01			5
Variation between aged and unaged after UVA	0,34	0,00	-0,56	-4		
Variation between aged and unaged after UVB	0,05	-0,34	-1,95	-13		
10 months in caribbean island	107,71	124,79	13,03		1685	4/5
Variation between aged and unaged after UV in caribbean	2,37	2,32	-1,92	-13		
S monofilament soft	**PE-LD peak (°C)**	**PE-MD peak (°C)**	**Maximum force (N)**	**Variation (%)**	**Pile weight (dtex)**	**Colour**
new	105,50	122,67	13,158			
3000 hrs UVA	105,89	122,75	12,275			5
3000 hrs UVB	105,82	122,47	12,017			5
Variation between aged and unaged after UVA	0,39	0,08	-0,88	-7		
Variation between aged and unaged after UVB	0,32	-0,20	-1,14	-9		
10 months in caribbean island	107,62	124,73	12,03		1686	4/5
Variation between aged and unaged after UV in caribbean	2,12	2,06	-1,13	-9		

Fibre : PA (nylon) (001966)

	DSC			Tensile strength (N)		Identification	
Monofilament	**Peak (°C)**			**Max force (N)**	**Variation (%)**	**Pile weight (dtex)**	**Color**
New	177,36	208,43	219,19	15,50		645	
3000 hrs UVA	176,78	206,76	217,64	5,52		840	5
3000 hrs UVB	166,74	-	210,96	0,686			5
Variation between unaged and UVA aged sample	-0,58	-1,67	-1,55	-9,99	-64,41		
Variation between unaged and UVB aged sample	-10,62	-	-8,23	-14,82	-95,58		
10 months in Caribbean islands	177,92	209,30	219,94	10,01		820	4
Variation between unaged and Caribbean UV aged sample	0,56	0,87	0,75	-5,49	-35,43		

2 fibres: Monofilament PE-LD and PE-MD; Fibrillated PE-MD (000397)

PE-MD	DSC		Tensile strenght
fibrillée	**peak (°C)**	**peak (°C)**	**Maximum force (N)**
3000 hrs UVA	↑		=
3000 hrs UVB	↑↑		↓↓↓
10 months in carribbean island	↑↑		↓↓

PE-LD et PE-MD	DSC		Tensile strenght
monofilament	**peak (°C)**	**peak (°C)**	**Maximum force (N)**
3000 hrs UVA	↓	=	=
3000 hrs UVB	↑↑	↑↑	↓↓
10 months in carribbean island	↑↑	↑↑	↓

2 fibres: PE-LD and PE-MD (000554)

PE-LD et PE-MD	DSC		Tensile strenght
hard	**peak (°C)**	**peak (°C)**	**Maximum force (N)**
3000 hrs UVA	=	=	↓
3000 hrs UVB	=	=	↓↓
10 months in carribbean island	↑↑	↑↑	↓↓

PE-LD et PE-MD	DSC		Tensile strenght
soft	**peak (°C)**	**peak (°C)**	**Maximum force (N)**
3000 hrs UVA	=	=	↓
3000 hrs UVB	=	=	↓
10 months in carribbean island	↑↑	↑↑	↓

↑↑↑↑	Very important positive variation
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↑↑	medium positive variation
↑	small positive variation
=	No variation
↓↓↓↓	Very important negative variation
↓↓↓	Important negative variation
↓↓	Medium negative variation
↓	Small negative variation

fibre: PA (nylon) (001966)

PA	DSC			Tensile strenght
	peak (°C)	**peak (°C)**	**peak (°C)**	**Maximum force (N)**
3000 hrs UVA	=	↓	↓	↓↓↓↓
3000 hrs UVB	↓↓	↓↓↓↓	↓↓	↓↓↓↓↓
10 months in carribbean island	=	=	=	↓↓↓

The melting point peak deviates (+ or -) in case of problems, due to a change in formulation. DSC results depend on the crystallisation process in the yarn and break of bounds. Both behaviour could equilibrate with no change in the melting point, so DSC can't bring to a conclusion in case of stability, but it is good information when it moves a lot (more than 3 °C).

Infrared spectroscopy seems better to assess UV ageing and the durability of protecting agents and polymers.

- **<u>Conclusion</u>**

Tensile strength is a good test to assess the ageing
DSC gives information on ageing but must be taken carefully
IR spectroscopy is better to control UV ageing

- **<u>GENERAL CONCLUSION</u>**

  - **AGEING MUST SIMULATE THE INTERACTION BETWEEN ELEMENTS: problem is to assess the physical properties.**

  - **AGEING MUST REPRODUCE THE SITE EXPOSURE AND ACCELERATE IT: hot air, hot water, UV... (5 months exposure seems to be a minimum)**

  - **PROPOSAL : UV B on the yarn : 4000 hours (3000 UV) to simulate a minimum of 2 years in tropical countries and 5 years minimum in Northern Europe.**