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Introduction to this Technical Information Manual (TIM)

This Technical Information Manual (TIM) is already the 6th edition, after it was first released in 1999. This latest edition contains updated technical information regarding Thiolon[®] fibers and backings from all our production plants.

At the end of the manual, we added our contact information including those of suppliers of infill material, glue, test institutes and sports federations.

We trust you will find this manual useful.

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1 Introduction TenCate Grass Group

The TenCate Grass Group is a division of Royal Ten Cate, a Dutch textile company with over 300 years of experience. This group is well known for the high quality artificial grass fibers and deep black UV stable carpet backing it develops, manufactures, and markets under the Thiolon[®] brand name. The TenCate Grass Group consists of 4 subsidiaries where Thiolon[®] artificial grass fibers and carpet backings are manufactured.



TenCate Grass North America is located in Dayton, Tennessee in the United States of America, TenCate Grass Asia is located in Hong Kong, Tencate Grass Middle East, LLC is located in Dubai, United Arab Emirates and the other companies are located in Nijverdal in the Netherlands.

2 TenCate Grass Group mission

Mission

TenCate Grass Group aims to satisfy the need for optimal (playing) surface systems in sport- and non sport markets worldwide by developing, manufacturing and supplying state-of-the-art value added artificial grass system components through close cooperation with preferred industry partners.



3 Product recognition of Thiolon[®] fibers

In order to make it as easy as possible for our customers to recognize our different materials, we have set up identification procedures. Midst 2006, the Nijverdal plant of TenCate Grass started using a new packaging concept that also changes the recognition of Thiolon products.

Shrink-foil label and recognition

The shrink-foil contains a label (refer to the example below) with amongst others the following information:

- Color batch code;
- Order code ("partij");
- Product style code (for example K661222383160);
- Product name (for example PP 6.600 T Olive);
- An unreadable barcode.





Bobbin (outside) colors

For all products and qualities one bobbin color is used (mint green). One exception is the use of different colors for internal reasons of Ten Cate Thiolon BV.

Bobbin labels

Each bobbin contains an outside bar code label. This bar code is for internal Ten Cate Thiolon BV use only.

The inside bobbin labels consist of stickers representing the different fiber styles. An example is shown directly below:



And stickers with the following information:

K661222383160 Batch: 1M3810S Partij: 5191

- = Product style code
- = Color batch code
- = Order code or creel lot no.



It is very important that the color batch codes within one and the same contract are identical, in order to guarantee a constant color throughout the contract.

Before you assume responsibility of combining material from different color batch codes for one and the same contract, we advise placing the coated versions next to each other and comparing them carefully. Also the creel lot-number is of importance, certainly in the case of relatively long batches. It is best to use the creel lot-numbers that are as close together as possible, because also in the case of a same batch, color differences can occur when older creel lots are being mixed with recent creel lots out of the same batch.

Explanation of the product style code:

V 11 1 2 20 38 80 60

V = Product group

11 = First two digits of decitex 1 = Number of threads 2 = Twist

20 = Design 38 = Color code Ten Cate Thiolon BV[®] 80 = Material composition 60 = Weight in kg

Groups:

Style	Thiolon [®] PP	Thiolon [®] LSR [®]	Thiolon [®] SPF	Thiolon Xtreme [®] CLMT	Thiolon Xtreme [®] MF
Straight	N	V	-	W	W
Dynacurl texturized [T]	K	Z	G	-	-
Multi colored	M	-	-	W	-
Multi colored, Dynacurl texturized [T]	D	-	-	-	-

Digits / Decitex straight:

11 = 11000 dTex

Twists and design:

For internal use

Material composition:

31 =	PP	43 =	SPF
89 =	Xtreme [®] MF	= 08	LSR®
93=	Xtreme [®] CLMT		

Color codes Thiolon fiber[®] fibers

Color	PP	LSR®	SPF	Xtreme [®] CLMT	Xtreme [®] MF
Beige	0231				
Grey	1231				
Black	1831	1880	1843		
Reflex Blue	2531	2580		2593	2589
Light Blue		2780	2743		
Karibik Blue		2880	2843		
Summer green	3531	3580	3543		
Verde		3780	3743	3793	3789
Olive green	3831	3880	3843		
Nature	3931				
Field green		6380	6343	6393	6389
Lime green		6680	6643	6693	6689
Dark green		6980		6993	6989
Yellow	4531	4580	4543	4593	4589
Red clay	5531	5580	5543	5593	5589
Fire	5631				
Red		5780	5743		
Brown	7631				
Violet		8180	8143		
White	9231	9280	9243	9293	9289



4 Product recognition TenCate Grass North America fibers

The following identification procedure has been set up in order to make it easy for our customers to recognize our different materials.

TenCate Grass North America PE Fibers:

- 1. Natural kraft colored tube
- 2. White cone or tube label will contain:
- A. Color and color number -B. Lot number -C. Denier and number of needles if KDK ITEM: **TenCate Grass North America** 110118 1131 Broadway St. (423) 775-0792 Dayton, TN 37321-1802 www.tencate.com Made In The USA PE DENIER: 10000 DESC: PE-10000 Red Clay PE #55P COLOR: RED CLAY 10-29-0710 LOT 10,000 PE # of Cones Net Wt. LBS TenCate Grass N.A. 29 64 10 07 834 00000267630 3. Skid labeling will contain: E. Denier F. Color G. Shipping and lot number -H. Item number I. Number of cones per skid J. Unreadable bar code -K. Net weight in pounds ____

It is very important that the LOT NO. / CODES (is 10 - 29 - 0710 in the label above) within one and the same contract are identical, in order to guarantee a constant color throughout the contract.

TenCate Grass Nor America PP Color	rth	5020 Denier	5700 Denier	6700 Denier	7600 Denier	10000 Denier
Olive *	411/5	-	120032	-	120017	-
Putting Green *	311	-	-	-	120016	120006
Winter Green *	27/5	-	120027	-	120012	120004
Lawn Green *	21/5	-	120025	-	120010	120002
Rust *	44/5	-	120029	120023	120015	-
White	1	-	120024	120019	120008	120000
Yellow *	63	-	-	-	120013	120005
* Contains Le	ad Chron	nate pigment				

4.1 Color codes TenCate Grass North America PP fibers

Contains Lead Chromate pigment

4.2 Color codes TenCate Grass North America PE fibers

TenCate Grass North America Standard PE Color	5000 Denier XP Pro	8000 Denier XP Pro	10,000 Denier XP Pro	10,800/6 Denier Xtreme MF
Bright Yellow # 584	-	120091	120070	130094
Field Green # 65	120135	120083	120067	130088
White # 92	-	120085	120068	130098
Red # 364	-	120092	-	130097
Black # 306	-	120096	-	130093
Florida Blue # 377	-	120095	-	130095
Tan # 809	-	120101	-	130106
Crimson # 188	-	120089	-	130104
Gray # 60	-	120086	-	-
Navy Blue # 29	-	120089	-	130096
Red Clay # 55	-	120084	110116	130099
Orange # 172	-	120098	-	130107
Olive # 38	120140	-	-	-
Lime Green # 66	120139	-	-	-
Field Green/Lime Green	-	-	-	130105
Field Green/Olive	-	-	-	130089



5 Thiolon XP Pro[™]: Most Durable Fibrillated Fiber Available. Period!

5.1 Engineered to Perform

Thiolon XP Pro has been specifically designed to withstand this intense use while retaining the softness and playing characteristics today's players desire. Developed with TenCate's exclusive Xtended Play fiber technology, Thiolon XP Pro is far more resistant to constant wear than any other fibrillated grass fiber available today.

5.2 Process + Pattern

Durability

Two factors set Thiolon XP Pro apart as the most advanced fibrillated fiber available today: Process and Pattern. Thiolon XP Pro is manufactured through a proprietary slit-film extrusion process and features a more narrow fibrillation pattern than other 3rd generation synthetic turf fibers. Generally designated as a "long slit" or "parallel" type fiber, Thiolon XP Pro's unique properties result in a grass fiber with enhanced durability and increased comfort and safety.

Split Resistant

Ordinary synthetic grass fibers experience secondary fibrillation or splitting as a result of normal wear. Over time, this fiber splitting can lead to a rather unnatural and worn looking surface. Thiolon XP Pro, with its long-slit pattern and patented fiber technology, resists secondary fibrillation over three times better than competitive "long slit" fibrillated grass fibers (see table below). This unsurpassed level of performance gives Thiolon XP Pro a clear advantage over all other fibrillated fibers and makes Thiolon XP Pro the ideal choice for indoor practice facilities and 5-on-5 soccer installations as well as any synthetic turf field experiencing more than thirty hours of use per week.

	THIOLON XP P	RO	Competitor /	4	Competitor B	
# OF CYCLES	Avg. Fiber Size, mm	% Original	Avg. Fiber Size, mm	% Original	Avg. Fiber Size, mm	% Original
0	1.213	100.0	1.160	100.0	1.542	100.0
2000	1.119	92.3	0.797	68.7	0.699	45.3
4000	1.119	92.3	0.645	55.6	0.444	28.8
6000	1.119	92.3	0.529	45.6	0.377	24.5
8000	1.119	92.3	0.476	41.0	0.324	21.0
10000	1.119	92.3	0.427	36.8	0.312	20.2

Lisport Studded Roll Test Data



6 Thiolon Xtreme[®]: The new Standard in Artificial Turf

6.1 Taking artificial turf to a higher level

TenCate Grass introduces a new development in artificial turf: Thiolon Xtreme[®]. This new product makes good use of the expertise and experience in sports that TenCate Grass has acquired over many years. Since the introduction of LSR[®], TenCate Grass' artificial turf has been seen as the standard for artificial turf fields. More than two years ago, Thiolon Xtreme[®] was installed as part of a pilot study in Heracles Almelo' Polman stadium. And last summer, another field was installed at the request of Ajax Amsterdam for a pitch located next to the Amsterdam ArenA. This field is used by its A-team. This season, Heracles Almelo was promoted to the Dutch Premier League. With the eyes of the football world focused on the achievements of the first club playing in the European top league on artificial turf, Heracles wanted to have the best pitch possible and one that would meet the highest requirements for quality: the FIFA 2-STAR recommendation. Once again, the playing surface selected was Thiolon Xtreme[®]. The system was further improved with Thiolon Infill.

6.2 Setting the standard for pro and amateur sports

The experiences and opinions of many players have contributed in recent years to the ongoing improvements made in artificial turf. With the experiences of Heracles Almelo in their minds, the Research & Development Department at TenCate Grass has been working in recent years on perfecting the Thiolon Xtreme[®] fiber and new production technologies. Thiolon Xtreme[®] is available as a fibrillated product (produced with new CLMT[®]-technology) and a monofilament product.

Soft

Thiolon Xtreme[®] is designed as the new standard in high quality turf: soft, sliding friendly and durable. Thiolon Xtreme[®] is softer than any other turf. This creates a softer and safer touch and feel and makes it far more comfortable to play on.

Safety & Comfort

Thiolon Xtreme[®] is developed for both comfort and safety. It makes it possible for players to make sliding tackles safely and without any risk of unpleasant skin abrasion. Thiolon Xtreme[®] meets all the requirements for optimal playing characteristics: a safe surface for turning, moving, stopping and sliding.

Durable

The increased durability is achieved by using a new patented polymer that combines a high tear resistance with a superior pile recovery and a soft appearance. Comparative tests show that Xtreme[®] is much more durable than standard polyethylene fibers.

Thiolon Xtreme[®] - the best solution for every sport field

With the look and feel of a perfect natural grass pitch (CLMT[®]), and the great sliding capabilities, Thiolon Xtreme[®] is the ideal pitch for soccer and American football. Xtreme[®] has even more advantages. Because of the durability, it is possible to have a constant playing surface for many years. Even at the most intensively used spots (goal area and penalty spot) the pitch will keep its original characteristics, ensuring the same sport technical characteristics. The ball roll and ball bounce will be optimal for years, as well as the sliding friendliness.





Cross Linked Monofilament Technology® (CLMT®)

Thiolon CLMT

The CLMT-fibrillation pattern is unique, almost immediately after installation and brushing in the infill material, the tips ("free pile") have the appearance of natural grass blades. The tips of the fibers have the soft and nice natural monofilament look; this is not the case for the lower parts of the fibers. The fibrillation pattern is kept in tact at this position, holding the infill in place.

In 2002 a test pitch was installed in Italy with a fibrillated fiber. In 2003, the first experiences with Thiolon Xtreme[®] as a "monotape" were acquired by working together with Heracles Almelo. Ajax Amsterdam requested the installation of a "monofilament" pitch next to the Amsterdam ArenA. The positive reactions from the group of Ajax players as well as the reactions from Heracles and a group of Italian players were analyzed and then resulted in a new production technology known as CLMT. The new field being used by Heracles Almelo was produced by applying this new technology.

CLMT advantages

- 1. Excellent pile anchoring
- 2. Easy installation
- 3. Natural look & feel
- 4. Encapsulates the infill
- 5. Best ball behavior (ball roll, bounce and speed)
- 6. Durability for a constant playing surface
- 7. Safety for players: stability and safe moving and turning
- 8. Easy maintenance



Optimal pile recovery after impact and long lasting ball roll performance with Cross Linked Monofilament Technology (CLMT).



8 Technical information Thiolon[®] fibers

APPENDIX 2 contains conversion formulas for your convenience.

8.1 Technical information Thiolon® PP

Fiber dimensions	Туре	РР 5000 Т	PP 6600	PP 6600 T	PP 7400	PP 8800
	Mean	5000	6600	7350	7400	8800
dTex [a/10000 m]	Min	4800	6200	7050	7000	8300
	Max	5200	7000	7650	7800	9300
	Mean	95	12	12 7	12	15
Width [mm]	Min	8.5	11	11.6	11	14
	Max	10.5	13	13.8	13	16
	Mean	63	60	63	70	65
Thickness [um]	Min	60	57	60	67	62
	Max	66	63	66	73	68
	Mean	40	35	40	35	35
Turns	Min	36	31	36	31	31
	Max	44	39	44	39	39
Fibrillation	Mean	6	6	6	6	6
Mechanical proper	ties	•		•		
Tensile strength	Mean	130	170	170	175	200
[N]	Min	105	150	150	150	175
	Mean	18	18	20	20	20
Elongation [%]	Min	14	15	16	15	15
	Max	22	21	24	25	25
	Mean	2	6.5	2	6.5	6.5
Shrinkage [%]	Min	1	5	1	5	5
	Max	3	8	3	8	8
Shrinkage Temperature [° C]		132	132	132	132	132
Texturizing		Micro	-	Macro	-	-
Operations	Mean	120	120	120	120	120
Coating Temperature I° C1	Min	110	110	110	110	110
	Max	120	120	120	120	120
Liebt feetrees	Mean	7/8	7/8	7/8	7/8	7/8
Light fastness	Min	7	7	7	7	7
	Max	8	8	8	8	8
Stitch longth	Mean	8	-	11	-	-
	Min	7	-	10	-	-
frind	Max	9	-	12	-	-

8.2 Technical information TenCate Grass North America PP

Fiber dimensions	Туре	PP 5020 Denier	PP 5700 Denier	PP 6700 Denier	PP 7600 Denier	PP 10000 Denier
	Mean	5000	5700	6700	7600	10000
Denier [g/9000m]	Min	4700	5358	6298	7144	9400
	Max	5300	6042	7102	8056	10600
	Mean	11.8	17.8	11.8	17.8	17.8
Width [mm]	Min	11.6	11.6	11.6	11.6	11.6
	Max	12.1	12.1	12.1	12.1	12.1
	Mean	51	39	69	52	69
Thickness [µm]	Min	48	36	65	49	64
	Max	54	41	73	55	73
	Mean	0	58	30	39	30
Turns	Min	0	52	26	34	26
	Max	0	64	34	44	34
Fibrillation Counts	Mean	12	20	10	20	20
Mechanical proper	ties					
Tensile strength	Mean	129	142	151	169	200
[N]	Min	89	98	107	125	156
	Mean	15	15	15	15	15
Elongation [%]	Min	12	12	12	12	12
	Max	18	18	18	18	18
	Mean	2 T	8	8	8	8
Shrinkage [%]	Min	1 T	6	6	6	6
	Max	3 T	10	10	10	10
Shrinkage Temperature [°F]		270 132°C	270 132°C	270 132°C	270 132°C	270 132°C

8.3 Technical Information TenCate Grass North America Thiolon XP Pro

Fiber dimensions	Туре	XP Pro 5,000	XP Pro 8,000	XP Pro 10,000
	Mean	5000	8000	10,000
Denier [g/9000m]	Min	4625	7400	9250
	Max	5375	8600	10,750
	Mean	6.1	9.0	12.0
Width [mm]	Min	5.9	8.5	11.5
	Max	6.3	9.5	12.5
	Mean	100	100	100
Thickness [µm]	Min	94	94	94
	Max	106	106	106
	Mean	28	28	20
Turns [T/m]	Min	22	22	16
	Max	33	33	24
Fibrillation	Mean	4	4	4
Tensile strength	Mean	49	80	98
[N]	Min	40	66	81
	Mean	75	75	90
Elongation [%]	Min	50	50	59
	Max	-	-	-
	Mean	11.0	10.0	10.0
Shrinkage [%]	Min	-	-	-
	Max	16.5	15.0	15.0
Shrinkage Temperature [° C]		90°	90°	90°
Texturizing		KdK	-	-
Coating	Mean	-	-	-
Coaling	Min	-	-	-
	Max	90°	90°	90°
Light factages	Mean	7/8	7/8	7/8
	Min	7	7	7
lpine scale]	Max	8	8	8



8.4 Technical information Thiolon LSR®

Fiber dimensions	Туре	LSR ^{®PLUS} 8800	LSR [®] 11000
	Mean	8800	11000
dTex [g/10000m]	Min	8300	10300
-	Max	9300	11700
	Mean	9	12
Width [mm]	Min	8	11
	Max	10	13
	Mean	100	100
Thickness [µm]	Min	97	97
	Max	103	103
	Mean	35	35
Turns	Min	31	31
	Max	39	39
Fibrillation	Mean	4	4
Mechanical propert	ies		
Tensile strength	Mean	100	128
[N]	Min	85	115
	Mean	40	48
Elongation [%]	Min	30	35
• • • •	Max	50	61
	Mean	3.5	4
Shrinkage [%]	Min	2.5	2.5
	Max	4.5	5.5
Shrinkage Temperature [° C]		90	90
Texturizing		-	-
Conting	Mean	90	90
Coaling	Min	85	85
	Max	90	90
Light footpoop	Mean	7/8	7/8
	Min	7	7
[Dine scale]	Max	8	8
	Mean	-	-
Stitch length [mm]	Min	-	-
	Max	-	-

Fiber dimensions	Туре	LSR [®]	^{MF} 8250	LSR®	^{IF} 11000
	Mean	8	250	11	000
dTex [g/10000m]	Min	7	650	10200	
-	Max	8	850	11	800
	Mean		1		1
Tape width [mm]	Min		-		-
	Max		-		-
	Mean	1	50	1	50
Thickness [µm]	Min	1	40	1	40
	Max	1	60	1	60
	Mean		25		25
Turns	Min		21		21
	Max		29		29
Nr of threads	#	6		8	
Mechanical properties		Straight	Multi directional	Straight	Multi directional
Tensile strength	Mean	70	90	90	120
[N]	Min	55	70	70	90
	Mean	50			50
Elongation [%]	Min		45		45
	Max		-	-	
	Mean		4	4	
Shrinkage [%]	Min		-	-	
	Max		-	-	
Shrinkage Temperature [° C]		90		90	
Texturizing			-		-
Coating	Mean		90		90
Temperature [° C]	Min		85		85
	Max		90		90
Light factness	Mean		7/8		7/8
[hlue scale]	Min		7		7
	Max		8		8
	Mean		-		-
Stitch length [mm]	Min		-		-
	Max	-		-	

8.5 Technical information Thiolon LSR^{®MT} and LSR^{®MF}

Fiber dimensions	Туре	L5 65(SR [®] D0 T	LSR [®] 7300 T	LSR [®] 9600 T	LSR ^{®MF} 12300 T
	Mean	6500		7300	9600	12300
dTex [g/10000m]	Min	6200		7000	9300	11700
	Max	68	300	7600	9900	12900
	Mean	9	.5	12.7	12.7	1.1
Width [mm]	Min	8	.5	11.6	11.6	1.0
	Max	1(0.5	13.8	13.8	1.2
	Mean	8	32	63	83	158
Thickness [µm]	Min	7	79	60	79	147
	Max	8	35	66	87	169
	Mean	e.	35	40	40	25
Turns	Min	3	31	36	36	21
	Max	60	39	44	44	29
Fibrillation	Mean	4		6	6	-
Nr of threads	#	-		-	-	8
Mechanical properties						<i>u</i>
Tensile strength	Mean	85		100	110	90
[N]	Min	75		90	100	70
	Mean	50		50	45	50
Elongation [%]	Min	4	10	35	35	45
• • • •	Max	6	60	65	55	-
	Mean	1	.5	1.5	1.5	1.5
Shrinkage [%]	Min		1	1	1	-
	Max		2	2	2	-
Shrinkage Temperature [° C]		ç	90	90	90	90
Texturizing		Micro	Macro	Macro	Macro	Macro
Conting	Mean	0,	90	90	90	90
Coaling	Min	8	35	85	85	85
	Max	9	90	90	90	90
Light factages	Mean	7	//8	7/8	7/8	7/8
	Min		7	7	7	7
	Max		8	8	8	8
	Mean	8	11	11	11	11
Stitch length [mm]	Min	7	10	10	10	10
	Max	9	12	12	12	12

8.6 Technical information Thiolon LSR[®] curled



8.7 Technical information Thiolon[®] SPF

Fiber dimensions	Туре	SPF 5000 T
	Mean	5000
dTex [g/10000m]	Min	4800
	Max	5200
	Mean	9.5
Width [mm]	Min	8.5
	Max	10.5
	Mean	63
Thickness [µm]	Min	60
	Max	66
	Mean	40
Turns	Min	36
	Max	44
Fibrillation	Mean	6
Mechanical propert	ties	
Tensile strength	Mean	120
[N]	Min	100
	Mean	20
Elongation [%]	Min	15
	Max	25
	Mean	2.5
Shrinkage [%]	Min	1
	Max	4
Shrinkage temperature [° C]		132
Texturizing		Micro
Coating	Mean	110
Coaling	Min	100
	Max	110
Light footpoop	Mean	7/8
	Min	7
[DINE SCALE]	Max	8
	Mean	8
Stitch length [mm]	Min	7
	Max	9

Fiber dimensions	Туре	Xtreme [®] 11000 Xtreme [®] 13800 Duo Tone		Xtreme [®] MF 12000	Xtreme [®] MF 16000
	Mean	11000	13800	12000	16000
dTex [g/10000m]	Min	10200	13000	11000	15000
_	Max	11800	14600	13000	17000
	Mean	9	5 + 7	1.5	1.5
Tape width [mm]	Min	-	-	-	-
	Max	-	-	-	-
	Mean	130	130	240	240
Thickness [µm]	Min	-	-	-	-
	Max	-	-	-	-
	Mean	25	25	25	25
Turns	Min	21	21	21	21
	Max	29	29	29	29
Fibrillation	Mean	CLMT [®] 1 mm	CLMT [®] 1 mm	-	-
Nr of threads	#	1	2	6	8
Mechanical propert	ies				
Tensile strength	Mean	90	95	110	150
[N]	Min	65	70	100	135
	Mean	40	30	70	70
Elongation [%]	Min	25	20	50	50
	Max	-	40	-	-
	Mean	7.2	7.2	3.0	3.0
Shrinkage [%]*	Min	-	-	-	-
Chinikage [70]	Max	-	-	-	-
Shrinkage Temperature [° C]		75	75	75	75
Texturizing		-	-	-	-
Coating	Mean	75	75	90	90
Temperature [° C]	Min	70	70	85	85
	Max	80	80	90	90
Light fastness	Mean	7/8	7/8	7/8	7/8
Light idstitess	Min	7	7	7	7
	Max	8	8	8	8
	Mean	-	-	-	-
Stitch length [mm]	Min	-	-	-	-
	Max	-	-	-	-

8.8 Technical information Thiolon Xtreme[®] CLMT and Xtreme MF

 * The mentioned shrinkage percentages of the Xtreme and Xtreme MF products are valid for coating at 75 $^{\circ}$ C. This precise coating temperature is very important for ensuring and maintaining the durable characteristics of Xtreme.



9 Thiolon[®] backing solutions

9.1 General

Ten Cate Thiobac BV, also a subsidiary of Royal Ten Cate, produces primary backings for outdoor purpose. These backings are developed for use in artificial grass carpets, especially in combination with Thiolon[®] fibers. The quality of the backing is essential for the quality of the grass-carpet.

Thiolon[®] backings for sports systems are size and form stable in length, width and diagonal for 10 to 15 years at temperatures between -20 °C and +50 °C. Thiolon[®] backings are also resistant to weather influences, such as UV light, moisture and warm / cold conditions.

Thiolon backing can be divided in three different product groups. Within each group different kind of articles can be find. These three groups are plain outdoor backing, fleeced outdoor backing and multilayer backings.

9.2 Changing to 118 threads/10 cm warp system

The warp system of Thiolon Outdoor Backing will be changed from 94- to 118-warp yarns/10 cm. This improvement started in 2005 and will be finished for all products in 2007. There are three major reasons for these import change:

- The higher number of warp yarns results in more yarn-crossings. The higher number of crossings results in better tuftlock and stitch bind;
- The new product line has a 15 % higher strength in warp direction;
- Better regularity of latex or poly-urethane absorption.

9.3 Plain outdoor backings

The following articles belong to this product group:

- P16 black/green;
- P13;
- P16;
- P10.

9.3.1 P16-black/green

This product is mainly advised for recreational applications, mostly in fine gauges like 5/32" or 3/16" and very often in combination with a high stitch rate of more than 30 stitches/10 cm.

9.3.2 P13 and P16

Most economical outdoor backings for low-budget grass systems. In sport systems never used as single layer but always in combination with other fabrics. While it is used in economical systems it is combined often with few latex or polyurethane addition. This means that the pressure load on the finished product should not be too heavy. These products are not advised to be used as an individual layer in sport-systems.

9.3.3 P10

P10 was initially used for waterbased hockey constructions but always in combination with support (polyester) fabrics. Our new product H18FLXXT is specially designed for waterbased hockey fields. In particular for constructions with a fine gauge like 3/16" or 5/32" combined with more then 30 stitches/10 cm.



9.4 Fleeced outdoor backings

9.4.1 General

Many synthetic grass producers have replaced plain outdoor fabrics by fleeced fabrics. During our more then 25 years experience with outdoor backing and particular with fleeced outdoor backing we have seen in practice several advantages of fleeced outdoor backing:

- Fleece acts as an additional reinforcement of the finished product. A sport-system with a fleeced backing as a basis is more stable than a sport system with a plain outdoor backing. We estimated higher tensile strength in sport systems with fleeced backing;
- Better adhesion of the pile to the fleeced backing;
- The hygroscopic characteristics of needled fabrics are higher, resulting in a higher absorption of latex or polyurethane;
- Less movement of warp and weft during tufting. This results in a more regular tuft patterns;
- With a soft subbase system a reliable (fleeced) backing is necessary.

The following articles belong to this product group:

- H13;
- H16;
- H10.

9.4.2 H13

H13 is mainly used in recreational systems. In dual feed primary systems, where 2 layers of outdoor backing are feed to the tufting machine, H13 could be one of the layers together with plain outdoor backing. Since we have developed a special multi-layer backing to replace dual feed or dual primary systems we like to introduce you the products D06 and D12 (paragraph 8.5.3.).



Pile side carpet grass carpet

Fleece side of backing

9.4.3 H16

H16 is mainly advised to be used in economical hockey- and tennis-constructions. The fleece side sits at the bottom; latex/polyurethane induction is put at the side of the fleece.



9.5 <u>Multi-layer backings</u>

Multi-layer backings or fabrics have been developed to satisfy the requirements of the market for yet more stable and stronger products. The majority of these products are used in infilled systems. In our product mix we distinguish three groups of multi-layer products:

- Thiobac Pro[®]: C18 and fabrics with an additional non-woven layer;
- Dual fabrics: like D12, these products consists of 2 fabric layers;
- Fabrics with an additional scrim.

9.5.1 Thiobac Pro[®] C18

The only carpet backing specially developed for high pile artificial grass systems, Thiobac Pro[®] (C08/C18: C18 is successor of C08), was introduced into the market in 2001. This unique carpet backing consists of 3 layers. The first layer is made of a polypropylene warp fiber, where a polyester weft fiber is woven in. A 50-grams non-woven layer provides the necessary dimensional stability of the backing and a third layer of needle punched fiber fleece is incorporated for additional stability.



The main characteristics of this product are:

- Non-woven is added to the construction for extra stability;
- Polyester yarn is used in the weft direction (XMD);
- Using the advantages of polyester.
 - o Lower shrinkage than polypropylene
 - o Lower creep than polypropylene
 - Higher strength than polypropylene

These characteristics can be translated in the following practical advantages:

- Stability in all directions;
- Straight lines, no line dancing;
- Good installing properties;
- No deformations as a result of temperature;
- Stronger then normal fleeced outdoor backing;
- No creep effects (deformation).

Speaking about experience and reliability: over the last 5 years more than 3.000 pitches tufted on Thiobac Pro[®] were installed!

Not recommended for fine constructions

Thiobac $Pro^{(8)}$ is not recommended for constructions with a high number of stitches (> 30 stitches/10 cm) and a fine gauge (5/16" or 5/32").

9.5.2 Explanation of creep

Unfortunately creep can occur in an artificial turf field. Creep occurs when the tension on the carpet is so high that it becomes longer after a certain time. To resist this tension a good outdoor backing is necessary. Otherwise the carpet starts to grow in horizontal direction. Polyester is a polymer that is known for its very low creep figures. For this reason C18 consists for more then 60 % out of polyester. We also use PET materials in H18FLXXT. Glass fiber also doesn't have creep effects. In our newest product G16R1 we use a glass fiber scrim to exclude creep effects.





We find out that creep occurs when there is a bad combination of:

- Bad engineered backing;
- Bad adhesion or low coefficient of friction between carpet and subbase;
- Significant height difference between the middle and the sides of the pitch (can be caused by a combination of culling and unintended or uncontrollable height differences);
- Intensive use;
- Strong player movements.

A backing is developed and intended for a certain use. Using the wrong backings can lead to serious problems. The two images below show what happens if a lower quality backing is used in severe conditions.

The left image shows a growing hockey pitch and the right image shows a soccer field with painted lines. The painted lines were applied in a straight line after which the field started to move.





9.5.3 Dual layer backings (D06 and D12)

Dual layer backings or dual fabrics are composed of 2 individual outdoor backing layers. The two layers are connected by a needling punching operation.

For example the D06 consists of 2 * P13 fabrics and the D12 is a dual layer of 2 * P16 fabrics. These dual layer fabrics are strong products with a very good tuft lock. The tuftlock of dual layer backings in combination with monofilament yarns is tremendous.

Advantages of Thiolon dual layer backings compared to using two separate roll off units are:

- Only one roll-off unit is needed saving factory space and decreasing maintenance costs;
- Eliminating tension differences decreasing downtime caused by wave profiles or folds;

 No adhesion problems between two separate layers. The latex or poly-urethane absorption only has to adhese to one layer instead of two securing a better long term quality.

9.5.4 Fabrics with additional scrim

Fabrics with an additional scrim are developed to suit the demands for high tenacity and creep resistant backing solutions. Most products are based on additional scrims made of polypropylene, polyester or glass fiber.

9.5.4.1 H16 XT

This product is mainly used in economical infill-pitches for soccer, rugby or baseball. The stability of this product is normal while the creep figures of this product are less then C18 and other products with a polyester or glass fiber addition.

9.5.4.2 H18FLXXT

This product has a polyester spunweft and a polyester scrim as an additional second layer for improved strength and creep resistance. H18FLXXT is advised for waterbased hockey pitches without the use of additional layers.

According to the standards for certification of the IRB (International Rugby Board) stability of rugby pitches can be reached with the use of H18FLXXT (when properly processed).

This product can also be used for golf-applications like tees and greens.

9.5.4.3 G16R1

The G16R1 is one of the newest products and is characterized by its glass fiber scrim. Including the glass fiber scrim into the fabric instead of adding it as a separate layer offers multiple advantages:

- Higher strength;
- Low shrinkage;
- No elongation;
- No creep.

Products with an additional glass fiber layer like the G16R1 are used for soccer fields and sometimes for hockey fields as well.

TENCATE



10 Technical information Thiolon[®] backing

10.1 P-series (plain outdoor backings)

Specifications Thiolon [®]	Туре	P13.xxx. 0044761	P16.xxx. 0044791	P16.xxx. 0044761	P10.xxx. 0040761
Weight (g/m ²]	Mean	121	102	137	155
0 .0 -	Min	115	97	130	148
	Max	127	107	144	163
Construction warp	Mean	118	118	118	94
[threads per 10 cm]	Min	117	117	117	93
	Max	119	119	119	95
Construction weft	Mean	51	63	63	79
[threads per 10 cm]	Min	50	62	62	78
	Max	52	64	64	80
Tensile strength warp	Mean	990	1050	1025	840
[N per 5 cm]	Min	891	945	922	756
Tensile strength weft	Mean	980	730	1280	1520
[N per 5 cm]	Min	872	649	1139	1353
Elongation warp [%]	Mean	15.0	19.0	22.0	15.0
	Min	12.6	16.0	18.0	12.0
	Max	17.4	22.1	25.0	18.0
Elongation weft [%]	Mean	15.0	16.0	20.0	15.0
_	Min	12.0	12.8	16.0	12.0
	Max	18.0	19.2	24.0	18.0
Shrinkage warp [%]	Mean	3.5	4.3	3.7	3.9
	Max	4.3	5.3	4.0	4.8
Shrinkage Weft [%]	Mean	2.0	2.8	2.8	1.4
	Max	4.8	3.9	3.0	2.0
Color warp	-	Black	Black	Black	Black
Color weft	-	Black	Green	Black	Black

"xxx" = width in cm

Test methods are according ISO 13934-1 standards.



10.2 H-series (fleeced backings)

Specifications Thiolon [®]	Туре	H13.xxx. 1144761	H16.xxx. 1144761
Weight [g/m ²]	Mean	121	137
	Min	115	130
	Max	127	144
Weight fleece [g/m ²]	Mean	27.5	27.5
	Min	25.7	25.7
	Max	29.3	29.3
Total weight [g/m ²]	Mean	148	165
	Min	135	156
	Max	164	173
Construction warp	Mean	118	118
[threads per 10 cm]	Min	117	117
	Max	119	119
Construction weft	Mean	51	63
[threads per 10 cm]	Min	50	62
	Max	52	64
Tensile strength warp	Mean	650	625
[N per 5 cm]	Min	525	519
Tensile strength weft	Mean	810	1000
[N per 5 cm]	Min	675	840
Elongation warp [%]	Mean	9.5	10.0
	Min	7.6	8.0
	Max	11.4	12.0
Elongation weft [%]	Mean	10.0	12.0
	Min	8.0	9.1
	Max	12.0	14.9
Shrinkage warp [%]	Mean	3.7	3.7
	Max	4.5	4.5
Shrinkage weft [%]	Mean	2.8	2.8
	Max	3.7	3.9
Color warp	-	Black	Black
Color weft	-	Black	Black

"xxx" = width in cm

Test methods are according to ISO 13934-1 standards.



10.3 C-series (Thiobac Pro® backings)

Specifications Thiolon [®]	Туре	C18.xxx. 7244P11
Weight fabric [g/m ²]	Mean	137
	Min	130
	Max	144
Weight fiber and fleece	Mean	77.5
[g/m ²]	Min	75.7
	Max	79.4
Total weight [g/m ²]	Mean	215
	Min	206
	Max	224
Construction warp	Mean	118
[threads per 10 cm]	Min	116
	Max	120
Construction weft	Mean	71
[threads per 10 cm]	Min	70
	Max	72
Tensile strength warp	Mean	900
	Min	792
Tensile strength weft	Mean	1290
[N per 5 cm]	Min	1113
Elongation warp [%]	Mean	16
	Min	11.5
	Max	20.5
Elongation weft [%]	Mean	14.0
	Min	10.7
	Max	14.7
Shrinkage warp [%]	Mean	3.5
	Max	4.3
Shrinkage weft [%]	Mean	0.8
	Max	1.1
Color warp	-	Black / anthracite
Color weft	-	Silver
Color fiber	-	Black

"xxx" = width in cm

Test methods are according ISO 13934-1 standards.

Specifications Thiolon [®]	Туре	D06.xxx. 8604091	D06.xxx. 8804091	D12.xxx. 8604041
Weight fabrics [g/m ²]	Mean	120 + 120	120 + 120	102 + 137
Weight fleece [g/m ²]	Mean	27.5	40.0	27.5
Total weight [g/m ²]	Mean	277	277	261
Construction warp [threads per 10 cm]	Mean	118	118	118
Construction weft [threads per 10 cm]	Mean	51	51	63
Tensile strength warp [N per 5 cm]	Mean	1075	1075	1100
Tensile strength weft [N per 5 cm]	Mean	1500	1500	1400
Elongation warp [%]	Mean	11.2	11.2	10.0
Elongation weft [%]	Mean	15.0	15.0	12.5
Shrinkage warp [%]	Mean	3.7	3.7	3.5
Shrinkage Weft [%]	Mean	2.0	2.0	2.2
Color warp	-	Black	Black	Black
Color weft	-	Black	Black	Black - Green

10.4 D-series (dual layer backings)

"xxx" = width in cm

Test methods are according ISO 13934-1 standards. Minimum and maximum values are still to be determined.

10.5 Fabrics with additional scrim

Specifications	Type	H16.xxx.	H18 FL	G16xxx
Thiolon [®]	Type	XT44761	XXT	R1
Weight fabric [g/m ²]	Mean	137	-	-
0 10 1	Min	130	-	-
	Max	144	-	-
Weight fleece [g/m ²]	Mean	-	28	28
	Min	-	25	25
	Max	-	31	31
Weight fleece + 2 nd	Mean	97.5	-	-
layer [g/m ²]				
	Min	95.7	-	-
	Max	99.4	-	-
Total weight [g/m ²]	Mean	234.5	272	303
	Min	225.7	259	288
	Max	243.4	285	318
Construction warp	Mean	118	118	118
[threads per 10 cm]	Min	117	116	116
	Max	119	120	120
Construction weft	Mean	63	71	63
[threads per 10 cm]	Min	62	69	61
	Max	64	73	65
Tensile strength warp	Mean	900	1525	1300
[N per 5 cm]	Min	747	1400	1100
Tensile strength weft	Mean	1150	1500	1550
[N per 5 cm]	Min	966	1300	1350
Elongation warp [%]	Mean	12.0	19.0	2.5
	Min	9.6	16.0	2.0
	Max	14.4	22.0	3.0
Elongation weft [%]	Mean	12.0	16.0	2.5
	Min	9.1	13.0	2.0
	Max	14.9	19.0	3.0
Shrinkage warp [%]	Mean	3.7	4.0	2.8
	Max	4.5	5.2	4.0
Shrinkage weft [%]	Mean	2.8	1.5	1.6
	Max	3.9	2.5	2.5
Color warp	-	Black	Black	Black
Color weft	-	Black	Black	Black

"xxx" = width in cm

Test methods are according ISO 13934-1 standards.



11 Coating of artificial grass

11.1 Coating specifications

For the coating of Thiolon[®] fibers we strongly advise to work with a lower processing temperature on the pile side of the grass carpet on behalf of uncontrolled pile shrinkage level. The different Thiolon[®] fibers show different shrinkage behavior, because of their basic polymers. Therefore we have determined the shrinkage levels of each fiber and can give advice on the processing temperature during coating.

Examples of shrinkage levels of Thiolon[®] fibers measured in 15 minutes hot air box with circulation:

Tempe	erature	PP 8800	LSR [®] 11000 LSR ^{® MT} 11000	LSR [®] 9600 T	SPF 5000 T	PP 5000T
70° C	158° F	0.5 %	2.4 %			
80° C	176° F	1.1 %	3.0 %			
90° C	194° F	1.5 %	5.0 %			
100° C	212° F	2.6 %	6.4 %	2.7 %		
110° C	230° F	3.2 %	11.6 %	10.0 %	1.1 %	0.1 %
120° C	248° F	4.4 %			1.3 %	0.2 %
130° C	266° F	6.0 %			2.2 %	0.5 %
140° C	284° F	8.6 %			5.0 %	1.7 %
150° C	302° F	16 %			11.2 %	10.7 %

"T" = Dynacurl texturized

Tempei	rature	XP Pro 5000	XP Pro 8000	XP Pro 10,000	10,800/6 Xtreme MF	Xtreme [®] MF	Xtreme [®] CLMT 130 micron
70° C	158° F	5.9	5.9	5.9		2.6 %	6.2 %
75° C	167° F	7.0	7.0	7.0		3.0 %	7.2 %
80° C	176° F	8.1	8.1	8.1		4.9 %	8.6 %
90° C	194° F	10.7	10.7	10.7		14.5 %	11.6 %
100° C	212° F	14.9	14.9	14.9			
110° C	230° F	21.6	21.6	21.6			
120° C	248° F						
130° C	266° F						
140° C	284° F						
150° C	302° F						

The advised processing temperatures during coating at the pile side of the carpet are those that result in approximately 5 % shrinkage of the Thiolon[®] fibers. These are:

Thiolon[®] PP Thiolon[®] SPF Thiolon LSR[®], LSR^{®MT}, LSR^{®MF} Thiolon XP Pro **Thiolon Xtreme[®] CLMT Thiolon Xtreme[®] MF**

120° C or 248° F 110° C or 230° F 90° C or 194° F 90° C or 194° F 75° C or 167° F 75° C or 167° F

Always check shrinkage levels in your own oven, since shrinkage is also related to the time the artificial grass spends in the oven. It is advised to run an entire field in 1 run through the oven in order to obtain a uniform shrinkage level. See chapter 21 Control Procedures.



11.2 General guidelines on coating of artificial grass with XSBR-latex

11.2.1 Introduction

Although coating is one of the last stages in the production of an artificial grass carpet, it is possibly the most critical step. Poor coating can affect the performance of the product dramatically. Poor coating is sometimes not immediately visible after processing but in such cases, problems are likely to appear after installation of the pitch. Coating is a very critical aspect of the production of artificial grass.

Below some of the major issues concerned in coating of outdoor carpet are summarized. The total process is that complex that it cannot be claimed that this is a full instruction manual, merely some important guidelines.

11.2.2 Types of latex

11.2.2.1 Ready for use latex compound

The compound must have the right viscosity, for example 8000 - 9500 mPa.s (= milli Pascal per second), measured according to test method Brookfield RVT (spindle 3, speed 4). A too high viscosity can restrict its penetration into the product. Poor penetration will influence the adhesion of the latex compound to the backing, and subsequently also the stability and the pile-lock of the carpet.

The compound itself must be waterproof; most compound suppliers have special grades with increased waterproof properties. The compound must have the right anti-oxidants to protect your product against 'aging' in outdoor conditions.

The use of a base latex with a low styrene content (< 50 %) is recommended; this should be hard enough to provide a good "hand" and be sufficiently flexible to avoid cracking.

The solids content of the latex compound should be as high as possible and will normally be, depending on the base-latex and filler-content, between 70 and 77 %.

11.2.2.2 Own made latex compound

Producing a latex-compound according to a company-own customized formula isn't that easy as it looks. Please be aware of the risks of a bad compound.

The latex must have good waterproof properties and the amount of styrene in the co-polymer should be 50 % or lower, to obtain a flexible backing of your product.

Relative low amounts of styrene in the polymer will also improve the (unwanted, but present) thermoplastic properties of the dried / cured latex.

Of course, all further specifications for latex compounds, as mentioned in paragraph 11.2.2.1, apply for own made compound as well.

11.2.3 Coating steps

In coating of artificial grass carpets with XSBR-latex compound, five major steps can be recognized:

- 1) Application
- 2) Heating to obtain a gelation
- 3) Drying out of water
- 4) Curing
- 5) Cooling

Before step 1, the application of the latex compound, it must be assured that the half-product will be delivered to the coating machine without any failures! The carpet must be lead to the applicator under low tension and diagonal tensions should be avoided!

Any failures present or caused by uneven tensions will be fixated in the coming process and can cause instant- or delayed-action dimension-stability problems in the finished product.

Thiolon

The total time for the drying / curing process is very important and depends on several factors as length of the oven, speed of the carpet, the amount of latex per square meter and the dry matter content of the latex. The latex must be dry after coating. A typical example is a $800 - 900 \text{ g/m}^2 \text{ dry}$ weight latex with an oven time of 5 - 6 minutes.

During step 2, before the gelation phase has been completed, the latex temperature must not exceed 95 °C. The oven temperatures itself could be higher but surface temperature of the latex is critical and must be carefully controlled. Use low air speeds in this phase.

If the surface of the latex compound is allowed to reach a temperature above 100 °C before the gelation phase has completed, blistering will occur. This decreases the stability of the carpet and causes reduced pile-lock.

Step 3. After the gelation of the latex, the temperature may be increased and the air speed set to maximum in order to evaporate the remaining water.

Step 4. During this stage, curing of the latex will take place. For sufficient curing, the latex should reach 110 - 115 °C for about 1.0 - 2.0 minutes. Here the same rules apply as in step 2, the oven temperature could be higher but the temperature of the latex is the important issue. Curing can only take place when water is out. Whitening of the coating by rubbing is a sign that water has not been removed from the compound.

The maximum temperature of the latex should be reached at about ³/₄ of the length of the oven.

In the final stage, **step 5**, the carpet must be cooled down. Ideally, the carpet should pass through a cooling zone where cold air is blown onto the carpet before it comes off the stenter (at the end of the stenter, depending on speed, one or two cool air blowers have to cool down the carpet). The carpet should be lead through a compensator / battery device under low tension to allow further relaxation, further cooling down and final inspection.

When the carpet is re-rolled at too high temperature relaxation problems can occur in the carpet. Temperature of the carpet should be 40 - 50 °C when it is coming off the pins of the stenter frame. A maximum temperature of 25 °C is advised before re-rolling of the carpet.

Some manufacturers use infrared (gas-heated or electrical) heating systems that are placed at the beginning of the oven. These systems are very efficient in putting energy / heat into the mass of your latex compound in the gelation phase.

Inadequate curing of the compound within the coating plant can cause other problems. In this case curing will take place gradually - at ambient temperature - and any deformation in the carpet, caused for instance during re-rolling or handling / storage, will become set into the carpet causing problems such as bubbling and poor lay flat. These deformations will be permanent and cannot be removed.

Controlling the degree of curing by assessment of the 'tack' of the dried carpet is unreliable. Such measurement is highly subjective and relies on the experience of the operator. Some producers are putting carpet samples directly into water after coating. If the backing stays black, with no white discoloration, this is an indication that curing is satisfactory. If the water stays clear, with no white discoloration (within 2 minutes), this is also an indication that curing is satisfactory. A good shape-recovery after pressure with a fingernail (thumbnail) or a knife could be used as an indicator for a sufficient cure by the machine personnel.

Important is to make quick production quality checks during production; checking the different available parameters like application weight, pile-bonding strength, pile-bonding strength after water-treatment, et cetera.



11.2.4 Equipment

Within the industry there are ovens in use with a length varying from 6 meters up to 60 meters and more. In every case the relationship between line speed and oven temperature remains highly important and of course all the different steps must be taken care of. Most artificial grass producers use an oven with a length of more then 40 meters. It is recommended to use a stenter-frame of at least 24 meters with a correct relationship between speed and oven temperature. Ideally, individual upper and lower zonal temperature control is required. This is particularly important where polyethylene and co-polymer pile fibers are used and where lower pile side temperatures are required.



The image above shows a pile side temperature of 90 °C. This temperature is based on polyethylene (LSR[®]) fibers. The recommended pile side temperature varies and depends on multiple factors. Paragraph 11.1 provides more information about advised processing temperatures for Thiolon[®] fibers.

The best way to measure the temperature of the latex is by using infrared-thermal probes (pyrometers).

For outdoor carpet, a drainage system is essential. Passing the dried carpet under a device designed to punch or to melt holes with heated metal spikes is the normal way to ensure that any water can drain through the carpet at a rate which satisfies a standard specification.

This advice from Ten Cate Thiobac BV is based on our experience in the market place. Processing conditions during coating can be influenced by many (local variables) and are the responsibility of the individual manufacturer. Therefore we can not accept any responsibility for decisions based on these recommendations.



12 Guarantee conditions

On the following pages you will find our updated, limited warranty. Please note that this warranty is only valid after returning a signed copy.

12.1 TENCATE GRASS Limited Warranty

1. <u>Limited Warranty</u>. Subject to the terms, conditions and limitations contained in this warranty certificate, TenCate Grass, a subsidiary of Royal Ten Cate NV, doing business as Ten Cate Thiolon BV and TenCate Grass North America, warrants to the person, firm or entity purchasing from TenCate Grass as indicated on the signature page hereof ("Purchaser") that under normal conditions during the applicable warranty period referred to below, the TenCate Grass products will maintain their UV stability and tensile strength. For purposes of this warranty, a Product will be deemed to have maintained its UV stability and tensile strength if the original tensile strength of the Product does not decrease by more than fifty percent. The warranty period varies by Product and geographical location of the synthetic turf installation site. A table containing the warranty period begins on the earlier of (i) the date of installation of the synthetic turf containing the Product or (ii) the date that is one year after the date of TenCate Grass' invoice for the Product.

2. <u>Remedy</u>. If a Product fails to perform as warranted during the warranty period, TenCate Grass will provide replacement Product, F.O.B. TenCate Grass' plant, for the Product determined by TenCate Grass not to comply with the above warranty, allowing the purchase price for the replacement Product multiplied by a fraction, the numerator of which is the number of months remaining in the unexpired portion of warranty period and the denominator of which is the total number of months in the warranty period. Purchaser shall be responsible for paying the portion of the purchase price for the replacement Product not allowed by TenCate Grass. TenCate Grass shall not be responsible for removal or disposal of the defective turf or manufacture or installation of new turf.

3. <u>Limitations on Coverage</u>. This warranty does not apply (i) if the Product is used for any application other than sports fields or courts or landscape applications, (ii) to any damage caused during or on account of improper processing, installation or repairs, or (iii) to the extent that any defect or damage is caused by:

- (a) Burns, cuts, accidents, vandalism, abuse, negligence or neglect;
- (b) Improper design or failure of the sub-base of the sports field or court;
- (c) Wear or abrasion caused by an inadequate sub-base;
- Use of infill products of an incorrect grade (according to FIFA accredited test institutes, such as ISA-Sport/Labosport, or other test institutes accredited by TenCate Grass);
- (e) Failure to maintain infill products at the correct level (according to FIFA accredited test institutes, such as ISA-Sport/Labosport, or other test institutes accredited by TenCate Grass);
- (f) Use of inappropriate footwear or sports equipment;
- (g) The playing surface being used other than for the purpose for which it was designed and installed;
- (h) Use of cleaning chemicals, herbicides or pesticides;
- (i) Use of improper cleaning methods;
- (j) Any harmful chemical reaction to the Product caused by infill materials;
- Acts of God or other conditions beyond the reasonable control of TenCate Grass;



- (I) Improper processing of the Product (*e.g.*, tufting, coating, texturizing or twisting);
- (m) Post fibrillation after or during installation for purposes other than to get the infill materials in place; or
- (n) Failure to properly maintain, protect or repair the Products or the turf.

All synthetic turf containing the Products is subject to normal wear and tear. Normal wear and tear is not a manufacturing defect and is not covered by this warranty. In addition to the factors mentioned above, wear and tear depends on, without limitation, the construction of the synthetic turf (fiber face weight, stitch rate, fiber pile height and gauge) and the intensity of use of the synthetic turf. TenCate Grass shall not be responsible for any warranty issued or made by Purchaser to third parties, including, without limitation, any warranty made by Purchaser with respect to the useful life of the synthetic turf containing the Products. Purchaser should carefully read the latest versions of TenCate Grass' product information materials and literature for information about optimising the performance of the synthetic turf containing the Products.

4. <u>Limitation of Liability</u>. IN NO EVENT SHALL TENCATE GRASS BE LIABLE, WHETHER IN CONTRACT OR IN TORT (INCLUDING NEGLIGENCE) OR UNDER ANY OTHER LEGAL THEORY (INCLUDING STRICT LIABILITY), FOR LOST PROFITS OR REVENUES, LOSS OF USE OR SIMILAR ECONOMIC LOSS, OR FOR INDIRECT, SPECIAL, INCIDENTAL, CONSEQUENTIAL, PUNITIVE OR SIMILAR DAMAGES ARISING OUT OF OR IN CONNECTION WITH THE USE, CONDITION, POSSESSION, PERFORMANCE, MAINTENANCE, NON-DELIVERY OR LATE DELIVERY OF THE PRODUCTS, EVEN IF TENCATE GRASS HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

5. <u>No Other Warranties</u>. THE WARRANTY PROVIDED HEREIN IS THE SOLE AND EXCLUSIVE WARRANTY WITH RESPECT TO TENCATE GRASS' PRODUCTS AND SUPERSEDES ANY AND ALL OTHER WARRANTIES, ORAL OR WRITTEN, OF ANY TYPE RELATING TO TENCATE GRASS' PRODUCTS. ANY PRODUCTS OF TENCATE GRASS NOT COVERED BY THIS WARRANTY ARE SOLD "AS IS." THE REMEDY OF REPLACEMENT SET FORTH IN SECTION 2 IS THE SOLE OBLIGATION OF TENCATE GRASS, AND THE SOLE REMEDY OF PURCHASER, UNDER THE WARRANTY PROVIDED HEREIN. EXCEPT AS PROVIDED HEREIN, TENCATE GRASS MAKES NO REPRESENTATIONS OR WARRANTIES OF ANY KIND, NATURE OR DESCRIPTION WITH RESPECT TO ANY OF ITS PRODUCTS, EXPRESS OR IMPLIED, INCLUDING, WITHOUT LIMITATION, ANY WARRANTY OF MERCHANTABILITY, FITNESS OF ANY OF THE PRODUCTS FOR ANY PARTICULAR PURPOSE OR NON-INFRINGEMENT OF THIRD PARTY RIGHTS, AND TENCATE GRASS HEREBY DISCLAIMS THE SAME.

6. <u>Notification of Claims</u>. Claims under this warranty must be submitted in writing, together with proof of turf production and installation date, name of installation company, batch and lot number, location of installation, product sample/fiber material, sample of infill material(s) and a minimum of three clear pictures showing the problem to:

Ten Cate Thiolon BV PO Box 9, 7440 AA Nijverdal The Netherlands

TenCate Grass shall not be responsible for any costs or expenses incurred by Purchaser or others with respect to any tests, inspections or consultations conducted by Purchaser or others. Claims must be submitted within 30 days after discovery of the alleged defect. Purchaser must promptly inspect all Products upon delivery. Anything herein to the contrary notwithstanding, to the extent that any defects, shortages or non-conformities in the Products are discoverable by inspection upon delivery of the Products, all obligations of TenCate Grass to Purchaser with respect to such defects, shortages and non-conformities shall be deemed to be satisfied, and all Products shall be



deemed to be free of such defects, shortages and non-conformities, unless Purchaser notifies TenCate Grass of such defects, shortages or non-conformities in writing within 30 days after the date of delivery.

7. Modifications. This warranty, together with TenCate Grass' standard terms and conditions of sale, is the complete, final and exclusive agreement of the parties with respect to the quality and performance of the Products and any and all representations and warranties concerning the Products. No dealer, sales representative or similar person has the authority to make any representations or warranties with respect to the Products, to extend any warranty period hereunder or otherwise to change, modify, amend or supplement the provisions of this warranty. None of the provisions of this warranty may be changed, modified, amended or supplemented except by a written instrument signed by an authorized representative of TenCate Grass. This warranty applies to all TenCate Grass products sold to Purchaser beginning on the date this warranty certificate is issued to Purchaser and continuing until TenCate Grass issues Purchaser a new warranty certificate signed by an authorized representative of TenCate Grass that expressly supersedes this warranty certificate in whole or in part. Any such new warranty certificate will be effective upon receipt by Purchaser. Purchaser's purchase of any TenCate Grass products following receipt of any new warranty certificate from TenCate Grass will constitute Purchaser's acceptance of the terms and conditions of such new warranty certificate.

8. <u>Waiver</u>. No failure on the part of TenCate Grass to exercise, and no delay by TenCate Grass in exercising any right, power or remedy hereunder shall operate as a waiver thereof, nor shall any single or partial exercise of any right, power or remedy by TenCate Grass preclude any other or further exercise thereof or the exercise of any other right, power or remedy.

9. <u>Governing Law</u>. This warranty and the rights and obligations of the parties under this warranty shall be governed by Dutch laws, without regard to its conflicts of laws principles. Sales of Products by TenCate Grass to Purchaser shall not be subject to the United Nations Convention on the International Sale of Goods.

10. <u>Severability</u>. If any provision or portion of any provision of this warranty shall be held to be illegal, invalid or unenforceable by a court of competent jurisdiction, the remaining provisions or portions thereof shall constitute the parties' agreement with respect to the subject matter hereof, and all such remaining provisions or portions thereof shall remain in full force and effect.

11. <u>Assignment</u>. Purchaser may not transfer, convey or otherwise assign all or any of its rights under this warranty without the prior written consent of TenCate Grass. Any such transfer or assignment by Purchaser without TenCate Grass's prior written consent shall be null and void and of no force or effect. This warranty shall inure to the benefit of and be binding upon TenCate Grass and Purchaser and their respective successors and permitted assigns. Claims under this warranty may only be made by Purchaser and not by Purchaser's customers or any other third parties.



12.2 Exhibit A to TenCate Grass Limited Warranty

Exhibit A describes the warranty on UV stability and tensile strength. For purposes of this warranty, a product will be deemed to have maintained its UV stability and tensile strength if the original tensile strength of the product does not decrease by more than fifty percent.

Solar Activity in W/m2	LSR 8000 XP Pro 5000 XP Pro 8000 XP Pro 10,000 Xtreme MF 10,800
100 - 160	11 years
161 - 200	10 years
201 - 240	9 years
241 and more	8 years

Solar activity in W/m2	10000 PP 6700 PP	5020 PP 7600 PP
100 - 160	8 years	6 years
161 - 200	7 years	5 years
201 - 240	6 years	4 years
241 and more	5 years	2 years

Solar activity of the turf installation site in W/m² is determined according to the climatic map of the world published by the KNMI, a copy of which is included in paragraph 12.3. Please be aware that TenCate Grass does not warrant wear and tear caused by any use of pitches incorporating Thiolon[®] fibers.

Everywhere, where "TenCate Grass["] is written in this warranty, this can be substituted for "TenCate Grass North America", "TenCate Grass EMEA" and "TenCate Grass Asia" where applicable.

Explanation of tensile strength

The tensile strength of a fiber is the maximum force that can be put on the fiber just before it breaks. In the usual tensile test, a sample of fiber is clamped in the tensile tester. The fiber is then slowly stretched until it breaks. While doing this, the force needed and the length of the fiber sample are continuously recorded. After the fiber breaks, the maximum force in the experiment and the maximum elongation is determined from the recorded data.

The tensile strength does not give any information about the hardness or softness of the fiber. As explained above, the tensile strength and elongation only give information about the breaking point of a fiber. A separate figure which tells something about the fiber is needed when there is only a small deformation. This number is called the modulus, and it can also be determined using the same test.





12.3 Annual average global radiation in W/m²

13 Guidelines for normal use of artificial turf incorporating Thiolon[®] fibers

13.1 Wear and tear and life expectancy

Like all products, Thiolon[®] fibers are subject to wear and tear. The life expectancy of artificial grass fibers is dependent on the intensity of use of artificial turf, as well as on local climatic conditions. The more a field is being used, the quicker its lifetime will pass. The intensity of use is a combination of several factors including the usage in hours per day, the number of people that sport or play (simultaneously) on the pitch, the type of sport or play and the type of footwear that is used.

Other factors determining the life expectancy of Thiolon[®] fibers are:

- Type of fiber (polymer type, thickness)
- Density of the artificial grass carpet (number of tufts or weight per square meter in reality)
- Quality of manufacturing of the artificial grass carpet
- Chosen sand and/or rubber grade
- Level of the sand and/or rubber infill (and thus the free pile height of the fibers)
- Quality of installation
- Quality of infrastructure
- Maintenance of the pitch, including the use of chemicals (detergents)

13.2 Rubber-infill pitches

Since the introduction of rubber-infill pitches, TenCate Grass has been monitoring the use and wear of these pitches. In addition, extensive research has been done on the effects of the abovementioned factors on the wear and tear of rubber-infill pitches. The following guidelines are the results from this experience and research:

Type of fiber

For rubber-infill pitches, TenCate Grass strongly advises to use LSR[®] fibers with a thickness of at least 100 microns. The use of PP fibers or LSR[®] fibers with a lower thickness, has a negative effect on the life expectancy of a rubber-infill football pitch. The reasons for this are the following:

- PP fibers are unsuitable for rubber-infill pitches, due to their inferior wear properties in high-pile systems
- PP fibers lack sliding friendliness
- Thicker fibers are better resistant to wear and tear and are more UV resistant

Tuft settings

A minimum of 8400 tufts per m² should be used.

Total pile height

The pile height should be between 35 and 75 mm (between 1 3/8 and 3 inches).

Infill height and free pile height

For the best performance of a rubber-infill pitch, a free pile (the height of the fibers above the infill) to a maximum of 15 mm (5/8 inch) is required. This in order to prevent the players from playing on the sides of the fibers, in stead of on the fiber tips.

If the free pile height exceeds 15 mm (5/8 inch), the artificial grass fibers will be exposed to heavier use that will accelerate the wear of the artificial grass field drastically.

TENCATE



Footwear

Appropriate footwear should be used. This means that the players should wear studded sole shoes or shoes with so-called "blades".

Using shoes with flat soles or other inappropriate footwear will accelerate the wear of the artificial grass field drastically.

Field size

Full-size fields should have a minimum size of 5,500 square meters (60,000 square feet).

Downsizing an artificial grass field to for example 600 square meters (6,500 square feet), quite common for 5-a-side or 7-a-side soccer fields, will accelerate the wear of the artificial grass field drastically (depending on the available field size per player).

Field size per player

Each player should have at least 125 square meters (1,350 square feet) available. This measurement is easily calculated by dividing the effective playing area by the number of players.

Decreasing the available field size per player, e.g. during training exercises, or by increasing the number of people using the field simultaneously, will accelerate the wear of the artificial grass field drastically.

Intensity of use

30 hours per week are to be considered as normal use (based upon a field size per player of at least 125 square meters (1,350 square feet)).

Increasing the intensity of use will accelerate the wear of the artificial grass field drastically.

Once again, please be aware that TenCate Grass only warrants UV stability and tensile strength, not wear and tear!

13.3 Influences of rubber infill materials on artificial grass fibers

A number of aspects of rubber infill materials can negatively influence the quality of artificial turf:

- Wear and powdering of the rubber;
- Morphology of the rubber;
- Particle size distribution of the rubber.

Based on these aspects, following guidelines have been set for rubber infill materials:

- The wear may not be higher than 250 mm³ (according to ISO 4649) to prevent powdering of the rubber and compaction;
- The roundness of 10 random rubber particles should at least be 0.70;
- The particle size should lie between 0.25 and 3.0 mm.

More detailed information about rubber infill materials and an explanation of the guidelines mentioned above can be found in paragraph 14.3.





14 Information on infill materials

14.1 Sand infill material; when a tiny sand granule becomes big

The quality of sand-filled pitches stands or falls with sand quality. TenCate Grass regularly inspects the various components of an artificial grass pitch. A very important component is the type of sand infill granules. These are small elements with a diameter of barely 1 mm. Something we don't normally think about when it comes to the quality and durability of (semi) sand-filled pitches, but the quality of such a pitch heavily depends on the quality of the sand used.

14.1.1 Fractions

Filcom BV in The Netherlands have been supplying quality sand world-wide for more than 25 years in various fractions (sizes) for a number of applications in artificial grass pitches. Depending on the sliding properties and stability requirements, different fractions are used. Artificial grass football pitches, for example, require finer sand than hockey pitches. Refer to the pictures below.



Football

Tennis

Hockey

14.1.2 Requirements

Not just any sand can be used for sand-filled artificial turf. It must meet a number of requirements. The roundness of the granule is an important feature. It has a direct effect on the splitting behavior of the grass fibers. When the sand granule has sharp edges, it can cut into the grass fibers and causes the fiber to split. Even the best grass fiber can split under the influence of sharp sand granules. Another important feature is the splittability of the sand granules: the less the sand splits, the fewer sharp particles among the granules. Another requirement is that the sand should not contain too much chalk. This could produce excessive powder causing the artificial grass pitch to become too compact. In addition, excessive chalk produces a dull-colored artificial grass pitch.



An ideal round grain of sand





The combination of quality sand and Thiolon[®] fibers is characteristic of quality and durability.

14.3 Requirements of rubber infill materials

14.3.1 Extractable, leaching components

The processing oil can leach out of the rubber. In laboratory tests, these oils can be extracted from the rubber. Apart from the extracted quantity, the type of extracted (leachable) component is also important.

Tests in the Thiolon[®] laboratory showed that SBR rubber showed a weight decrease of 5.3 % after extraction. The extracted material is brown and consists of aromatic and naphthenic oil. The EPDM rubber showed a weight decrease of 9.6 % after extraction. The extracted material is transparent and consists purely of paraffin oil.

Tests on the effect of these oils on the artificial grass and its life expectancy show no negative effect of any of these oil types on Thiolon[®] LSR[®] fibers.

For the latest information about these effects, if any, on the environment and personal health, refer to the news section of our website: <u>http://www.thiolon-grass.com</u>.

14.3.2 Wear and powdering of the rubber

Both EPDM and SBR rubber are originally manufactured for a different use. Car tires are manufactured to resist extensive and long use. EPDM infill material is made especially for the use in artificial grass. Consequently, SBR rubber has a higher resistance to wear and tear.

Both rubber types were submitted to a standardized wear test (ISO 4649, in which standardized sandpaper is used to determine the wear of the material).

	SBR rubber	Commercial EPDM	Commercial EPDM Pro
Wear [mm ³]	120	737	523
Material density [kg/l]*	1.17	1.54	1.33
ISO 4649 wear norm [mm ³]		250	

The higher density of the EPDM rubbers is due to the different amounts of filler material that are used in the rubber.



14.3.3 Morphology of the rubber

All rubber infill material that is currently used is made by shredding. The rubber particles made by this process generally look rather irregular, but can usually be recognized as either spherical or baculiform.

Lisport[®] tests showed that baculiform particles generate more wear of the artificial grass then "normal" spherical particles. In order to judge the shape of rubber particles, we can calculate the "roundness". The roundness can be calculated as follows.

Smallest particle dimensionRoundness= Largest particle dimension

In the close-up image of a rubber particle, the red lines represent the smallest particle dimension and the blue lines represent the largest dimension.

In this particular case, the smallest dimension is 1.12 cm and the largest is 1.23 cm (in reality, image is not on scale). The roundness is 0.91.

Analyze at least 10 rubber particles this way. The average roundness should be at least 0.70 to make sure that the particles are round enough to have no negative influence on the life expectancy of Thiolon[®] fibers.

Make sure that the intended rubber infill material is tested on roundness before applying it to the installed pitch.

14.3.4 Particle size distribution of the rubber

The particle size distribution is analyzed using a laboratory sieve installation with different sieve sizes. It is important that the quantity of small particles is very low. Small particles cause the rubber infill to compact leading to a hard non-permeable layer. The number of large particles should be limited as well.

A lot of rubber samples show a distribution of particle sizes between 0.75 and 2.0 mm.

Thiolon[®] advises to use rubber particle that show a distribution of particle sizes between 0.25 and 3.0 mm. An infill rubber with these particle sizes can be considered as a good quality infill material.

Make sure that the intended rubber infill material is tested on particle size before applying it to the installed pitch. The particle size should lie between 0.25 and 3.0 mm. Particles smaller then 0.25 mm are considered as dust and can build a health risk.

Chemicals within rubber infill materials could affect the UV stability of artificial grass fibers, especially that of PP fibers. Thiolon LSR[®] and Xtreme[®] are significantly more resistant, but it is not excluded that chemicals in the rubber infill material, which are outside our control, can affect these fibers. Ten Cate Grass cannot be held responsible for any chemical reaction between fibers and infill material.





TENCATE



15 Ten Cate Thiolon BV ISO 9001 certificate

Quality control ISO 9001: 2000

All raw materials and products of Ten Cate Thiolon BV are subject to random checks before, during and after the production process due to our quality system according to ISO 9001: 2000. Optimum quality makes Ten Cate Thiolon BV the ideal partner for the sports field industry, guaranteeing an excellent product, already for more than 20 years. A full color copy of our ISO 9001: 2000 certificate can be found below.



Integral publication of this certificate and adjoining reports is allowed.



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16 Ten Cate Thiobac BV ISO 9001 certificate

Quality control ISO 9001: 2000

All raw materials and products of Ten Cate Thiobac BV are subject to random checks before, during and after the production process due to our quality system according to ISO 9001: 2000. Optimum quality makes Ten Cate Thiobac BV the ideal partner for the sports field industry, guaranteeing an excellent product, already for more than 20 years. A full color copy of our ISO 9001: 2000 certificate can be found below.





17 Environment

Thiolon[®] fibers (produced in The Netherlands) are made out of raw materials that do not contain any color pigments based on heavy metals. Thiolon[®] fibers may be used anywhere and without any restrictions in sensitive areas.



The use of pigments without heavy metals has been possible for some time, but at the expense of the color fastness and lifetime. Since 1992 however, TenCate Grass has found the natural balance between environmental and quality requirements. Thiolon[®] fibers are easy to recycle based on the character of polyolefins.

In order to determine the concentrations of heavy metals in the Thiolon[®] fiber styles (produced in The Netherlands), Dr. Grunder from the Institute for Ecological Building Products has performed tests to measure the heavy metal concentrations. The requirements are based on the LAGA norm, which is a very strict German norm. The results are listed below:

Heavy metal	Unit	Thiolon [®] PP	Thiolon LSR [®]	Thiolon [®] SPF	Thiolon Xtreme®	NORM
Lead	mg/kg	< 3	< 3	< 3	< 3	85
Cadmium	mg/kg	< 0.3	< 0.3	< 0.3	< 0.3	0.8
Chromium total	mg/kg	0.8	1.9	1.0	6.4	100
Copper	mg/kg	24	18	32	18	-
Mercury	mg/kg	< 0.2	< 0.2	< 0.2	< 0.2	0.3
Zinc	mg/kg	4.4	5.3	5.0	9.4	140
Tin	mg/kg	< 5	< 5	< 5	< 5	-

'<' Means that the measured value is below the detection limit of the measuring device.

These measurements confirm that TenCate Grass uses pigments and materials without heavy metals.

Besides the absolute concentration of heavy metals it is also important to know to which extent the present heavy metals are leachable. Dr. Grunder also measured this. The results can be found on the next page. The requirements are based on the DIN 18035-7 norm.



Heavy metal	Unit	Thiolon [®] PP	Thiolon LSR [®]	Thiolon [®] SPF	Thiolon Xtreme®	NORM DIN 18035-7
Lead	mg/l	0.010	0.012	0.009	< 0.005	≤ 0.04
Cadmium	mg/l	< 0.0005	0.0011	< 0.0005	< 0.0005	≤ 0.005
Chromium total	mg/l	< 0.005	< 0.005	< 0.005	< 0.005	≤ 0.05
Copper	mg/l	< 0.01	0.05	< 0.01	0.05	-
Mercury	mg/l	< 0.0002	< 0.0002	< 0.0002	< 0.0002	≤ 0.001
Zinc	mg/l	0.01	0.27	0.02	0.094	≤ 3.0
Tin	mg/l	< 0.005	< 0.005	< 0.005	< 0.005	≤ 0.05

'<' Means that the measured value is below the detection limit of the measuring device.

These measurements confirm that Thiolon[®] fibers (produced in The Netherlands) may be used anywhere and without any restrictions in sensitive areas.



18 Ten Cate Thiolon BV ISO 14001 certificate

Environmental standard ISO 14001: 2004

All raw materials and products of Ten Cate Thiolon BV are subject to random checks before, during and after the production process due to our quality system according to ISO 14001: 2004. Optimum quality makes Ten Cate Thiolon BV the ideal partner for the sports field industry, guaranteeing an excellent product, already for more than 20 years. A full color copy of our ISO 14001: 2004 certificate can be found below.



KEMA Quality B.V.

ir. P.J.J.G. Nabuurs Managing Director

Integral publication of this certificate and adjoining reports is allowed.

drs. A. Diedering Certification Manager

SCCM.

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<u>19</u> Important product information

19.1 Resilience

In the product range of TenCate Grass there are, apart from different colors and dTex, also differences in width and thickness. The thickness varies roughly from 50 μ m to 250 μ m. The choice depends on the type of sports, but also the pile characteristics for bringing in sand or rubber. For rubber-infill playing surfaces for example, TenCate Grass advises to use LSR[®] 11000 dTex with a thickness of at least 100 - 150 μ m for good playing characteristics and easy rubber and sand infill. Thicker fibers also are better resistant to wear and tear and more UV resistant. It will therefore increase the life span of your artificial grass system compared to identical systems that are made with similar, but thinner fibers.





60 µm, PP 6600 dTex

19.2 Maintenance

Every artificial grass system requires maintenance. Although, compared to natural grass fields, an artificial grass field requires less maintenance, a maintenance free artificial grass field is an illusion. The manufacturer and/or the installer of the artificial grass system are responsible for sound advice to end-users for adequate maintenance information. A solid maintenance program will increase the life span of your artificial grass field and provide a longer period of consistent playing characteristics of the field.

Maintenance of artificial grass is a very specialized job. Besides, it is hard to generalize when it comes to maintenance as there are multiple factors that determine the type of maintenance and the frequency of maintenance, including:

- Construction of the pitch, its sub-base and its surroundings;
- Weather conditions: wet or dry, high or low temperature, etc.;
- Frequency and intensity of use: hours per day, number of players per square meter.

For these reasons and the fact that maintenance procedures are upgraded continuously because of constant developments in artificial grass, TenCate Grass can not advise any type of maintenance in this Technical Information Manual. A lot of very detailed information about maintenance of artificial grass pitches is available at most installers, specialized maintenance companies and international sports associations.



20 TenCate Grass Research and Development Department

20.1 Introduction

TenCate Grass has been leading the field for years with the best artificial grass fibers for numerous sporting applications. One of the reasons behind this success is the emphasis TenCate Grass places on Research & Development (R&D).

In the past 30 years, developments have gone from changing elements like color and dTex to new polymers such as those being applied in grass fibers like Xtreme[®].

20.2 Laboratory

The Thiolon[®] laboratory comprises a section containing testing equipment used for conducting all kinds of tests in the field of synthetic fiber technology. A mechanical testing bench, an FTIR, a DSC and an MFI enable us to examine the material up to molecule detail, and to calculate all heat influences. The mechanical part of the laboratory consists of synthetic fiber processing machinery such as an injection molding machine and a lab extruder. Taber and Lisport[®] tests are also conducted in the laboratory.

These tools enable the R&D department to conduct extremely accurate trials and tests according to international standards like **DIN**, **CEN** and **ASTM** and to give the correct advice in the development and manufacturing of new products.

20.3 When new products are born

The development process of a new fiber can normally take up to 3 years. When the R&D department starts a new development in consultation with the client, a model is built for processing purposes, prior to producing a first batch of fibers. A computer model can provide a good prognosis, which means we do not need to test 25 different polymers before getting a good result. This model is used to produce a number of test fibers. The test fibers are tested in the laboratory of TenCate Grass for UV stability and color fastness in the Weather-O-Meter test machine combined with tensile strength testing.

This represents the <u>first step</u> in the development process of a new product.

20.3.1 Fiber testing: UV stability, color fastness and Weather-O-Meter tests

Unstabilized polyolefins become brittle after exposure to UV light and loose their strength. Therefore it is necessary to stabilize our fibers with UV stabilizers. TenCate Grass tests its fibers on UV stability and UV resistance in the Weather-O-Meter (WOM), a machine that simulates a fastened outdoor exposure. The tests are done according to the **DIN EN ISO 4892-2** and **ASTM G151 (G155)** standards.







The Weather-O-Meter exposes the fibers in cycles with artificial sunlight and rain. Every 1,000 hours the tensile strength of the fibers is measured, and the reduction in tensile strength is calculated. The fibers may not exceed 50 % reduction after 4,000 hours in the WOM.

As soon as the fiber has passed the trials (6,000 hours, 9 months) in the WOM test and has succeeded to pass the subsequent tensile strength test, a limited number of fibers are tufted for initial carpet performance tests.

This represents step two in the development process of a new product.

20.3.2 Carpet testing: Taber and outdoor exposure tests

The Taber test is used to determine the resistance to wear of tufted materials (only samples with a low pile height can be tested on the Taber abrader). The Taber abrader is a standardized method, which measures the wear according to **DIN 53754** and **ASTM D3884**. A sample is placed on a rotating disk and two roughened wheels are placed on top of the sample with a defined force. The wheels make a combined roll-slide movement over the surface of the sample. The loss of mass is determined after 2000 rotations and presented as promillage loss of the original sample weight.

Besides laboratory tests of the fibers in the Weather-O-Meter, tests of tufted carpet samples are done by means of outdoor exposures in three different places in the world:

- In Arizona where it is hot and dry
- In Florida where it is hot and humid and
- In Nijverdal where it is cold and wet.

These outdoor exposures give us a good reference on the UV resistance of our fibers and the tufted carpets.



Outdoor exposure in Florida, USA

As soon as the tufted carpet samples have past the Taber tests and outdoor exposure tests, the carpet undergoes a next series of tests where interactions between grass fiber, carpet backing and infill material are analyzed.

This represents step three in the development process of a new product.

20.3.3 Top layer testing: Lisport[®] and Sunbed test

The Lisport[®] test (developed by Labosport) or stud roll test gives a visual indication on how an artificial grass carpet will age in time as a result of the usage by the players on the field.



For this test a sample of artificial grass will be filled in with rubber and/or sand and two heavy rolls equipped with numerous studs, the same studs that are used on regular football shoes, will roll back and forth over the filled in artificial grass.



To avoid reoccurring impact on exactly the same places, the rolls move with different speeds and at the same time the artificial grass is moved slowly from left to right. Research done by Labosport showed that on sand filled samples, 2.000 cycles of the Lisport[®] tester represent a physical aging of 5 to 6 years and on rubber filled samples, 5.000 cycles represent a physical aging of 4 to 5 years. TenCate Grass always tests samples for a duration of 10.000 cycles in steps of 2.000 cycles.

Since 2004, the R&D department uses a sunbed tester to test interference between grass fibers, carpet backing and infill materials (especially rubber infill).

This ability to test the interference between the grass fibers, the carpet backing and the infill material is not the only advantage of the sunbed tester. The other big advantage is that we can test the interference between influences of UV light and usage of the top layer. Two test protocols are used on the sunbed tester. The first protocol prescribes alternating the sunbed and Lisport[®] test. This is done until the sample passes 5.000 hours



Sunbed tester

on the sunbed test and 10.000 cycles on the Lisport[®] test. The other protocol prescribes a full 5.000 hours on the sunbed test after which the sample is tested for 10.000 cycles on the Lisport[®] test. This way we can test the top layer of an artificial grass pitch and make sure that the grass fibers and carpet backing are not influenced nor damaged by the infill material.

After completing the above mentioned three steps in the development of a new product, the stage has been reached that a first test field can be installed. After the installation, testing does not stop. Testing and monitoring the installed field is a big part of the overall testing protocol used by the TenCate Grass Research and Development Department.



This represents the fourth step in the development process of a new product.

20.3.4 System testing: Field testing and monitoring

What is particularly important for the R&D department is that new and existing products are tested on their performance. For that reason, the R&D department developed their own in field testing equipment in co-operation with an engineering company. This resulted in 3 patented professional test apparatus'. Tests are done to evaluate player - field interaction, ball - field interaction as well as player - ball - field interaction.

With this test equipment, the R&D department performs tests in situ according to the newest international standards for testing artificial grass pitches and surfaces. This assures continuous feedback from praxis and thus enabling TenCate Grass to keep feeling with what is "happening out there". This test equipment assures that TenCate Grass stays ahead. The test equipment and its packaging is designed to be used around the world under all circumstances.



Thiolon[®]'s patented test equipment: linear friction, computer, shock absorption and rotational friction (from left to right)



User feedback: grip, ball behavior and shock absorption (from left to right)

In concordance with testing with the Thiolon[®] test equipment we use feedback from users of our systems to evaluate the performance and user friendliness of the pitch. Using professional questionnaires, interviews (done by professionals like Dutch TNO Industrial Technology and Spanish IBV Research Institute) and equipment, we try to get an objective user opinion about various aspects of the field, like grip, ball behavior and shock absorption. The user feedback is integrated in the total evaluation of an artificial grass pitch making it possible to improve existing products and develop even better products in the future.



The R&D department also disposes off it's own Artificial Athlete for testing characteristics of artificial grass installations according to DIN 18032-2 and DIN 18035-6.

As part of the development process of new products, a large number of sports fields using synthetic fibers from Thiolon $^{\mbox{\tiny B}}$ are regularly tested with the Thiolon[®] test equipment as well as monitored with a videoscope to get a detailed picture of the grass fiber condition on the playing surface. This way of working assures that we can always follow up new developments with a number of years monitoring on the ground. One thing we have learned in recent years is that fiber quality alone does not give the full picture. The manufacturer of the artificial grass, for example, has a very important role to play. So does



Artificial Athlete

the sports field construction firm. For this reason, we keep a very close eye on what happens to the grass fibers after they leave the factory of TenCate. The product is therefore carefully monitored at the installation stage and during the period of use in various types of sport.

20.4 External testing

It is vital that new and existing products are not only tested on their performance both internally, but also externally. To achieve this, the R&D department works closely together with a number of recognized institutes.

In the environmental tests, these institutes apply the strictest European standards. We have passed these tests without any problems in recent years, both in relation to the leaching of heavy metals and in field burning trials at the end of the life span.

The technical and sports technical standards are tested by bodies such as the Byggforsk, CST, FIFA, ISA Sport (NOC*NSF), Labosport, SKZ, UEFA and the American Synthetic Turf Council (STC). These are all prestigious institutes which have expert knowledge of the requirements placed by users in each country.



21 Control procedures of delivered Thiolon[®] fibers

Optical inspection after tufting

After each delivery of Thiolon[®] fibers (please note the batch number and lot number on the boxes and inside the cones), the first meters of the tufted artificial grass carpet must be inspected in full width on the floor, irrespective of whether the Thiolon[®] fibers are tufted by TenCate Grass' direct customer or by a contracting firm that is tufting for our direct customer. The ultimate inspection can be done after the sample has been coated in full length and width.

Optical inspection after heat steam treatment

The tufted artificial grass carpet must be inspected before and after heat steam treatment. For the respective coating temperatures, please see the advised processing temperatures in chapter 11 of this information manual. During this inspection, all irregularities must be listed in order to eliminate the risk of second choice material before actual production has started. Especially with larger production runs we therefore advise the tufter to recheck point 1 (optical inspection after tufting) the moment a new production shift is taking over from the previous production shift.

If an artificial grass carpet is to be made of a Thiolon[®] fiber style with (Dynacurl) texturizing, the first meters of every lot must be submitted to a heat steam process (98 °C, 15 minutes) and inspected afterwards. This is necessary to be able to check the consistency of the Dynacurl effect of the fibers and the lots.

Thiolon[®] fiber styles with (Dynacurl) texturizing must be processed within 6 months after the TenCate Grass production date to avoid risks of alterations in shrinkage characteristics.

Inspection of actual production

If, from the perspective of its intended use of the carpet, no irregularities have occurred, tuft production can be started. A tufted roll must at all times be inspected quickly and accurately in full width on the floor, and marked "inspected by ... ; date ... ; time ...".

Defects

The moment defects are discovered, production must be stopped, and TenCate Grass must be consulted.

Presentation of samples in case of defects

In the event of defects, the coated and heat steamed sample must be shown to our staff, clearly identified with all TenCate Grass batch and lot data.

Color consistency - guarantees and responsibilities

We can say that we devote a great deal of care and expense on the color consistency of batches supplied by TenCate Grass. This means that we guarantee color consistency within the batches. However, although an optimal color consistency between batch numbers is aimed at, it can not be guaranteed 100%. Therefore, before taking responsibility of mixing material of different batch numbers for one and the same contract / project, coated versions of the tufted material must be placed next to each other and compared carefully.



22 Recommendations for the handling of Thiolon[®] backing

22.1 Introduction

Transport and storage of primary backing can seriously influence its quality and condition. Using the guidelines for handling rolls of Thiolon[®] outdoor backing below, an important step can be taken to ensure that optimum condition of the rolls is maintained.

22.2 Storage methods

The method of storage is critical towards maintaining rolls of backing in prime condition. Incorrect storage methods can introduce faults into the fabric which later cause problems in the finished carpet.





Rolls should be arranged in a pyramid as shown in the diagram, so that the sides of the two rolls below it equally support each roll.

When rolls are not placed directly on top of each other, the rolls may become distorted. Similarly, the weight of a large roll that is insufficiently supported may cause it to deform. In either case these deformations can transmit through to the finished carpet.



Storage against pillars causes deformations



Rounded plates for fixation of rolls

Rolls should be stored on an even surface. Uneven surfaces such as an unprepared floor can cause localized pressure on the fabric. Care should also be taken to avoid storing rolls against sharp edges of pillars or pallets etc. This also can cause damage as a result of pressure and may result in faults within the finished carpet.



To stabilize stacks of rolls, the use of rounded plates as can be seen in the right hand picture above is recommended. Accurately placed, rounded plates minimize distortion due to pressure. Rolls should be stored indoors in a dry environment. Fleeced products in particular are sensitive to moisture or high humidity, this can influence processing of the carpet. For example on the coating line, more water has to be dried out.

The Ten Cate Thiobac BV cardboard backing tubes have an internal diameter of 120 mm and an external diameter of 144 mm.

22.3 Transport

During transport, the design of a forklift or boom-truck and the way of handling can influence the quality of primary backing.

It is essential that a boom of adequate length is used when lifting rolls. In general its length should be no less than 80 % of the roll length. This means that a 4.20 meters wide roll should be lifted with a boom of no less than 3.40 meters and the boom should be fully inserted into the core of the roll. Rolls with a width of 5.20 meters can have a weight up to 900 kg (1980 lbs), so it is important to use a truck with sufficient lifting power that is designed to handle this type of material. At the widest point the boom has a diameter of 95 mm.



When a roll is lifted, care should be exercised not to push against the core of the roll. This can cause movement of the core and "coning" of the fabric. This can also occur if the roll is lowered to the ground when the boom truck is still moving. The outcome is that the roll is no longer wound straight, which can influence the quality of for example, tufted lines in the carpet. For this reason use of a soft block of rubber at the end of the boom is recommended, this absorbs the shock when the truck picks up a roll. The rubber block also protects the end of the core of damage.

Use of a boom that is slightly flattened at the end simplifies lifting of rolls (see right picture).



Soft rubber block on forklift truck



Boom has a flattened tip



APPENDIX 1 USEFUL CONTACTS

TenCate Grass EMEA Ten Cate Thiolon BV PO Box 9 7440 AA Nijverdal The Netherlands Telephone : +31 548 633 944 Fax : +31 548 633 372 E-mail : thiolon-info@tencate.com

TenCate Grass North America

1131 Broadway Street Dayton, Tennessee 37321-1802 United States of America Telephone : +1 423 775 0792 Fax : +1 423 775 5813

Ten Cate Thiobac BV PO Box 9 7440 AA Nijverdal The Netherlands Telephone : +31 548 633 944 Fax : +31 548 633 399 E-mail : backing-info@tencate.com

TenCate Grass Asia

Ten Cate Thiolon Asia Suite 3205, The Center 99 Queen's Road, Central, Hong Kong Telephone : +852 2280 4616 Fax : +852 2295 0323

www.thiolon-grass.com www.thiolon.cn www.tencate.com

Sand suppliers

Filcom BV P.O. Box 9 NL-3350 AA Papendrecht The Netherlands www.filcom.nl

Installation and maintenance equipment suppliers

Charles Lawrence International Ltd Jessop Way, Newark Nottinghamshire NG24 2ER England www.clgplc.co.uk

Redexim Charterhouse Kwekerijweg 8 3709 JA Zeist The Netherlands www.redexim.com

SMG GmbH Robert Bosch Strasse 3 D-89269 Vöhringen Germany www.smg-gmbh.de



Glue & seam tape suppliers

Forbo Genderen BV Hoofdstraat 46 NL-4265 HL Genderen The Netherlands www.forbo.nl

Synthetic Surfaces Inc. P.O. Box 241 Scotch Plains, NJ 07076, USA www.nordot.com

Unipro BV Postbus 33 NL-7480 AA Haaksbergen The Netherlands www.unipro.nl

Test institutes

ISA Sport Papendallaan 31 Postbus 302 NL-6800 AH Arnhem The Netherlands <u>www.isa-sport.com</u>

IBV Parque Tecnológico de Valencia Avda. Juan de la Cierva, 24 Apartado 199 E-46980 Paterna, Valencia Spain www.ibv.org

Labosport Technoparc du Circuit des 24 heures Chemin aux Boeufs F-72100 Le Mans France www.labosport.com

Byggforsk Forskningsveien 3b P.O. Box 123 Blindern N-0314 Oslo Norway www.byggforsk.no

Süddeutsches Kunststoff-Zentrum (SKZ) Frankfurter Strasse 15/17 D-97082 Würzburg Germany www.skz.de



TNO Industrial Technology P.O. Box 6235 NL-5600 HE Eindhoven The Netherlands www.ind.tno.nl/en/index.html

Federations

FIFA Fédération Internationale de Football Association FIFA-Strasse 20 P.O. Box 8044 Zurich Switzerland www.fifa.com

FIH Avenue des Arts 1, Bte 5 B-1210 Brussels Belgium www.fihockey.org

ITF The International Tennis Federation Bank Lane Roehampton London SW15 5XZ United Kingdom www.itftennis.com

UEFA Route de Genève 46 CH-1260 Nyon Switzerland www.uefa.com

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APPENDIX 2	CONVERSION FORMULAS

Celsius to Fahrenheit:	(1,8 x °C) +	(1,8 x °C) + 32		
Fahrenheit to Celsius	<u>°F - 32</u> 1.8			
Grams to Ounces	1 G	= 0.0353 Oz		
Ounces to Grams	1 Oz	= 28.350 G		
Kilograms to Pounds	1 KG	= 2.2046 LB		
Pounds to Kilograms	1 LB	= 0.4536 KG		
Centimeters to Inches	1 CM	= 0.3937 IN		
Inches to Centimeters	1 IN	= 2.54 CM		
Meters to Yards	1 M	= 1.0936 YD		
Yards to Meters	1 YD	= 0.9144 M		
Meters to Feet	1 M	= 3.281 Feet		
Feet to Meters	1 Foot	= 0.3048 M		
Square Meters to Square Yards	1 M ²	= 1.1960 YD ²		
Square Yards to Square Meters	1 YD ²	= 0.8361 M ²		
Square Meters to Square Feet	1 M ²	= 10.764 Feet ²		
Square Feet to Square Meters	1 Feet ²	= 0.929 M ²		
Grams per Square Meter to Ounces per Square Yard	1 G/M ²	= 0.0295 Oz/YD ²		
Ounces per Square Yard to Grams per Square Meter	1 Oz/YD ²	= 33.91 G/M ²		

The following Internet sites also offer a huge number of (metric to imperial) conversion formulas:

- <u>www.sodsolutions.com/turfmgt/metric.html</u>
- http://website.lineone.net/~cspsweb/siinfo.htm



APPENDIX 3 TENCATE GRASS TRIAL FEEDBACK INFORMATION FAX

Return to:	Ten Cate Thiolon [®] BV
	R&D Department
Fax no.	+31 548 633 398

Trial reference:	Batch number:		
	X-number:		
	Date:		

Issues	Answers / remarks
1. Product use / sport	
2. Gauge	
3. Stitches	
4. Pile length	
5. Face weight	
6. Tuft backing/coating	
7. Tuftability	
8. Coating result / optics	
9. Location of project	
10. General remarks	
11. Evaluation trial	
12. Reference sample sent to:	Ten Cate Thiolon [®] BV R&D Department PO Box 9 7440 AA NIJVERDAL THE NETHERLANDS
13. Conclusion:	

APPENDIX 4 REGISTERED BRAND NAMES AND BRAND NAME USE

TENCATE

niolon

Thiolon®

Polyloom[®]

LSR[®] (Lower Sliding Resistance[®])

Arena Grass[®]

Xtreme[®]

CLMT[®] (Cross Linked Monofilament Technology[®])

Thiobac®

Thiobac Pro[®]

All these names are registered brand names of Royal Ten Cate NV. Use of brand names, product names and company information without approval of Ten Cate Thiolon[®] BV is prohibited. If approved, third parties should always indicate the fact that they are using a trademark registered by Royal Ten Cate NV or its subsidiaries and use a proper form (Initial capitals) and spelling. Our guidelines for proper trademark use apply equally to business documents; correspondence; advertisements; promotional material; displays; packaging; product labels; signs; dictionaries; Web pages, and other media, containing, discussing, or describing, marks. The list is not exhaustive; whenever you are in doubt about how to use a trademark properly our trademark officer should be consulted.



APPENDIX 5 DISCLAIMER

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