ATARFIL geomembranes

ISO 9001
ISO 14001
BUREAU VERITAS Certification

CE
1349-CPD-014
06
EN 13361, EN 13362, EN 13491, EN 13492, EN 13493

ATARFIL TM/TMT

Raw Material	High Density Polyethylene

ATARFIL TM/TMT is a **structured geomembrane** manufactured from maximum quality high density polyethylene resins.

ATARFIL TM/TMT contains 97,5% of pure polymer, and approximately 2,5% of Carbon Black, antioxidants and thermal stabilizers. The product does not contain plasticizers or fillers that can migrate over time.

The geomembrane **ATARFIL** TM/TMT is manufactured under rigorous quality controls.

Surface	TM Structured 1 side TMT Structured 2 sides	**Surface**	**Black**
		RAL Code	-

	Tested Property	Unit	Test Method	Value
Raw Material Identification	Density of Raw Material	g/cm^3	UNE EN ISO 1183-1	≥ 0,932
	Density of Geomembrane	g/cm^3	UNE EN ISO 1183-1	0,946 ± 0.004
	Melt Flow Index	g/10 min	UNE EN ISO 1133 D Condition (190ºC/2,16 Kg)	≤ 0,40
			UNE EN ISO 1133 T Condition (190ºC/5 Kg)	≤ 1,30
	Carbon Black Content	%	ASTM D 4218	2,0 - 2,5
Durability	Oxidative Induction Time (OIT)	min	UNE EN 728 (200ºC)	> 100
	Stress Crack Resistance/NCTL (1)	h	ASTM D 5397	≥ 400
	Oxidation	%	UNE EN 14575	≤ 15

	Tested Property	Unit	Test Method	Value
Functional Properties	Low Temperature Brittleness (tª: -40ºC)	-	UNE EN 495-5	No cracks
	Water Permeability	m^3/m^2·day	UNE EN 14150	< 1·10^{-6}
	Coefficient of Linear Thermal Expansion	1/ºC	ASTM D 696	2,15·10^{-4}
	Water Absorption	%	UNE EN ISO 62 (24h)	≤ 0,1
			UNE EN ISO 62 (6 days)	≤0,1
	Thickness of Coextruded Layer	%	UNE EN 1849-2	-
	Asperity Height	mm	ASTM D 7466	≥ 0,90

(1): NCTL is conducted on representative smooth membrane samples

	Tested Property	Unit	Test Method	Value				
Strength Characteristics Quality of Final Product	Thickness	mm	UNE EN 1849-2	1.00	1.50	2.00	2.50	3.00
	Confidence level 95%	%	-	Tolerance: ± 6				
	Confidence level 90%	%	-	Tolerance: ± 4				
	Tensile Properties (*)							
	Tensile strength at Yield	N/mm	UNE-EN ISO 527 (Type 5)	18 (16)	27 (24)	36 (32)	45 (40)	54 (48)
	Elongation at Yield	%		12 (9)				
	Tensile strength at Break (**)	N/mm		32 (26)	48 (39)	64 (52)	80 (65)	96 (78)
	Elongation at Break (**)	%		800 (700)				
	Tear Resistance	N	ISO 34-1	140 (135)	210 (202)	280 (270)	350 (337)	420 (405)
	Puncture Resistance (**)	KN	UNE-EN ISO 12236	3,0 (2.5)	4.5 (4.0)	5.5 (5.0)	6.5 (6.0)	6.8 (6.5)
	Exploding Resistance	%	pr EN 14151	< 15				
	Dimensional Stability	%	UNE EN ISO 14632 (100°C, 1h)	± 1,5				

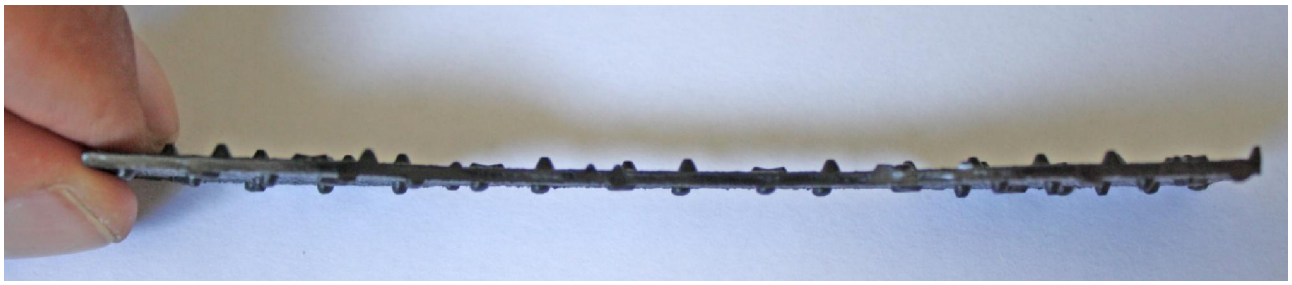
		Parameter	Units	1,00	1,50	2,00	2,50	3,00
181111	PRESENTATION (Standard Sizes)	Roll width	m	6	6	6	6	6
		Roll Length	m	140	115	100	85	60
		Surface	m^2	840	690	600	510	360

(*)Values indicated are MEDIUM. In brackets values with 95% confidence level.
(**) Values obtained from the smooth part of geomembrane. See Data Sheet.

Headquarters: Ctra. de Córdoba, Km 429 - Complejo El Rey – E-18230 Atarfe – GRANADA – SPAIN – Tel.: +34 958 439 200 – Fax: +34 958 439 128 – www.atarfil.com

Textured membranes exist in the market to fulfill a clear need:

> The friction angle of any area lined by a smooth geomembrane, be it protected or not by a geotextile, is some 8 - 10°, thus in situations where a geomembrane must be laid on a slope with a greater angle and a layer of earth must be spread over it some slipping will occur.



One solution (technically not the only one) is to cover the surface of the membrane with a textured finish to increase the friction angle to levels of 30 to 35° which are generally the naturally occuring friction angles of soil. This is typical in landfill capping and it is obvious that the textured finish should be permanent as the application requires long term stability. There are currently **three processes for obtaining a textured finish** within the industry. These all have similar friction angles but with some noteable differences:

- ***"Structured Geomembrane".*** Only suitable for calandered production, the textured finish is obtained by using a roller indented with the finish desired by the manufacturer, normally this finish is patented. Texturing obtained in this way is very regular,indelible, definite and will always remain a part of the membrane throughout its lifespan. (see photo above)

- ***"Sprayed Geomembrane (Sand-paper o Spread-on)".*** The texture is obtained by spraying particles onto a smooth membrane which was manufactured in another machine and thus has cooled. Evidently, the regularity of the surface and the consistency of the product are not as high as those of the first example and the long term durability cannot be assured due to the possibility of the texturing particles separating from the membrane. Furthermore, the friction depends on the gr/m2 of the sprayed material. To ensure sufficient adhesion in the production process, the system requires that the material sprayed on to the cold surface of the base material should be softer than the base material (if this is high density the resulting disparity is that the sprayed on material is not). Furthermore the material is covered and submitted to a strong impact , degrading its properties and in consequence creating serious doubts as to its long term durability.

> Atarfil holds two patents for both geomembrane texturing systems; TMT being the first and TXT the second although in 2006 it was decided that the second should be discontinued due to its obvious disadvantages.

- ***"Blown Geomembrane (Textured Blown-film)".*** Only used in the blown film production system, the textured effect is obtained by placing onto the surface, during fabrication a fine layer of material which contains a sealed gas within it (usually nitrogen). When this gas comes into contact with air it exits the covering material violently, creating peaks in the surface and thus a rough surface. The finish is permanent as in the first example, though the regularity is greatly inferior. Its principle disadvantage is a double one: on the one hand, it is impossible to guarantee the minimum thickness of the geomembrane due to the irregularity of the bubbles and on the other hand the mass which is now dissipated by the bubbling loses its properties dramatically.

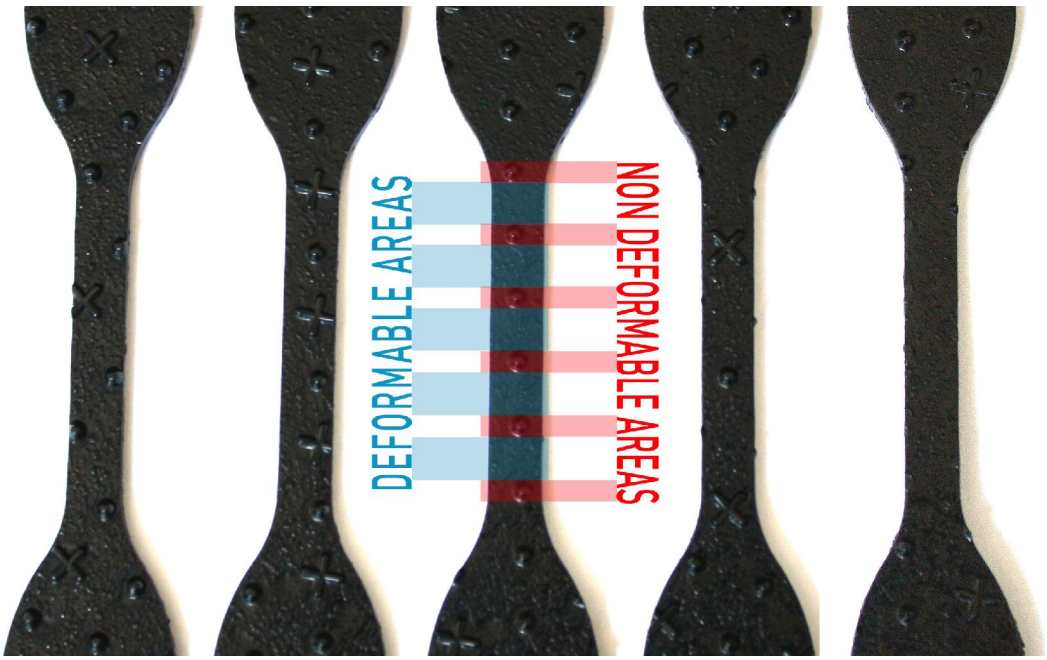
Properties of Geomembranes with a Textured Surface

The characteristics of a textured surface greatly affect certain physical properties of the geomembrane, such as elongation at break. This is expressed by "Werner Muller" in his book titled: **"HDPE. Geomembranes in Geotechnics"**, and particularly in chapter **6.2** ***Test on Textured Geomembranes***, where he writes:

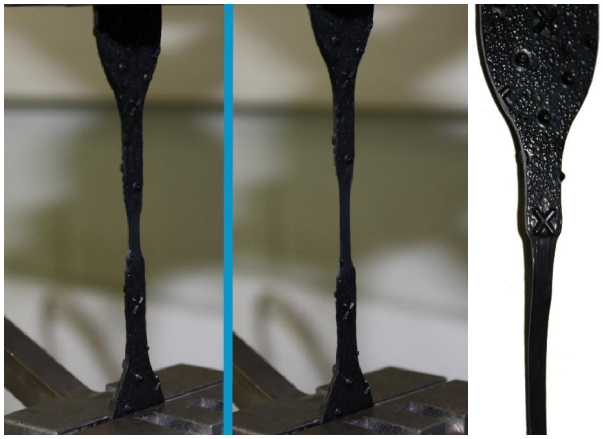
> "Textured HDPE geomembranes must agree in all substantial mechanical properties, such as yield stress, elongation at yield and arc elongation at break un burst testing within the typical variation of the measured values with those of the smooth geomembrana from the same resin. However, the achievable elongation at break is closely linked to the kind of surface texture. Depending upon the texture it can decrease very strongly. However, since elongations at break are never relevant for practical applications, this does not represent any reduction in performance quality...."

Thus he concludes that the **values of tensile strength at break have no practical relevance nor are they bound to the quality of the product**. This is as it should be as the changes in properties are more ficticious than real.
The norms in use for obtaining the arc tensile strength-elongation of a geomembrane are designed for smooth membranes. They are all based around a sample cut into the form of an hour glass with one part which is where the actual testing takes place. The two wider ends are where the sample is fixed by clamps to the test machine. The extensometer is placed in the calibrated area of the sample at a width dependant on the norm: 25mm between points when applying the EN ISO 527 Norm (applicable in Europe) and 33/50mm if the test is according to the ASTM D 6693 Norm (applicable in the USA).

It is evident that the "texturing bumps" which are within the calibrated zone are basically a thickening of the membrane which will not deform in the same way as the rest, they are hard areas of between 2 and 4 mm in length which will not deform (see photograph).



The result is that the initial theoretical distance of 25mm - 33/50mm becomes significantly reduced and this reduction depends on the number of "bumps" within the calibrated zone of the sample. As the result is given based on the initial value of 25mm 33/50mm the final deformation at break is greatly inferior to that of a smooth product which is used as a reference. Moreover, the values vary greatly as there are no two samples which are the same. We arrive at an inconsistency where the more bumps the product has due to the producers wish to offer a superior level of friction, even though this signifies a higher cost due to greater quantities of raw material used, the lower the results obtained for resistance and elongation at break.



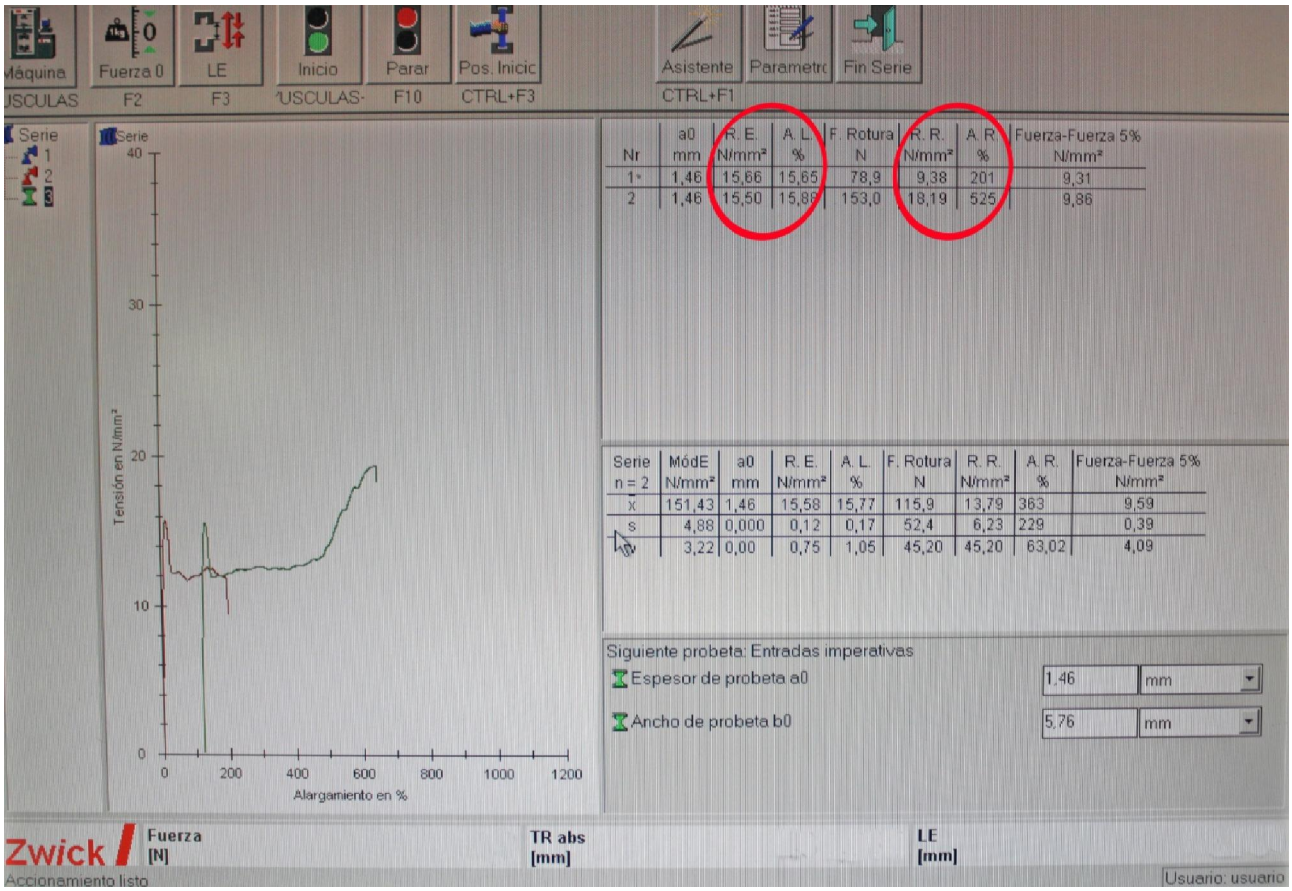
Naturally, the effect of a reduced elongation is more apparent in materials of high density which have a greater crystallinity and less for thinner materials with a lower crystallinity, such as linear or low density polyethylene.

It is also less apparent if the texturing bumps are smaller however then, clearly the material has a lower performance.

Thus we return to the obvious conclusion that the lower the quality of the texturing, the better the results obtained for elongation at break. Basically, the smoother the membrane the more similar are its resistances.

This discrepancy is removed if the bumps can be removed in a way that does not affect the surface of the sample. In this situation the results return to being very similar to those of a smooth membrane (in both regularity and magnitude).

Nevertheless it is possible to evaluate the transformation quality of these geomembranes. Returning to Mr Mullers book, he clearly establishes that other physical properties such as elongation at yield, tensile strength at yield and exploding resistance are NOT influenced by surface type and as such ARE relevant. This can be seen on the photograph which shows the results of two tests on textured material where the break parameters (Elongation AR and tensile strength RR) vary greatly whereas those obtained at yield (Tensile strength RR and elongation AR) do not.



From the point of view of International Norms, the only one which has minimum requirements that must be fulfilled by textured membranes is that published by the "Geosynthetic Research Institute", in particular the "GRI Test Method GM13", titled: *"Test Properties, Testing Frecuency and Recommended Warranty for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes"*. In **table 2(b).** *High Density Polyethylene (HDPE) Geomembrane-Textured*, it establishes the values that should be fulfilled (Tensile Strength at Break ≥700% for smooth liners and ≥100% for textured liners), and as can be seen, corroborates the reasoning expressed by Werner Muller, requiring, from textured geomembranes, values far below those of a smooth membrane in tensile strength and elongation at break.

Nevertheless, it is a fact that the GRI Norm is directed at textured products produced through the blown film method which are a majority in the USA, but in Europe are non-existent or only have a token presence. In this case the limitation to elongation at break is established to limit an excess mixture of nitrogen air bubbles and plastic mass which could cause very low results, this not being due to the reason previously mentioned of bumps in the area being tested but because of the real degradation of the geomembranes base material.

The different certifications and/or European norms run along similar lines:

- **CE marking:** No requirements. The product Atarfil TMT holds this certification
- **BAM Certification, Germany**: Establishes exceptions for textured membranes in respect to the tests of Tensile strength at break, Elongation at break and dimensional stability for smooth membranes.
- **Dibt Certification, Germany**: No requirements for tensile strength at break nor for Elongation at break. The product Atarfil TMT holds this certification.
- **Kiwa Certification**: Evaluates in detail the performance of each product prior to certification. The product Atarfil TMT holds this certification.
- **Asqual Certification**: Does not have requirements for Tensile strength at break nor for Elongation at break.
- **Spanish, Italian, UK and Scandinavian Norms**: Have not regulated these products.