Advanced Thin Film Geomembrane Technology

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Introduction

- Many geomembranes are used in exposed applications, the ability to resist UV degradation is an important performance property.
- In the past long term exposed service warranties have been limited to relatively thick materials such 1.5 or 2.0 mm thick High Density Polyethylene (HDPE).

Introduction

- The goal of our study was to develop an additive package of antioxidants and UV stabilizers that would allow a thin film polyolefin geomembrane (0.75 mm), to outperform a 1.5 mm HDPE geomembrane in a prolonged UV exposure.

Introduction

- HDPE geomembranes are stabilized with 2 to 3% carbon black alone.
- Our developmental thin film geomembrane would be stabilized with carbon black, or titanium dioxide, in combination with a proprietary blend of UV stabilizers & antioxidants.

Introduction

- To evaluate the performance of the tested geomembranes an accelerated weathering study was conducted for 20,000 hours.
- To relate the accelerated study to real life exposed service conditions, a six year natural weathering study was run concurrently.

Accelerated Study

- The accelerated weathering study was run using a QUV/SE model Accelerated Weathering Tester, operated in accordance to ASTM G154.
- Based on the experience of others in the weathering of highly durable geomembrane samples, it was decided to use aggressive weathering conditions.

Accelerated Study

- UVB bulbs were used for the exposure, with an irradiance setting of 0.80 $W/m^2/nm$ (measured at the peak wavelength of 313 nm).
- A cycle of 8 hours UV exposure at 60 C, followed by 4 hrs condensation exposure at 50 C was used for the first 10,000 hours of the study.

Accelerated Study

- For the second 10,000 hours of the study a cycle of 10 hours UV exposure (at 60 C), followed by 2 hours condensation exposure at 50 C was used.
- The change in weathering cycle was made because we showed no deterioration in the 1.5 mm HDPE or our highly stabilized 0.75 mm samples after 10,000 hours.

Natural Weathering Study

- Geomembrane samples were placed at an angle of 3 horizontal to 1 vertical, facing south, on the roof of the Layfield building in Edmonton, AB, Canada.
- The sample were removed after 5 or 6 years of natural weathering.

Relating the Natural and Accelerated Studies

- In order to use the data from the accelerated studies to quantify weathering warranties for our thin film geomembranes, some sort of approximate relationship had to be established.
- We decided to compare the two exposures based on a total energy approach, and test the resulting relationship by comparing the results for similar materials used in the natural and accelerated studies.

Relating the Natural and Accelerated Studies

- For a total energy calculation we looked at energy between 300 and 320 nm.
- This approach ignored the energy below 300 nm which is present in the UVB radiation used for the accelerated study. This energy is not present in sunlight and therefore we could not think of a way to include it in our comparison.

Relating the Natural and Accelerated Studies

- 300 nm is considered to be the most damaging wavelength for polyethylene (Searle,1999)
- For our calculation we used 4,640 MJ/m^2/year as the average irradiance hitting a horizontal surface in Edmonton per year (Mazria, 1979). The total irradiance between 300 and 320 nm was considered to be between 0.6% (ASTM G154, 1998) and 0.1% (Grossman,1977).

Relating the Natural and Accelerated Studies

- Based on our calculation we determined that one year of natural weathering was roughly equivalent to between 200 and 1000 hours of our accelerated exposure.
- For purposes of quantifying warranties we used to most conservative measure of 1000 hours accelerated exposure roughly equating to 1 year of natural weathering in Edmonton.

Relating the Natural and Accelerated Studies

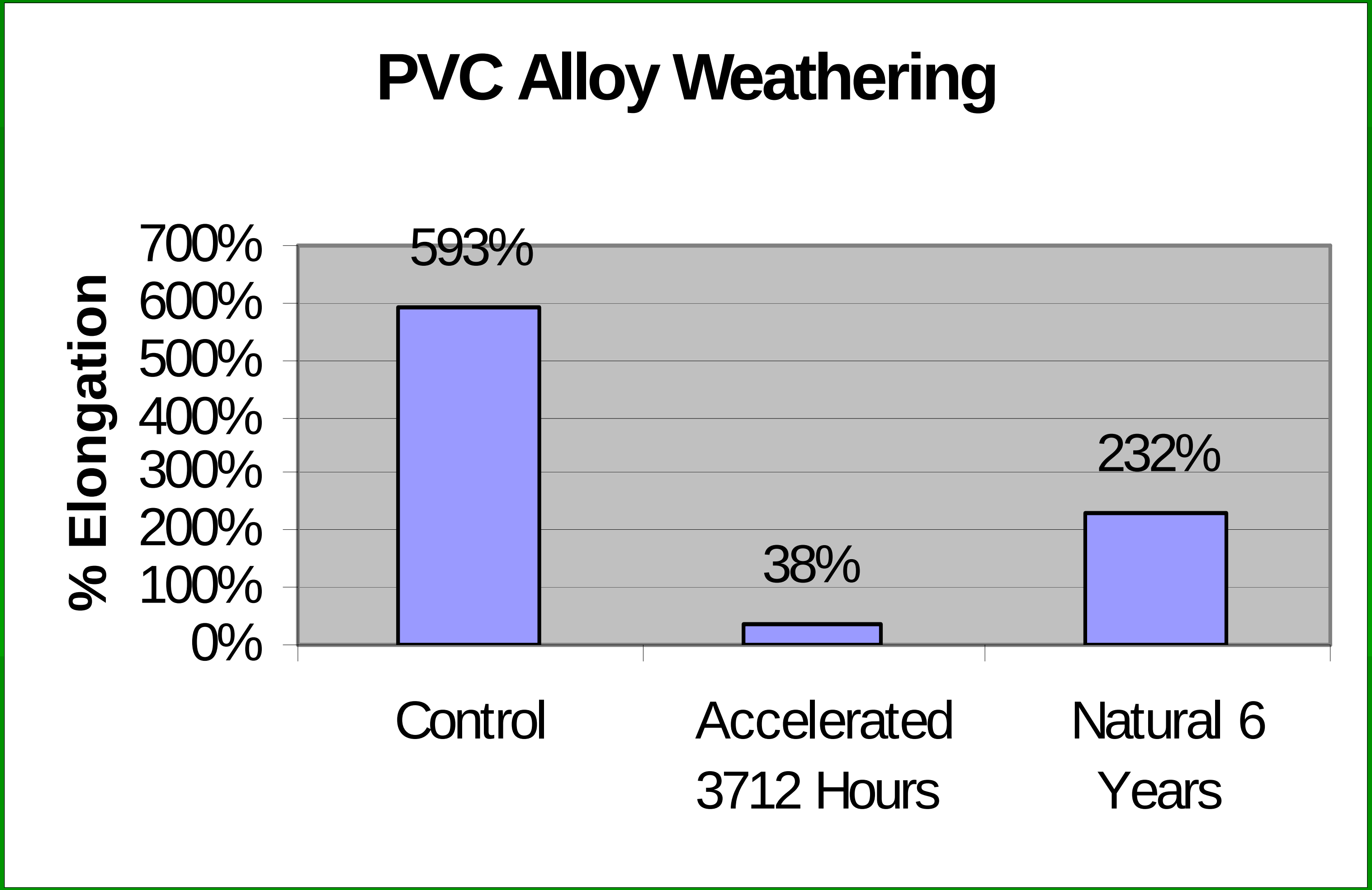
- Wagner and Ramsey (2003) of GSE make reference to a loose correlation used in the paint and coatings industry of 500 to 1500 hours of accelerated exposure equating to one year of natural weathering.
- We were in the middle of this correlation.

Relating the Natural and Accelerated Studies

- To test our calculated relationship we used samples of PVC based materials which were included in the natural and accelerated weathering studies.
- The HDPE and polyolefin samples could not be used for a meaningful test, as they showed no signs of degradation after 6 years of natural weathering, and after 15,000 hours of accelerated wathering

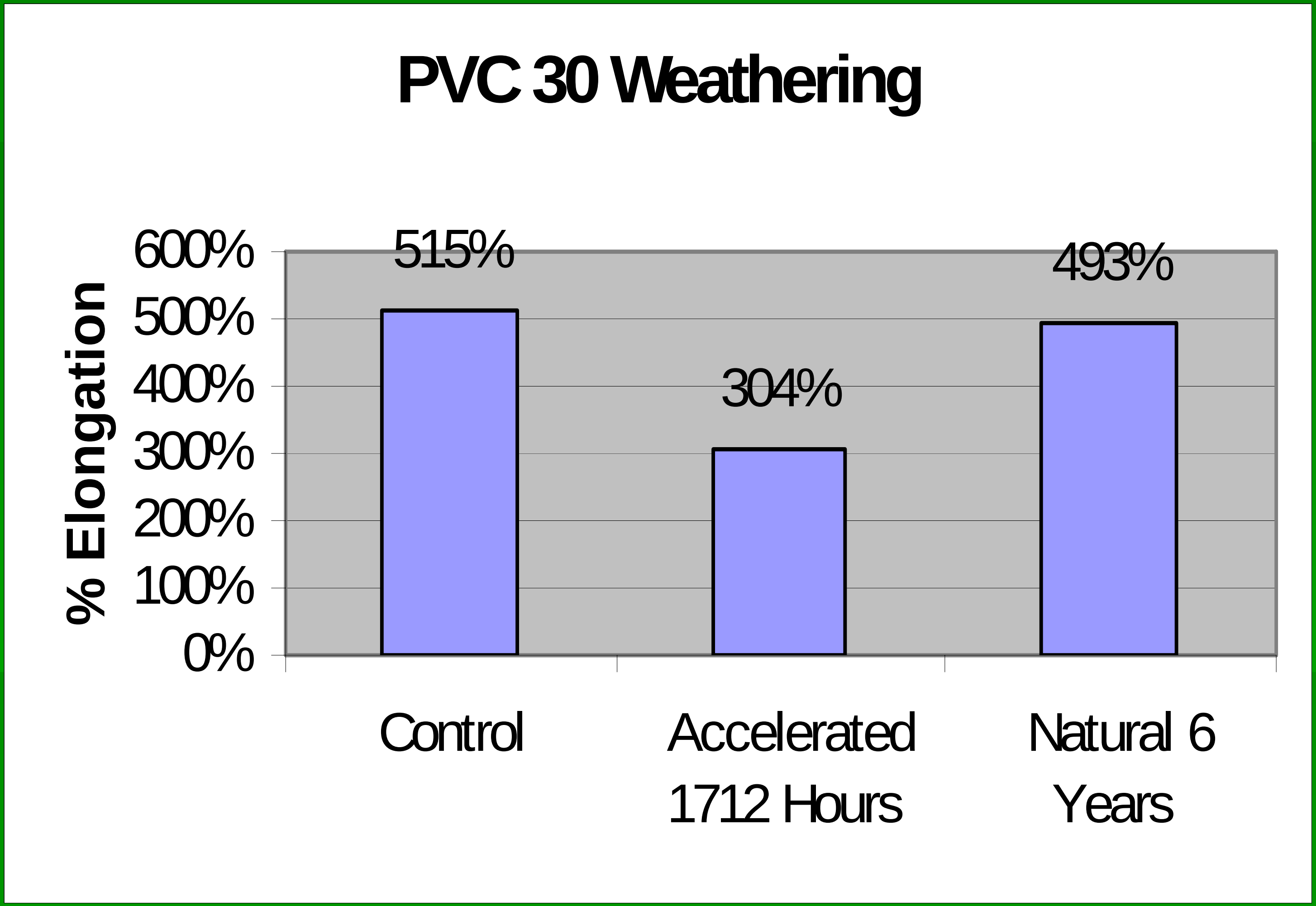
Relating the Natural and Accelerated Studies

- In the first case a PVC alloy was tested for the loss of properties after 6 years of natural weathering and 3712 hours of accelerated weathering.
- The loss of elongation at break was greater in the accelerated exposure, showing that our 1000hours/1 year relationship was conservative.


PVC Alloy Weathering
% Elongation
700%
600%
500%
400%
300%
200%
100%
0%
593%
38%
232%
Control
Accelerated 3712 Hours
Natural 6 Years

Relating the Natural and Accelerated Studies

- In the second comparison a PVC 0.75 mm geomembrane was tested for loss of properties after 1712 hours of accelerated exposure, and 6 years of natural exposure.
- The 1712 hours of accelerated exposure was found to be slightly more damaging, again suggesting that in reality 1000 hours of our accelerated exposure was equivalent to more than one year of natural weathering.


PVC 30 Weathering
% Elongation
600%
500%
400%
300%
200%
100%
0%
515%
304%
493%
Control
Accelerated 1712 Hours
Natural 6 Years

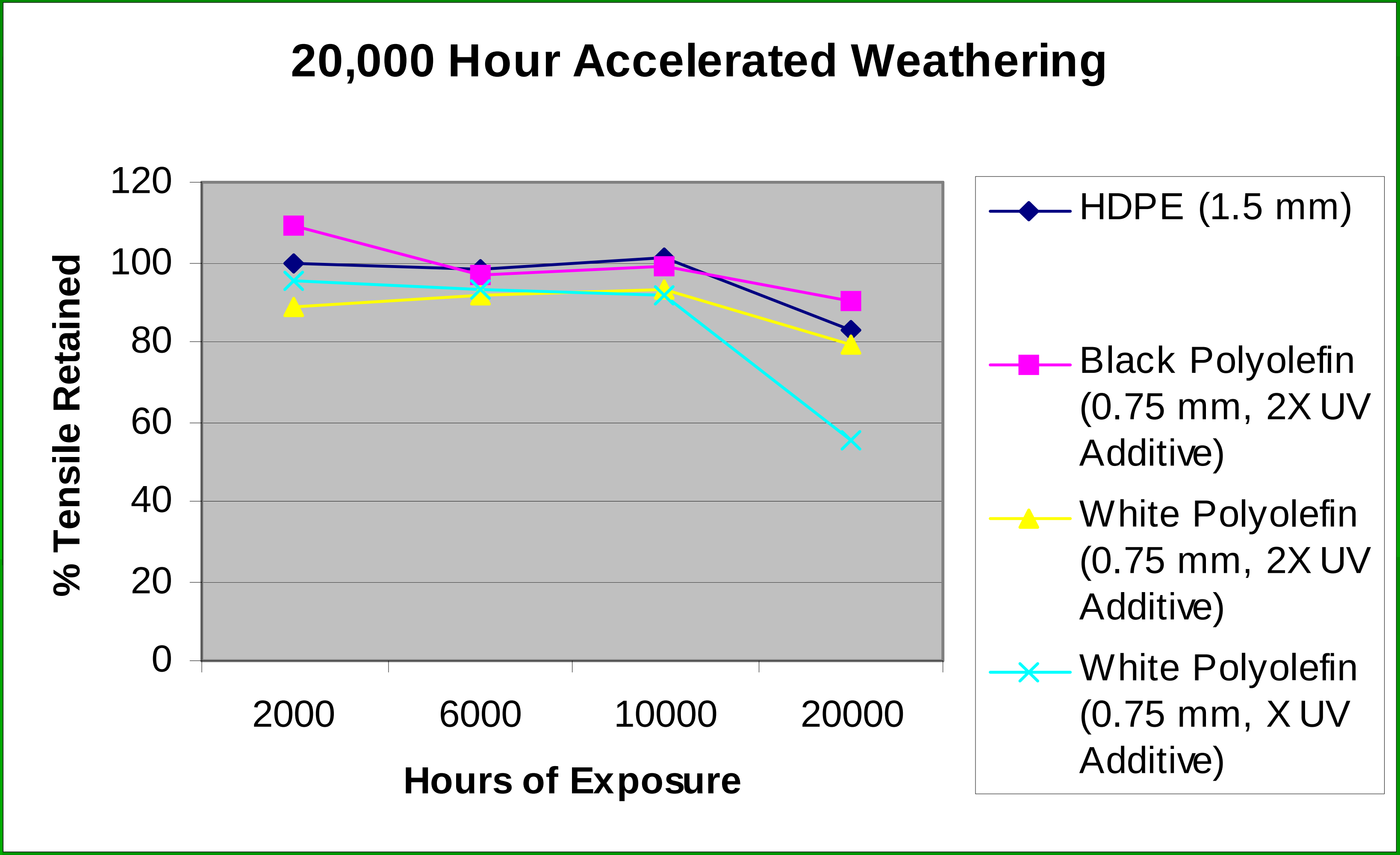
Results of Accelerated Study

- The samples exposed to the accelerated weathering study were tested for a loss of properties after 2000, 6000, 10,000 and 20,000 hours of exposure.
- HDPE samples were tested according to ASTM D638.
- The white and black polyolefin samples were tested according to a modified version of ASTM D882 (the sample width was narrowed to ¼” to increase the number of tests)

Description of Samples in the Accelerated Weathering Study

Material	Thick-ness (mm)	Titanium Dioxide/ Carbon Black (%)	Baseline Antiox-idant (OIT)	Additional Antioxidant Estimated (HPOIT)	Additional UV Stabilizer (ppm)
HDPE	1.5	2 to 3	100 Minutes	No Additonal A/0	No AdditonalUV Stab.
Black Polyol-efin	0.75	2 to 3	100 Minutes	2000 minutes	2X*
White Polyol-efin	0.75	3.5	100 Minutes	2000 Minutes	2X*
White Polyol-efin	0.75	3.5	100 Minutes	1000 Minutes	X*

Results of Accelerated Study



Results of Accelerated Study

- The black 0.75 mm polyolefin sample (stabilized with 2X UV/antioxidant additive) outperformed the 1.5 mm HDPE stabilized with carbon black alone.
- The white 0.75 mm polyolefin sample (stabilized with 2X UV/antioxidant additive) performed almost as well as the black HDPE after 20,000 hours.

Results of Accelerated Study

- A white polyolefin 0.75 mm sample (stabilized with only 1X amount of UV/antioxidant additive) did not perform well at 20,000 hours, losing almost 50% of its original tensile strength.

Antioxidant Consumption

Material	Baseline Antiox-idant (OIT)	Additional Antioxidant Estimated (HPOIT)	HPOIT Before Exposure (minutes)	HPOIT Following Exposure (minutes)
HDPE	100 Minutes	No Additional A/0	301	248
Black Polyol-efin	100 Minutes	2000	3930	3757
White Polyol-efin	100 Minutes	2000	4205	2695

Antioxidant Consumption

- The result of HPOIT testing shows much more consumption of antioxidant in the white polyolefin.
- The carbon black stabilized systems appear to be superior in terms of stabilization against oxidation.

Second 20,000 Hour Exposure

Material	Elongation Retained	Tensile Strength Retained
1.5 mm HDPE with 2 to 3% carbon black	79%	76%
0.75 mil Polyolefin with 2 to 3 % carbon black and X amount of UV stabilizer.	103%	97%

Conclusions

- With sufficient UV/antioxidant additives a thin film white or black polyolefin can perform roughly equivalently to a thicker (1.5 mm) section of black HDPE in a prolonged UV exposure.

Conclusions

- Based on our calculated and tested relationship of 1000 hours of accelerated exposure being roughly equivalent to one year of natural exposure in Edmonton, an exposed service life of over 20 years could be predicted for an adequately stabilized thin film polyolefin geomembrane.