White Polyethylene Geomembrane: It lasts longer

GEOANZ #1 ADVANCES IN GEOSYNTHETICS

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- The author would also like to thank the prior researchers on this topic as well as George Koerner of the Geosynthetic Institute who conducted the exposures, Evi Kroeger of Solmax-Rechlin who conducted the testing and Adam Maskal who served as program coordinator.

Paper summary:

- The purpose of this investigation, testing and paper is to evaluate the hypothesis that white surfaced geomembrane will have superior durability to a similar, black colored geomembrane. The basis for this improvement is the reflection of solar energy and thus a lower "regular-daily" temperature of white materials. The cumulative effect of this lowering of temperature is slower/less degradation, and thus improved durability.
- This includes three surveys of data, one a review of the publications asserting this lower temperature performance, a second survey of sites where white geomembranes have performed better / longer than expected and testing of field samples under temperature representative of the field conditions.

Field performance

- The first “white” geomembranes were actually green in color. The goal was to improve the aesthetic appearance of a large area of exposed geomembrane.

This photo was taken at the Gundle Road facility in 2017. The materials pictured (green in foreground and white in background) had been installed 30 years prior and were the initial colored formulations with no additional stabilization.

Sites and samples

The evaluation program took samples from materials manufactured for several commercial sites – some exposed, some also had materials stored as reserve.

- Polk County landfill in Florida
- Palo Verde Nuclear Generating Facility – near Phoenix Arizona
- Cowlitz County Washington (state)
- Shell QGC facility – near Brisbane, Queensland, Australia
- As well as current production of black and white surfaced geomembrane

Polk County Florida Cap – Jan. 2015

Figure 2 from the Eichelberger paper – Palo Verde Electrical Generating Station near Phoenix, AZ. (For scale the three blue rectangular buildings are nuclear reactors.) All ponds pictured were lined with white materials totaling appx. 310 acres/1.25 square km.

Figure 2. Aerial view of the lined containment reservoirs for municipality wastewater and Evaporation Ponds. The 85-acre and the 45-acre reservoirs are shown above

Cowlitz County site photos from Thiel paper (figures 1 and 4)

Used for liquid storage for over two decades

Multiple ponds/liquid storage for natural gas production.

Ponds – Queensland AU

Existing specification – GM-13

- GSI published the GM-13 specification originally in June 1997
- Durability was/is a component of the specification
- OIT retention after oven aging and accelerated UV light exposure were selected as the durability criteria
- These requirements have served the industry well since the publication of the specification.

GM-13 Oven aging (HP-OIT retention)

- Samples are aged for 90 days at 85^{o} C
- The specifics of this testing are included in ASTM specifications: ASTM D 5885 and D 5721 respectively.
- To comply with GM-13 the requirements are a minimum initial HP-OIT of 400 minutes with the retention of HP-OIT of 80% of the initial value after oven aging at 85^{o}C for 90 days.

Lower daily temperature of white materials

- **Koerner (G.)** in "Temperature Behavior of Field Deployed HDPE Geomembranes," addresses both the overall difference and the seasonality in the northern hemisphere (Latitude 40^{o} North). **Rentz** reports a temperature delta (Black vs. White geomembrane) of 22^{o} C at the Queen's University Queen's University Environmental Liner Test Site II (QUELTS II) in August at Latitude 44^{o} North. **Cadwallader** reports a 25^{o} temperature differential, presumably at Latitude 36^{o} North. **Pelte** reports the largest differential of 35^{o} C at latitude 45^{o} North. Pelte also conducted laboratory scale testing demonstrating greater differentials in the temperature response of black and white geomembranes, both polyethylene and polyvinylchloride.

Sample exposure and testing

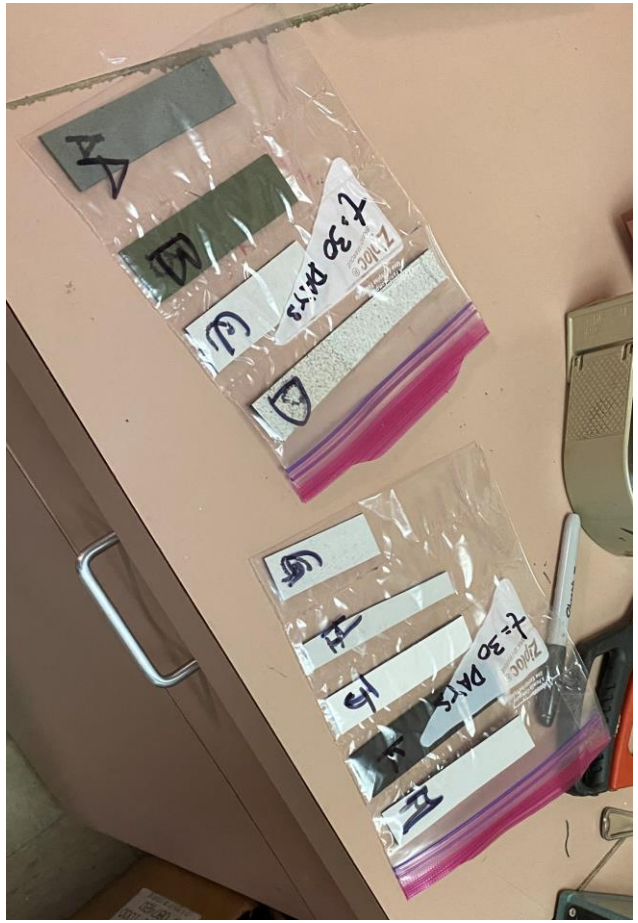
- Materials were exposed using a modified version of ASTM D5721, “Standard Practice for Air-Oven Aging of Polyolefin Geomembranes”

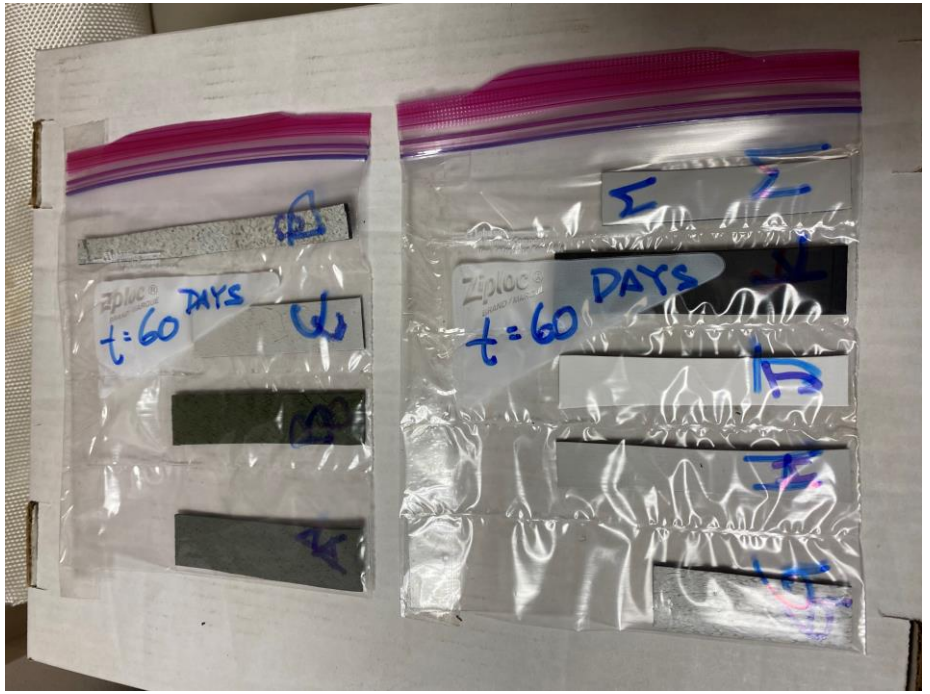
- The modification was temperature – reduced to 60^{o} C to match the reported reduction in field temperatures.

- HP-OIT testing at the Solmax Rechlin Quality Control Laboratory - This laboratory is certified within the GAI-LAP (Geosynthetic Accreditation Institute-Laboratory Accreditation Program) to conduct this test as well as multiple other certifications.

Oven photo from GSI video - GRI GM13 ASTM D5721 & D7238 Oven and UV Aging of HDPE Geomembranes

https://www.youtube.com/watch?v=tRjsb83UoKg





Samples: 0,30,60,90 days

Sample A – Polk County, Florida, USA 1.5 mm exposed green landfill cap. Sample exposed outdoors for 21 years at Latitude 27^{o} North tropical environment

Sample B- Polk County, Florida, USA 1.5 mm exposed green landfill cap. Sample from original installation, but stored in a warehouse, aged 21 years but no UV/solar exposure

Sample C- Toowoomba, Queensland, Australia. 1.0 mm white geomembrane from an exposed outdoor evaporation pond in service since 2012 at Latitude 27^{o} South, warm and temperate environment

Sample D – Cowlitz Country, Washington, USA 1.5 mm exposed white geomembrane from an exposed outdoor pond in service since 1993 at Latitude 46^{o} North, Mild Mediterranean climate

Sample G- Palo Verde Nuclear Generating Station, Phoenix AZ, USA 2.0 mm sample from 1999 installation, but stored in a warehouse, aged but no UV/solar exposure.

Sample H – Commercial sample from 2013, 1.5 mm white geomembrane, but stored in a warehouse, aged but no UV/solar exposure

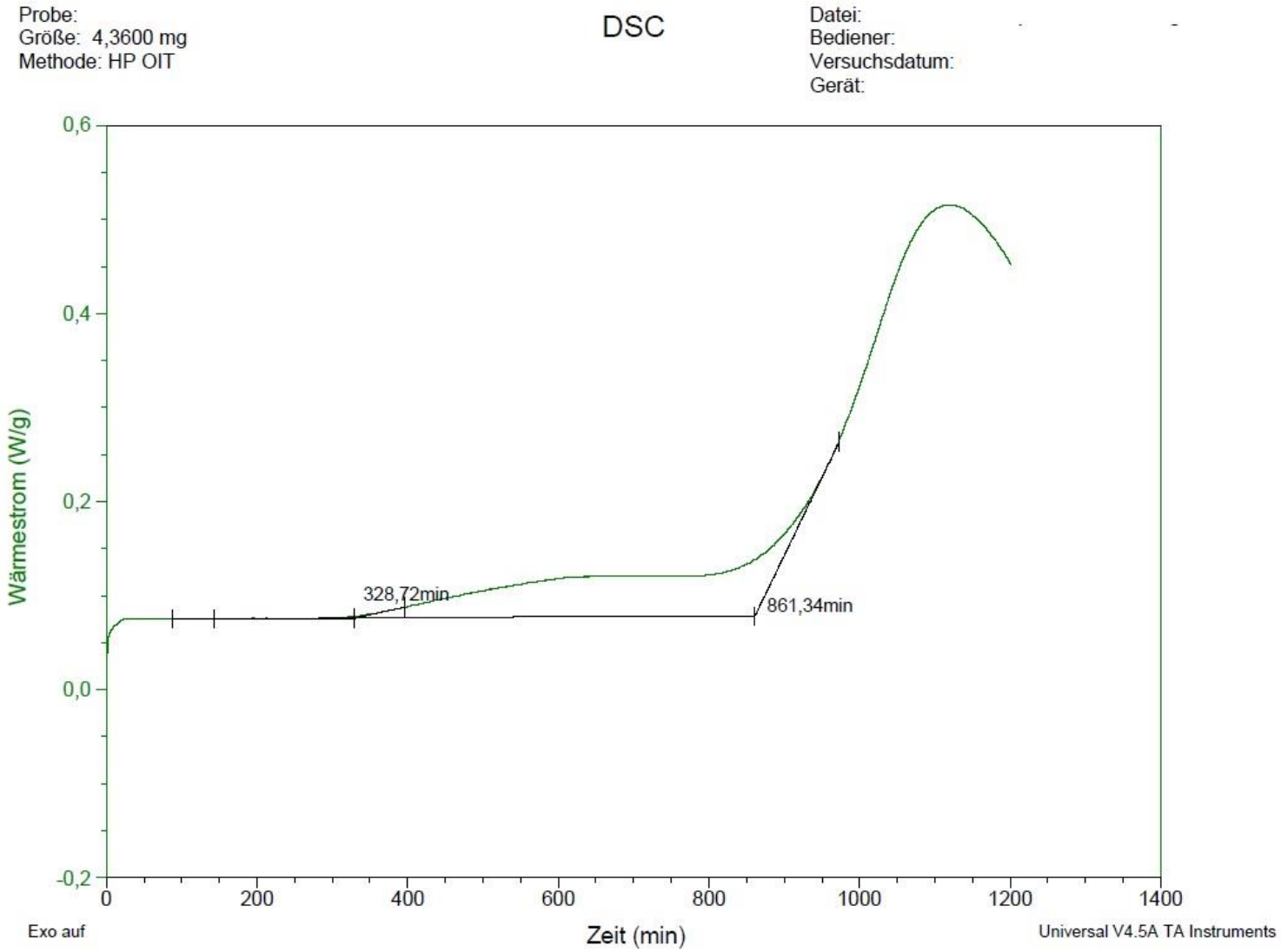
Sample J - Commercial sample from 2020, 1.5 mm white geomembrane, stored in a warehouse, no UV/solar exposure

Sample K - Commercial sample from 2020, 2.0 mm black geomembrane, stored in a warehouse, no UV/solar exposure

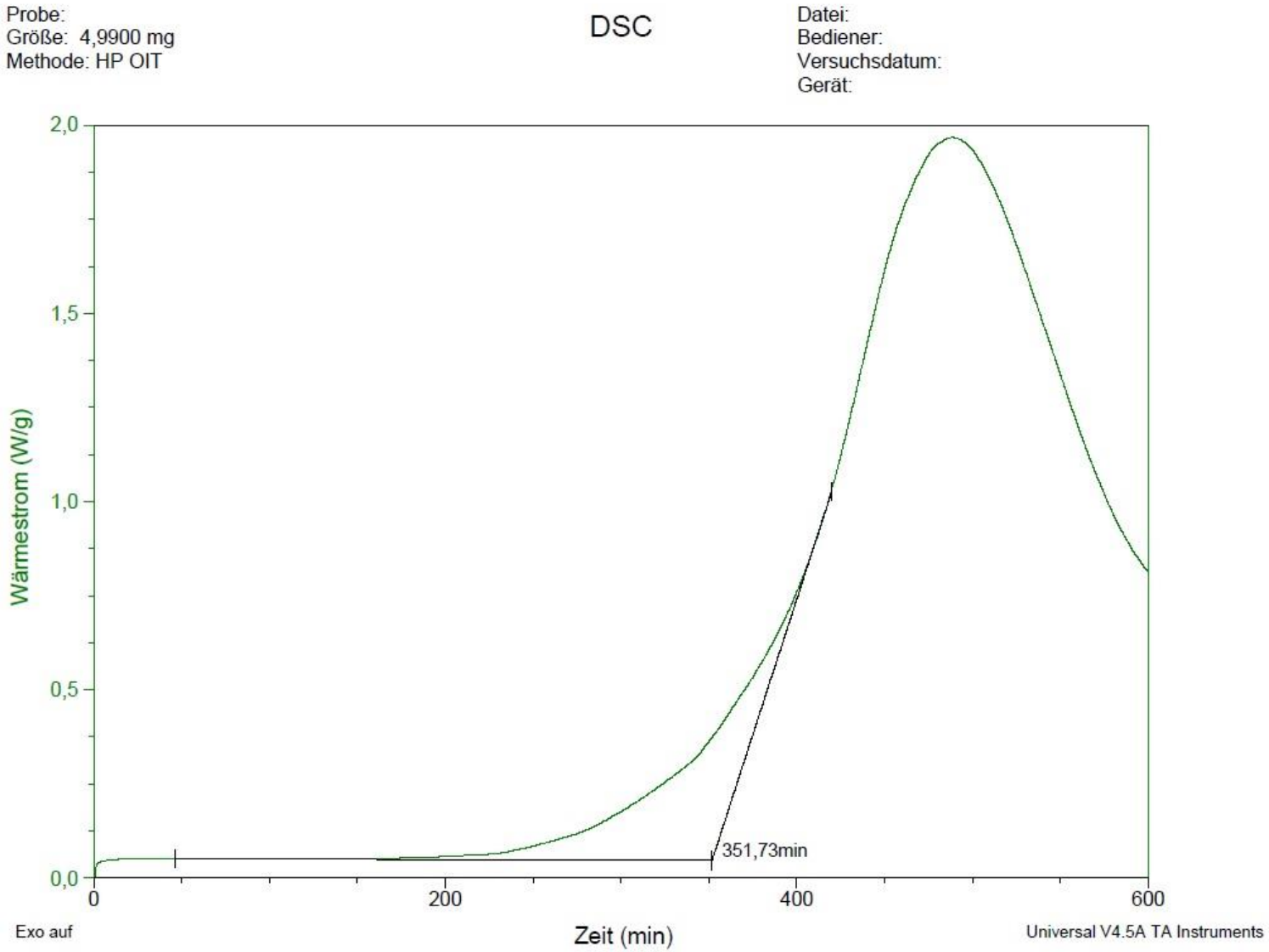
Sample M - Commercial sample from 2013, 2.0 mm white conductive geomembrane, but stored in a warehouse, aged but no UV/solar exposure

HP-OIT testing details

- ASTM D5885, “Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry”,
- The samples tested herein were tested in the “as-is” condition. That is, a section was taken from the entire thickness of the sample, weighed and tested for HP-OIT properties as it existed at that point. No grinding, homogenization, plaque preparation or other alteration of the samples occurred prior to testing.



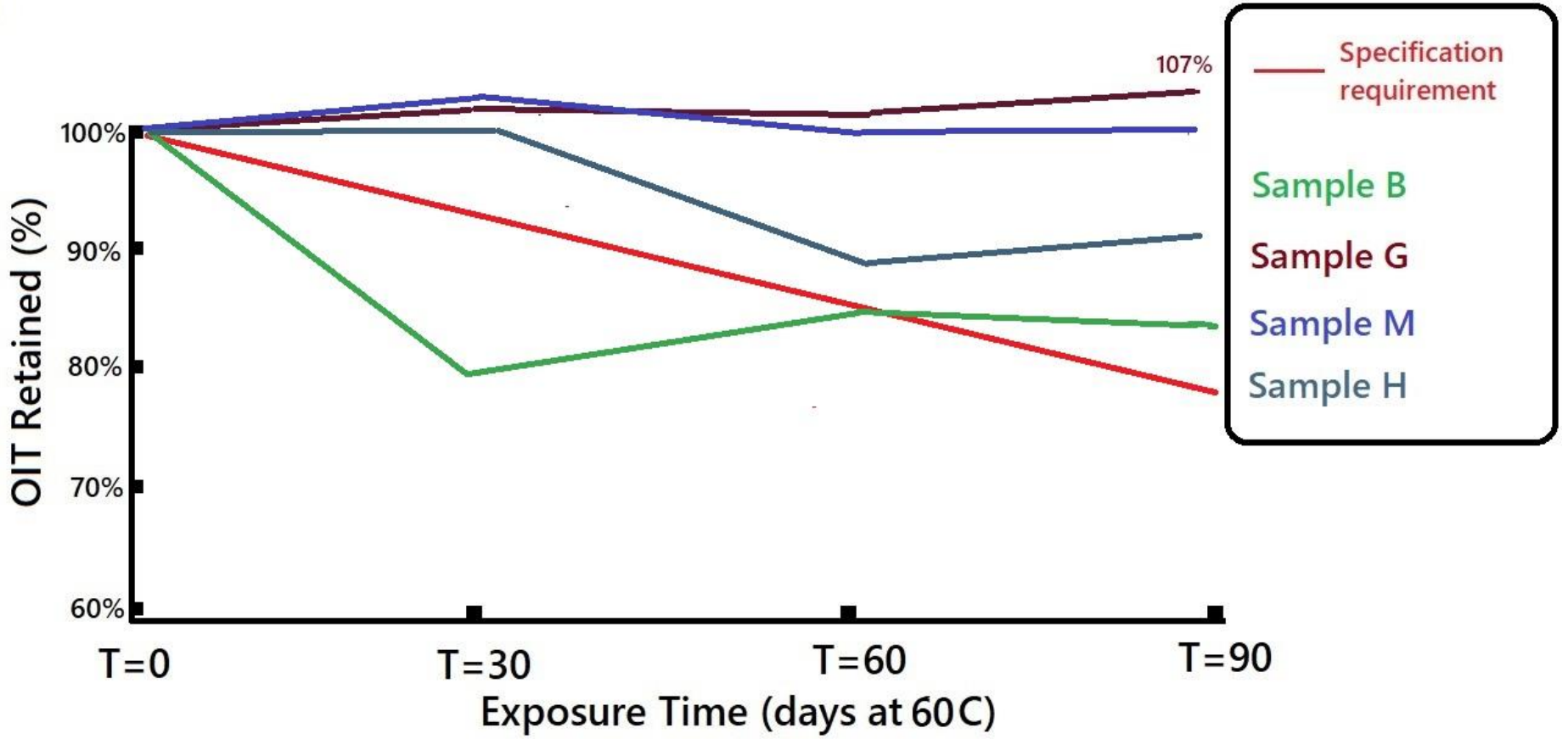
OIT test result with shoulder



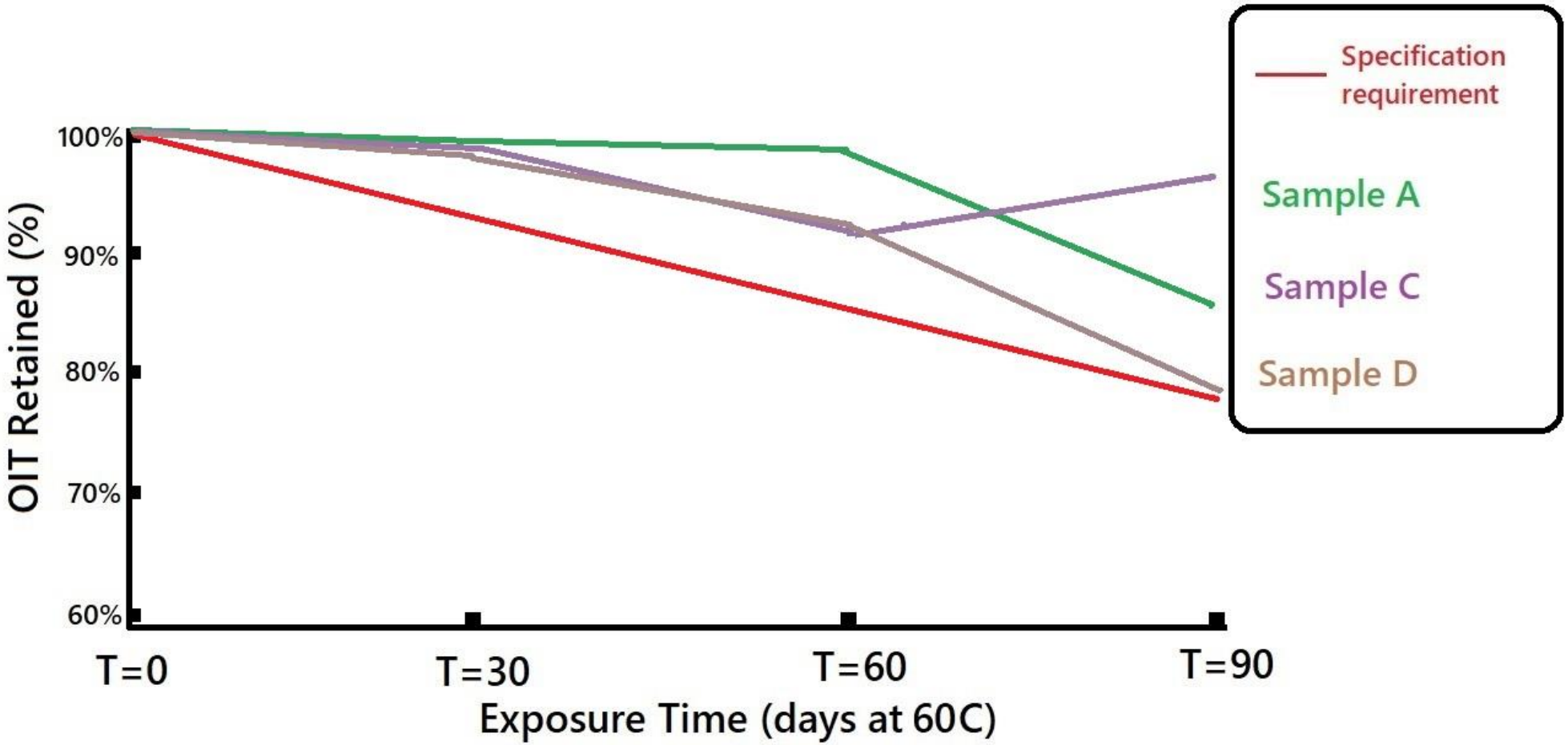
OIT test result no shoulder

Oven Aging Results

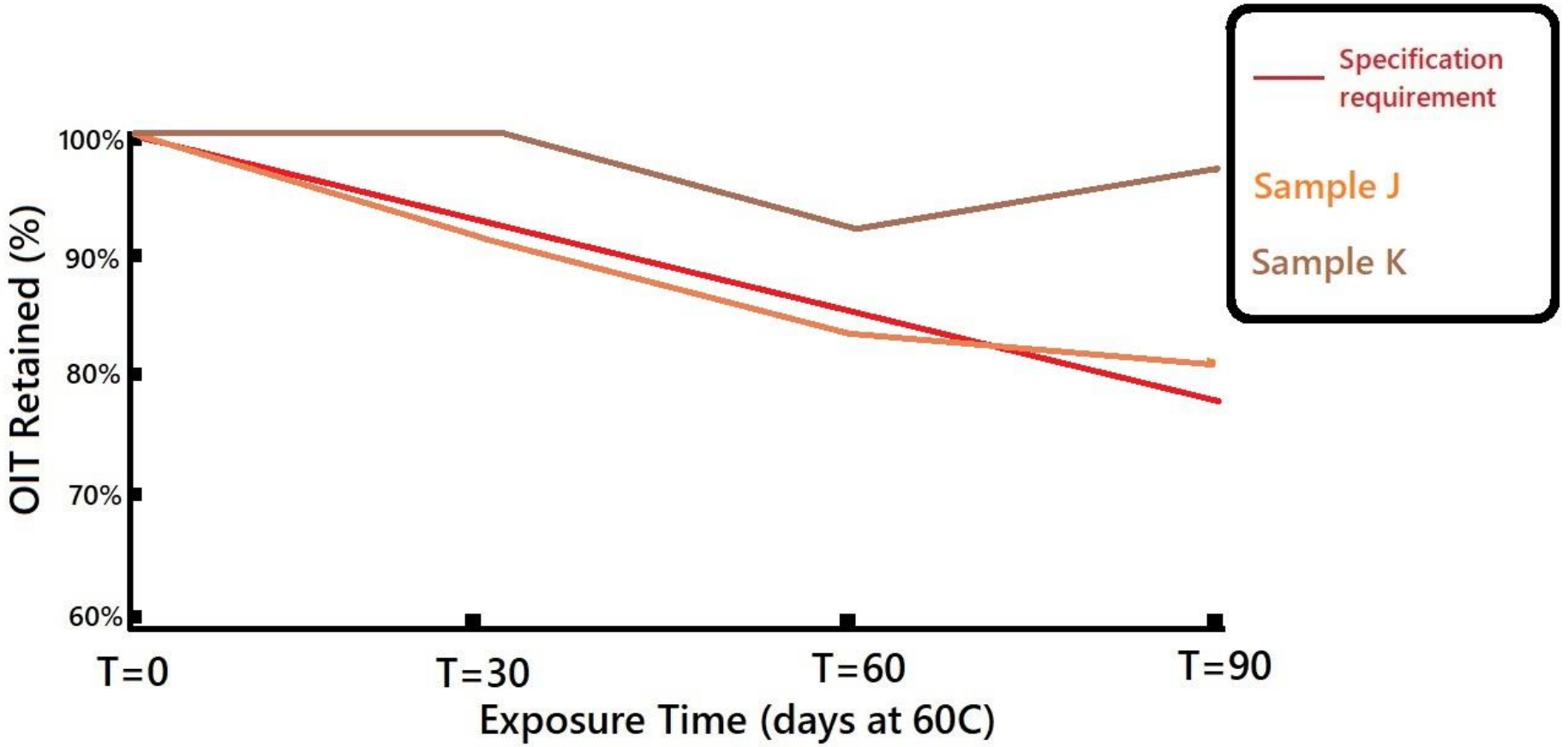
- Specification line in red – the requirement is >80% of original value after 90 days of aging.
- No error bars are included. ASTM 5885 reports a repeatability standard deviation of 5.7 min (2.5 %) and a reproducibility standard deviation of 18 min (7.6 %)
- In some cases, retesting was done to validate results that appeared inconsistent or unexpected. In every case, no data points were discarded and the values reported below are the results of one, or the average of two test results.



Data results – no previous exposure - aged



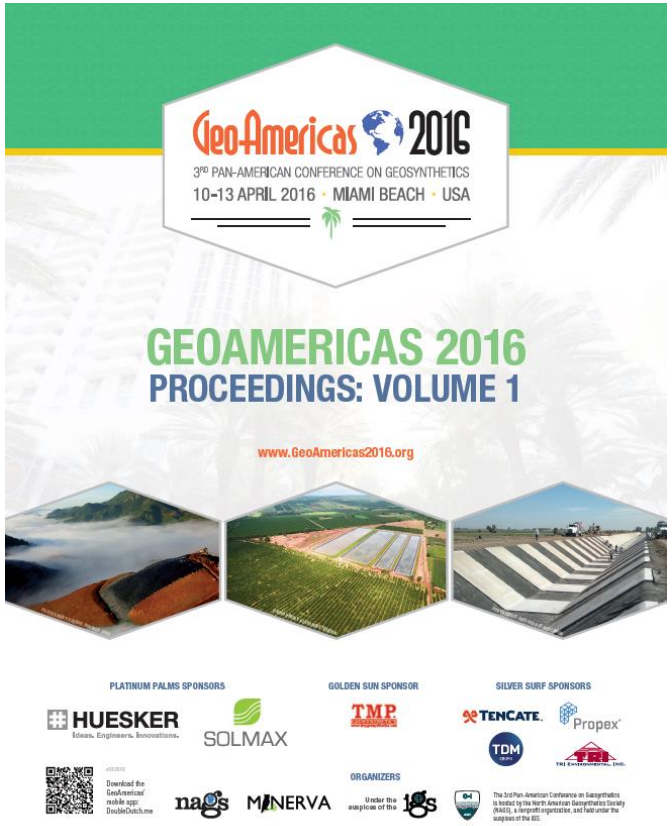
Data results – after exposure



Data results – new materials no exposure

Application of results to lifespan predications

- How long do geosynthetics last?



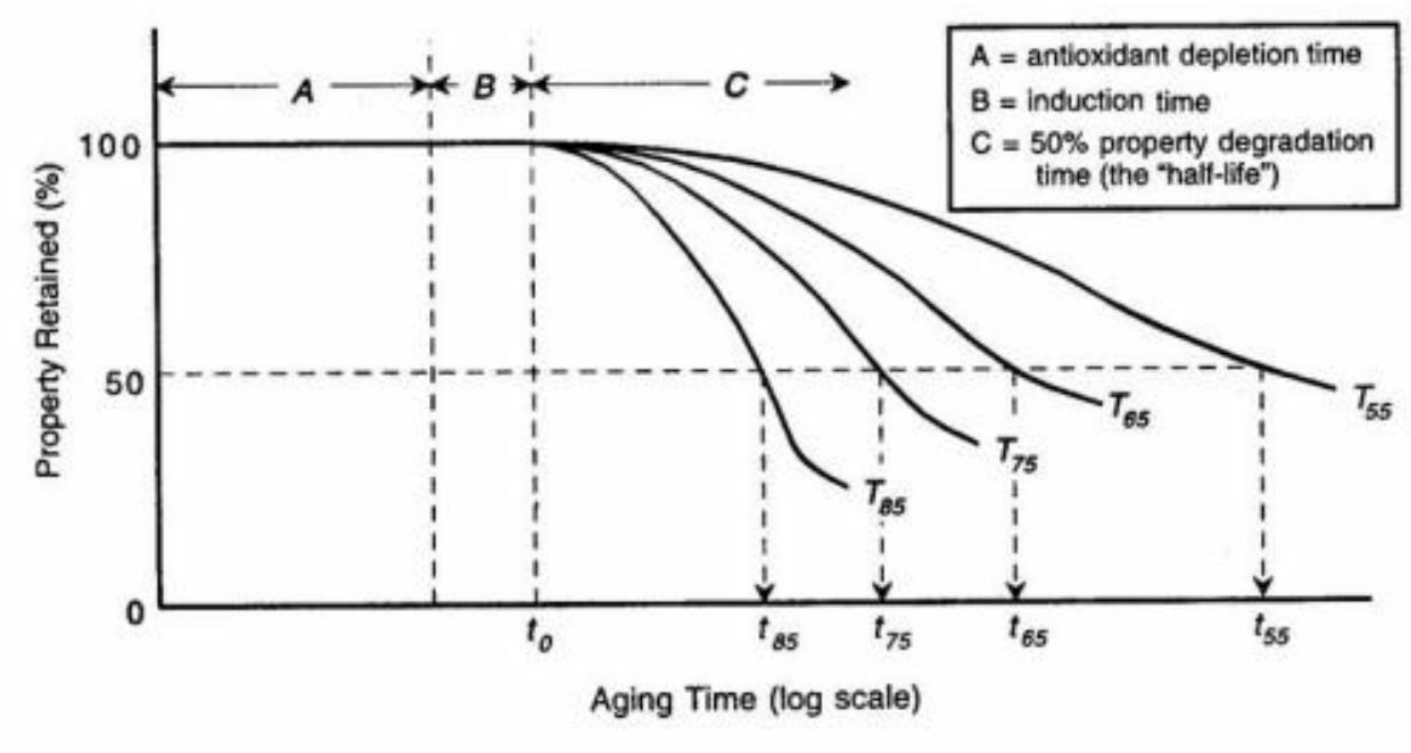
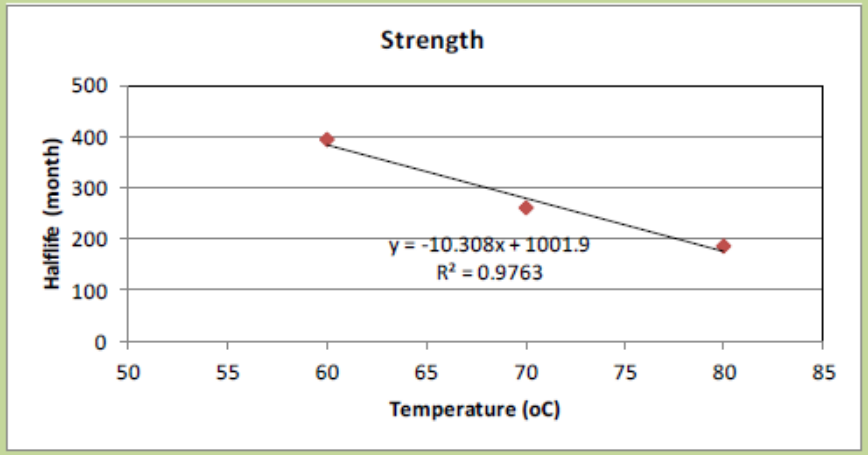
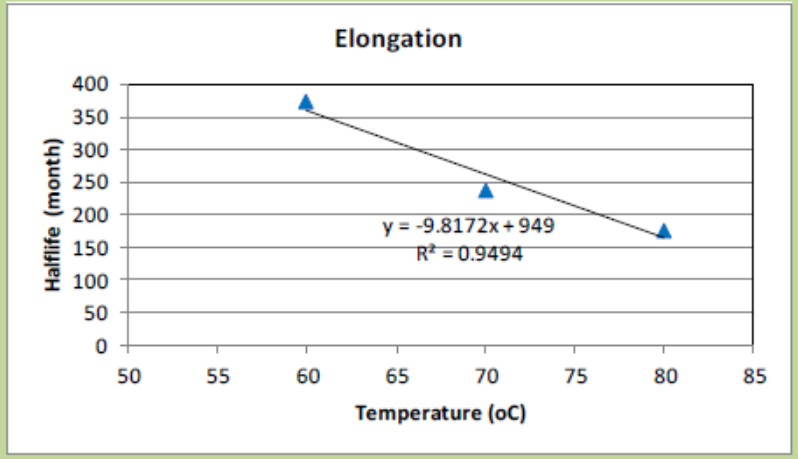


Figure 2. Three individual stages in the aging of most geomembranes.

Extrapolation





Strength

halflife (month) = A*(site temperature,°C)+B

A	-10.308
B	1001.9

Site Temperature (°C)	Halflife (months)	Halflife (yrs)
80	177.3	14.77
70	280.3	23.36
60	383.4	31.95
50	486.5	40.54
40	589.6	49.13
30	692.7	57.72
20	795.7	66.31

Elongation

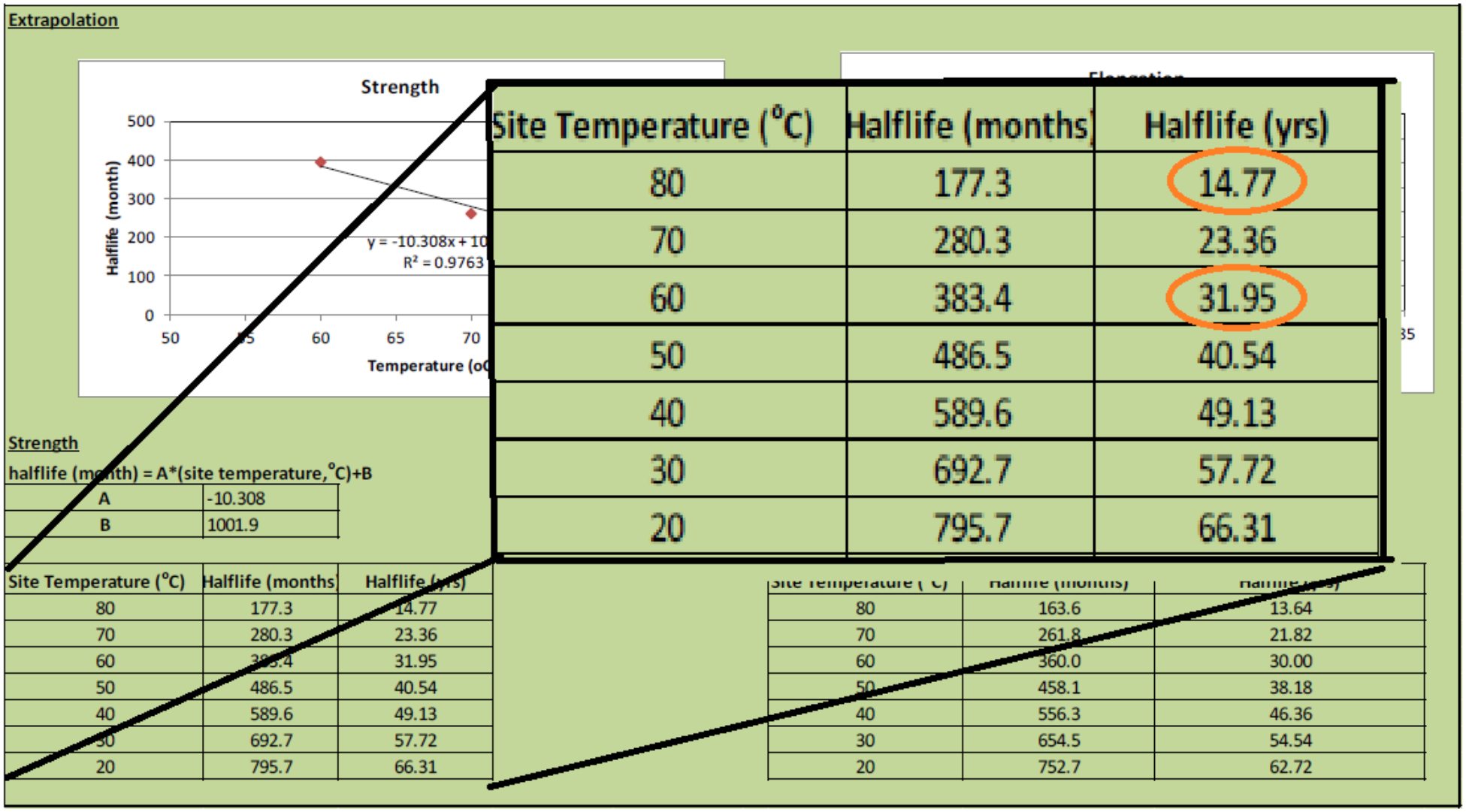
halflife (month) = A*(site temperature,°C)+B

A	-9.8172
B	949

Site Temperature (°C)	Halflife (months)	Halflife (yrs)
80	163.6	13.64
70	261.8	21.82
60	360.0	30.00
50	458.1	38.18
40	556.3	46.36
30	654.5	54.54
20	752.7	62.72

c) Halflife field predictions in Phoenix, Arizona down to 20°C

Koerner, R. "*Lifetime Predictions of Exposed Geotextiles and Geomembranes*" Keynote lecture and Proceedings of GeoAmericas 2016 3rd Pan-American conference on Geosynthetics, Miami, FL USA



c) Halflife field predictions in Phoenix, Arizona down to 20°C

Figure 19C from "Lifetime Predictions of Exposed Geotextiles and Geomembranes"

What has been presented is a combination of forensic field evaluations, public literature information and in a new addition to the industry knowledge, the behavior of white surface polyethylene geomembranes in retention of HP-OIT at a temperature that reflects field exposure temperatures. This data and information all imply and support the hypothesis that these materials will have a longer lifespan than that of the equivalent black geomembrane materials. Literature suggests that this **improvement is approximately 17 years** in duration of lifespan.

Exposed White Geomembrane lasts longer than Black Geomembrane.

Thank you for your attention

- Design, specify, buy and use white/ light reflective geomembrane