IS 17025 ACCREDITED LABORATORY
ExcelPlas

Technical Note EP-52

The '*Benjamin Button*' of Polymeric Liners

1. Introduction

Most polymeric liners undergo oxidative ageing immediately after installation and this continues over time ultimately leading to a reduction of their molecular chain length (this destructive process is referred to as *oxidative degradation*).

In particular HDPE, LLDPE and PP are highly susceptible to chain scission by strong oxidizing agents such as chlorine and chloramine used in potable water. This means statistically just one break in a polymer chain could lead to a halving of the chain molecular weight when the stabilizer package is depleted. Loss of molecular weight of these polyolefins is accompanied by drastic reductions in mechanical properties.

CSPE is the opposite and is truly the 'Benjamin Button' of polymeric liners. The progressive cure of CSPE over time effectively reverses the ageing process and offsets the detrimental effects of oxidative degradation. The chlorosulfonic groups along the polymer backbone act as active cross-linking sites during the polymer aging process.

Its progressive crosslinking after installation leads to a 3D network structure and a greater degree of effective molecular chain length. This means the critical properties of a CSPE liner such as tensile strength, modulus and its tolerance to damage and degradation actually improve with time in service.

Every molecular chain becomes linked to every other chain giving the cured CSPE liner an infinite molecular weight. This makes CSPE bulletproof against free-radical attack by oxidizing agents. This ability of CSPE liners to vulcanize over time to become a true *thermoset rubber* with outstanding endurance properties sets it apart from all other polymeric liners.

This also gives CSPE the distinction of having the longest proven service life of any geomembrane. Installations as old as 42 years are still functioning with no obvious signs of degradation or deterioration even in constant contact with chlorinated water. This is why CSPE is considered the only geosynthetic liner and cover material with a demonstrated track record longer than most people's careers.

Another reason for the outstanding UV resistance of CSPE liners is they typically contain double to four times the carbon black content of HDPE liners. Since carbon black is an effective UV screen this prevents UV light from penetrating into the structure.

Even when pigmented black the very low coefficient of thermal expansion of CSPE means it doesn't produce the waves and wrinkles that plague the installation of black HDPE geomembranes.

Furthermore the absence of crystallinity in CSPE means that it is immune from stress cracking which is the Achilles Heel of HDPE geomembranes.

The fact that no other geomembrane has demonstrated the successful long-term (40 year plus) performance in potable water applications explains why CSPE liners and covers come with a 30 year weathering warranty (which is the longest offered in the geomembrane industry).

The outstanding weatherability of CSPE liners is underscored by the requirement in the GRI GM-28 Specification for CSPE-R (reproduced below) for 20,000 light hours of QUV exposure without surface cracking which equates to some 40 -120 years of outdoor life depending on the specific location and level of terrestrial solar radiation.

SI (Metric) Units

Table 1(b) – Reinforced Chlorosulphonated Polyethylene (CSPE-R) Geomembranes

Property	Test Method ASTM or GRI	CSPE-R 0.91 mm	CSPE-R 1.14 mm	CSPE-R 1.52 mm	Testing Frequency (minimum)
Mass per Unit Area – kg/m^2 (min. ave.)	D5261	0.73	0.88	1.17	7500 kg
Thickness – mils (min. ave.) • lowest individual specimen – mils, (nominal – 10%)	D5199	0.91 0.82	1.14 1.03	1.52 1.37	per roll or panel
Tensile Strength • grab[1] – N (min. ave.)	D7004	890	1110	1340	7500 kg
Tensile Elongation • grab[1] - % (min. ave.)	D751-A	15	15	15	7500 kg
Tear Resistance • reinforced[1] – N (min. ave.)	D5884	315	315	315	7500 kg
Puncture Resistance – N (min. ave.)	D4833	330	380	440	7500 kg
Ply Adhesion – N (min. ave.)	D6636	65	65	65	7500 kg
Low Temperature Flexibility - °C	D2136[3]	-40	-40	-40	per formulation
Dimensional stability - % change max.	D1204[4]	2	2	2	per formulation
Carbon Black Content[5] - %	D4218	5-36	5-36	5-36	22,000 kg
Ultraviolet Light Resistance[5,6]	D7238				per formulation
(a) Surface Cracking Observation after 20,000 light hrs. (Reinforced)	GM16		none		
(b) Surface Chalking (or Powdering) after 20,000 light hrs. (Reinforced)	GM23		minor		
(c) % strength retained after 20,000 light hrs. (Non-Reinforced) - or -	D6693-IV		≥ 50		
(d) % elongation retained after 20,000 light hrs. (Non-Reinforced)	D6693-IV		≥ 50		

(1) Test methods modified to 500 mm/min. for unreinforced and 12 in./min. for reinforced material
(2) Calculation based on a 50 mm gage length
(3) Using 3.2 mm mandrel for 4-hours.
(4) Incubated at 100°C ± 1°C for one hour.
(5) Applicable only to black geomembranes. Also D1603 is an acceptable method to determine carbon black content.
(6) The conditions of the UV Fluorescent exposure method should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
(7) See Section 5.2 for fPP-R geomembranes.

A good example of amazing durability of a CSPE floating cover is the Hinkle Reservoir in Folsom California. The CSPE (Hypalon) floating cover was installed in 1979 and is still in service 42 years later under the hot Californian sun.

In summary, there are 4 key reasons why CSPE liners outperformed other polymer liners over decades of service in potable water applications:

(i) they crosslink with time hence reversing the typical polymer ageing process;

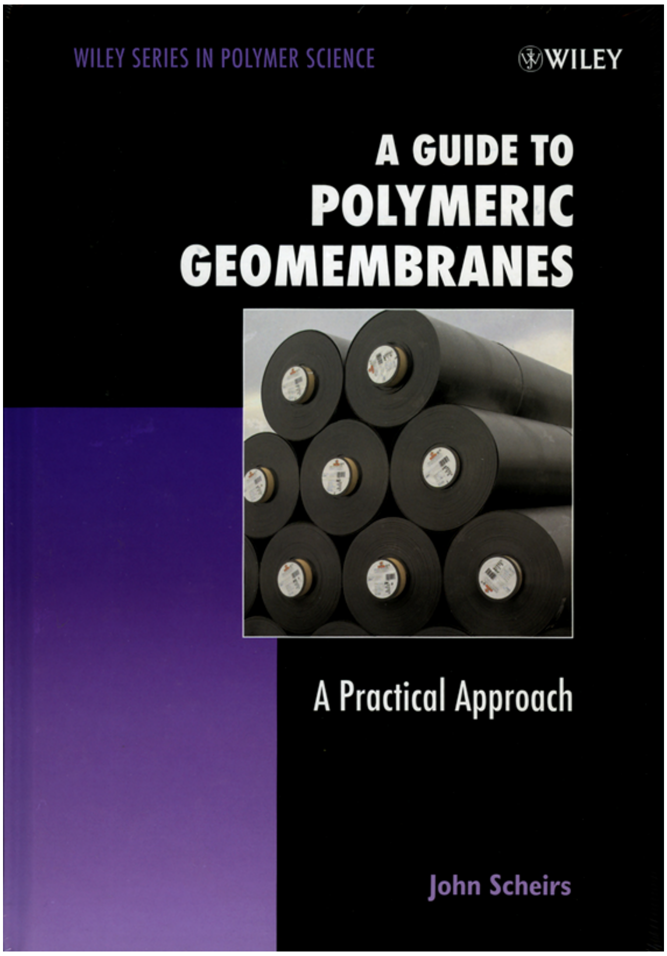
(ii) they contain 2-4 times the carbon black screening content of polyolefin liners;

(iii) they are highly flexible yet contain no plasticizers that can be extracted, leached or broken down over time and;

(iv) they have a completely saturated backbone (that is there are no reactive double bonds in the backbone that can react with oxygen or ozone) hence conferring to it outstanding oxygen and ozone resistance.

2. Further Reading

CSPE Geomembranes in Scheirs, J. '*A Guide to Polymeric Geomembranes*' Published by John Wiley and Sons (2009), Chapter 6, pp. 117-126.



Long-Term Repair of Aged CSPE Geomembranes
https://www.layfieldgroup.com/English/Knowledge-Center/August-2019/Long-Term-Repair-of-Aged-CSPE.aspx

Performance History of CPSE Liners and Covers in Long Term Potable Water Storage Applications
http://docplayer.net/179039818-Cspe-performance-history-in-long-term-potable-water-storage-applications.html

CSPE Case Study Hinkle Reservoir
https://www.layfieldgroup.com/getmedia/ca7777fa-0d32-4e5b-9bb2-77d3ee3cb031/Case-Study_Hinkle-Reservoir.pdf