Geomembrane Performance in Landfill Cover Systems

George R. Koerner Ph.D., P.E. & CQA

gkoerner@dca.net

Geosynthetic Institute, 475 Kedron Ave. Folsom PA USA

(610) 522-8440 www.geosynthetic-institute.org

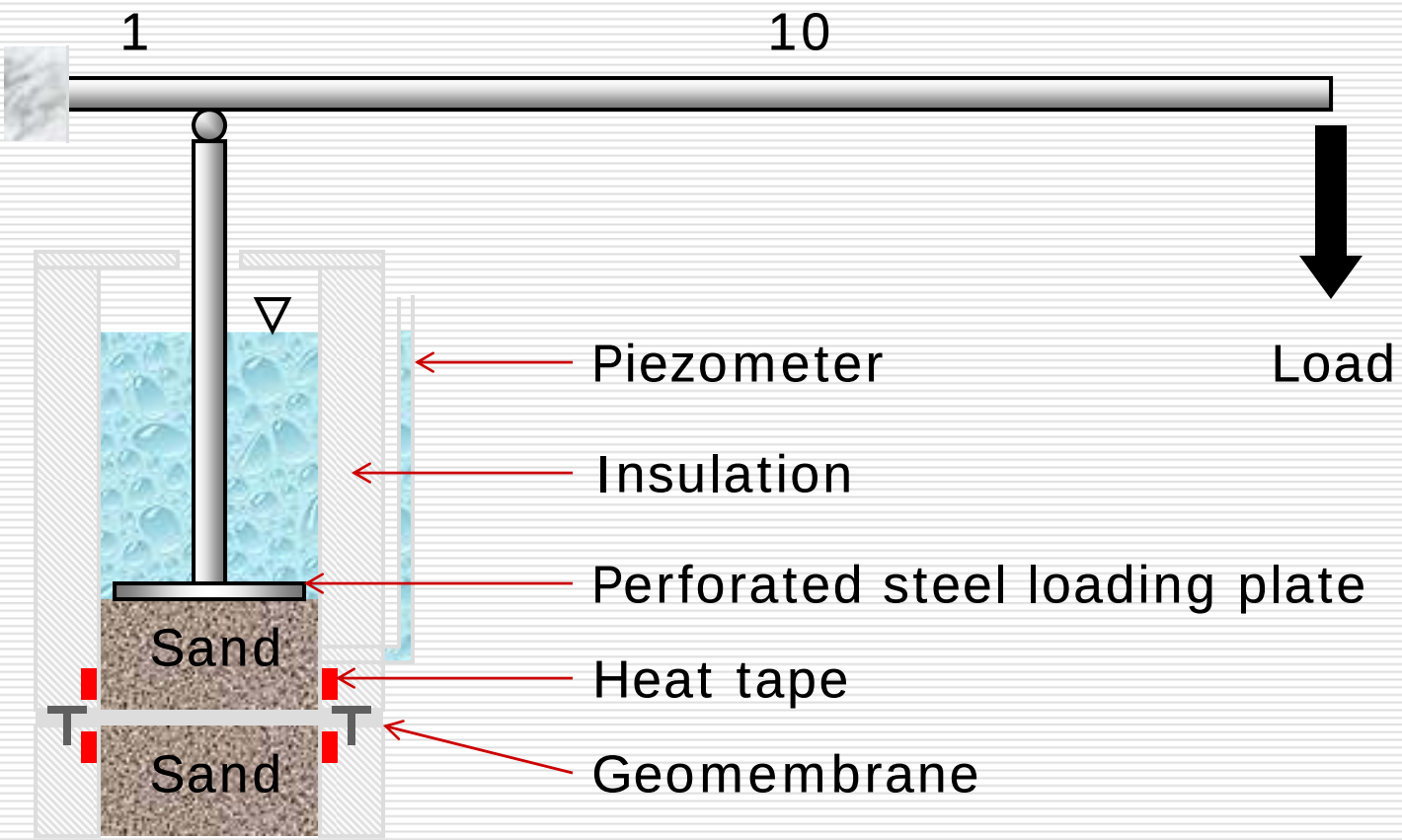
Background and Baseline

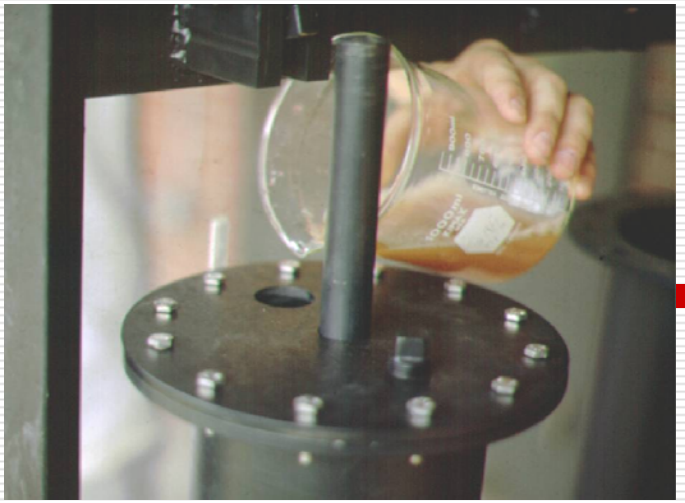
- This is a PE discussion (Haxo 1981)
- Composite liners work well (Koerner 1985)
- High gradients and low heads result in less leakage (Fluet 1987)
- The properties of a PE start to change at a total radiation dose of between 10^6 and 10^7 rads (Charlesby 1960, Edy 1979 , Schabel 1981, Carlson, Chnela and Lacoste 1991, Whyatt and Fansworth 1990 and Nimitz et. al. 2001.)

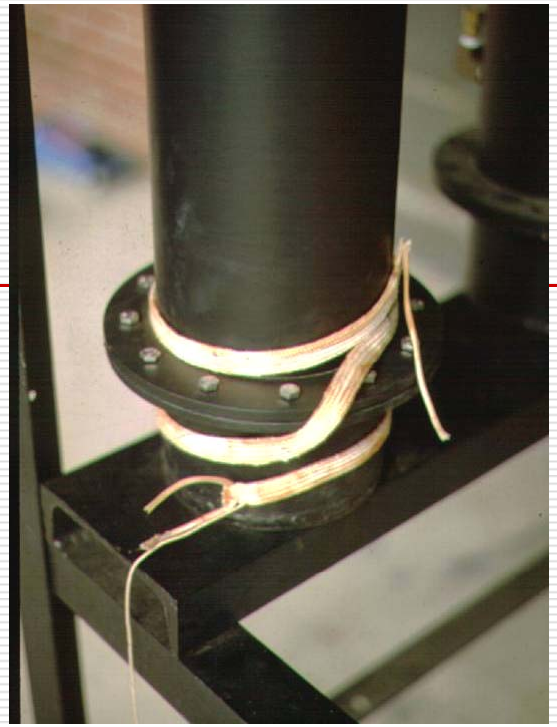
Geosynthetic Lifetime (Long-Term Aging)

- ultraviolet
- radiation
- oxidation
- chemical (water and/or leachate)
- elevated temperature
- various types of stress

How Long Will PE GM's Last??







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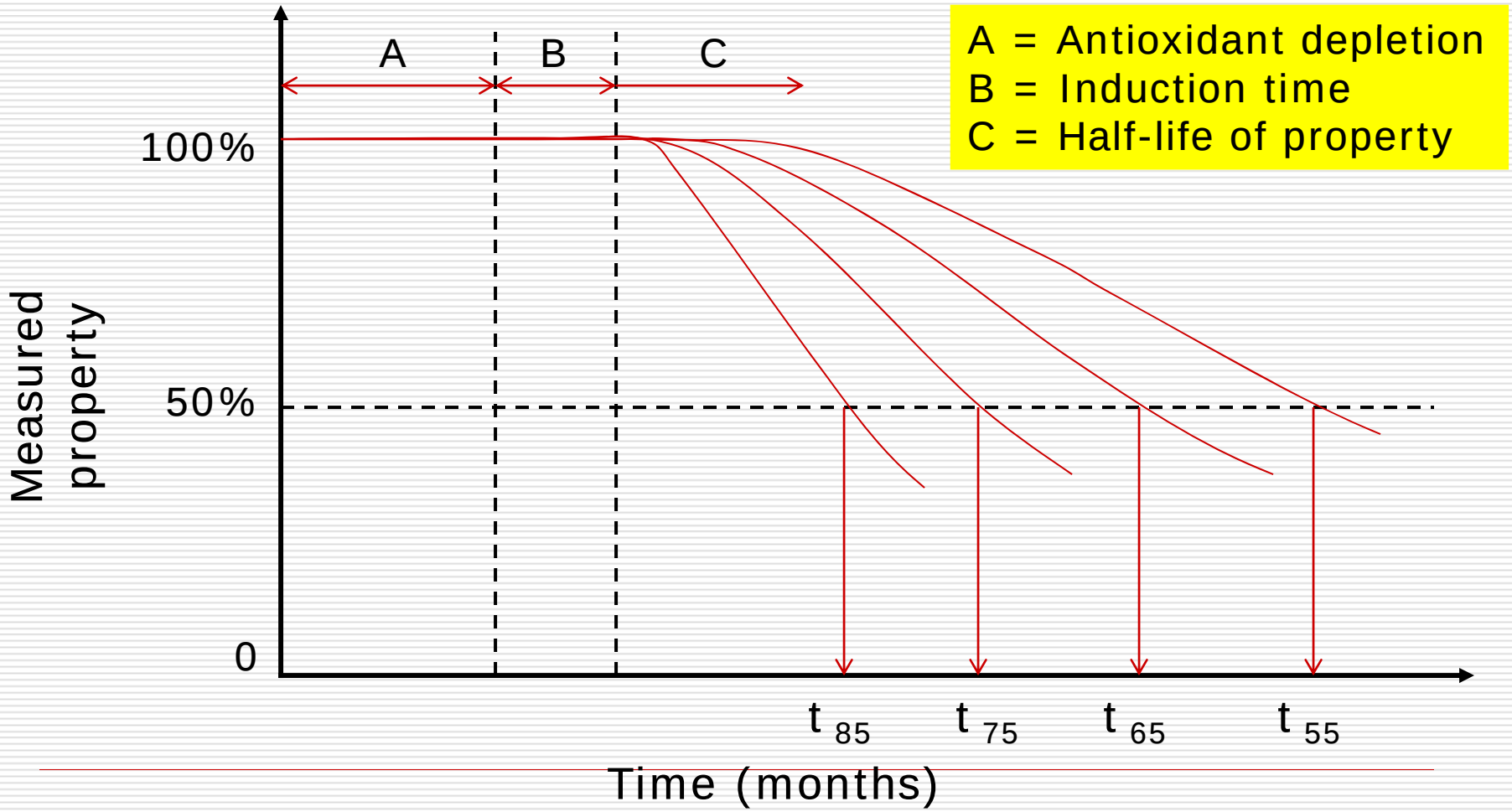
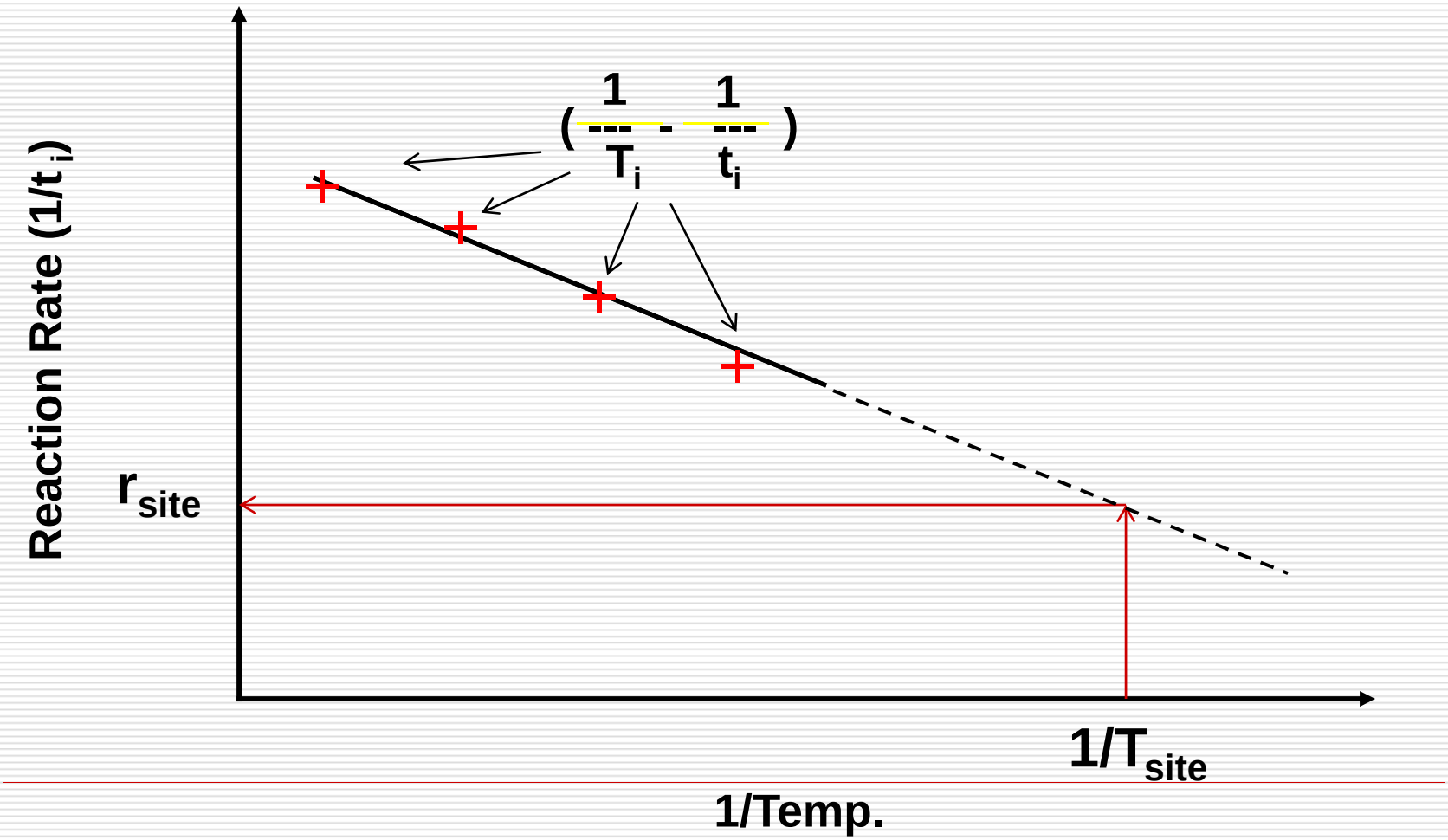
9
10

Incubated Property Behavior



Arrhenius Plot for Stage "C" (1/2 Life)



HDPE Lifetime Estimate 20° C

A - Antioxidant Depletion = 50 to 150 years

B - Induction Time = 20 to 30 years

C - Half-life Estimates (from GSI & literature)

- gas pipe = 200 years
- GSI = 500 years
- cable shielding = 750 years

Total (est.) = 270 to ~ 1000 years

Lifetime Prediction of HDPE at Elevated Field Temperatures

Field Temperature		Stage "A" (yrs.)		Stage "B"	Stage "C" (yrs.)		Total
C (deg)	F (deg)	Std OIT	HP-OIT	(years)	Ref. 1	Ref. 2	Ave. Years
20	68	200	215	30	208	740	712
25	77	135	144	25	100	441	435
30	86	93	98	20	49	259	270
35	95	65	67	15	25	154	170
40	104	45	47	10	13	93	109
45	113	32	33	5	7	57	70
50	122	23	24	0	4	36	43

Notes: Stage "A" measured values from G. Hsuan research
Stage "B" estimated values from field samples
Stage "C" lit. values from Martin & Gardner[1] and Viebke[2]

Exposed GM Lifetime Prediction

- buried lifetime prediction well researched
- regulators, owners, and designers are becoming more acceptable of adequate GS durability when soil covered
- exposed; it is another story…
- full oxygen, UV exposure, and high temperatures are fundamental differences

Methods of Exposed Lifetime Prediction Using Weatherometer

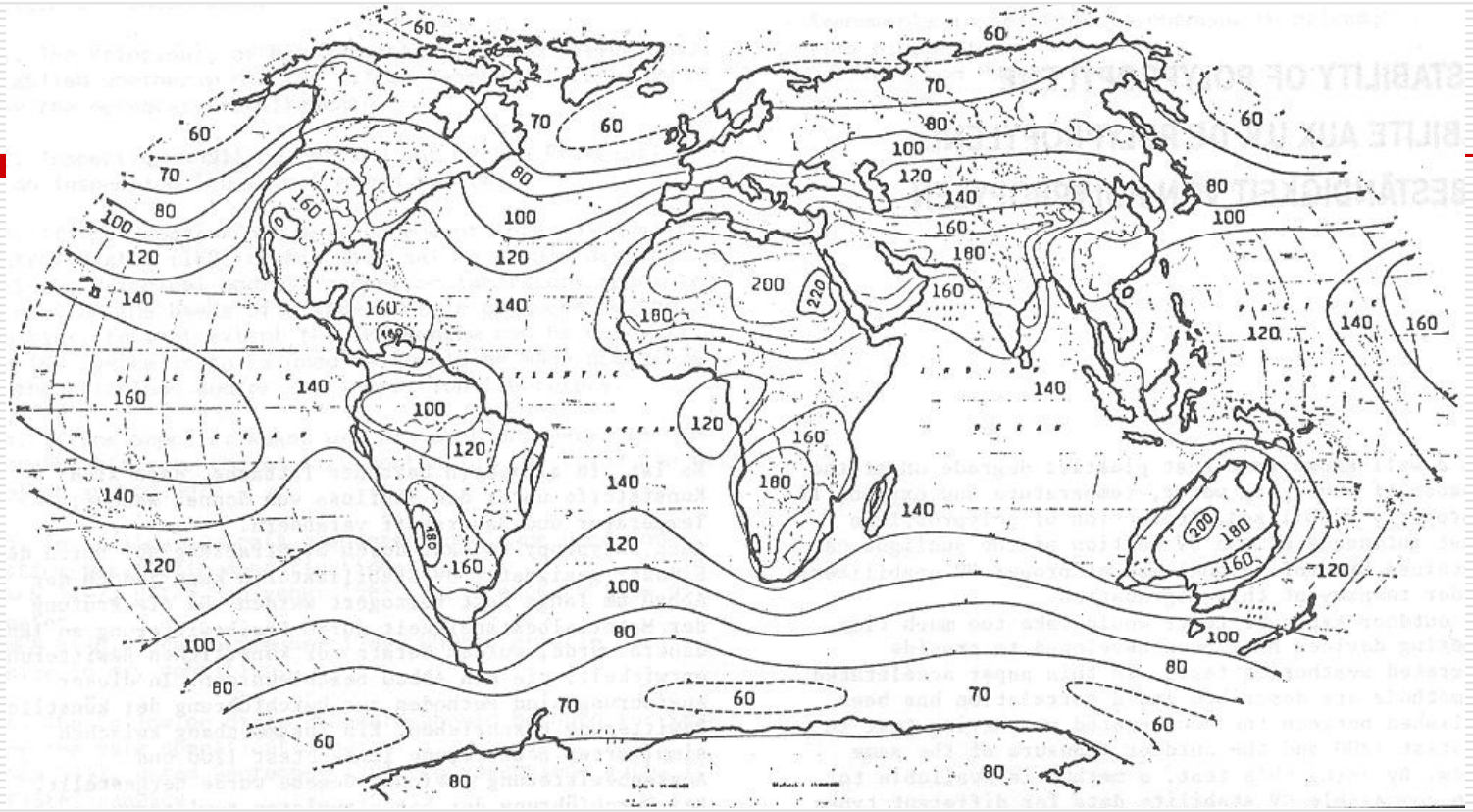
Option “A” –Correlation to World Energy Information Maps

Option “B” –Time-Temp.-Superposition; then Arrhenius

Option “C” –Correlation to Field Failure Samples of Similar GSs

Option “A” – Correlation to World Energy Information Maps

- incubate sample until halflife is reached
- record UV energy in MJ/m^2
- obtain UV energy at field site
- ratio approximates field life
- temperature correlation is not available
- considered to be <u>very</u> approximate

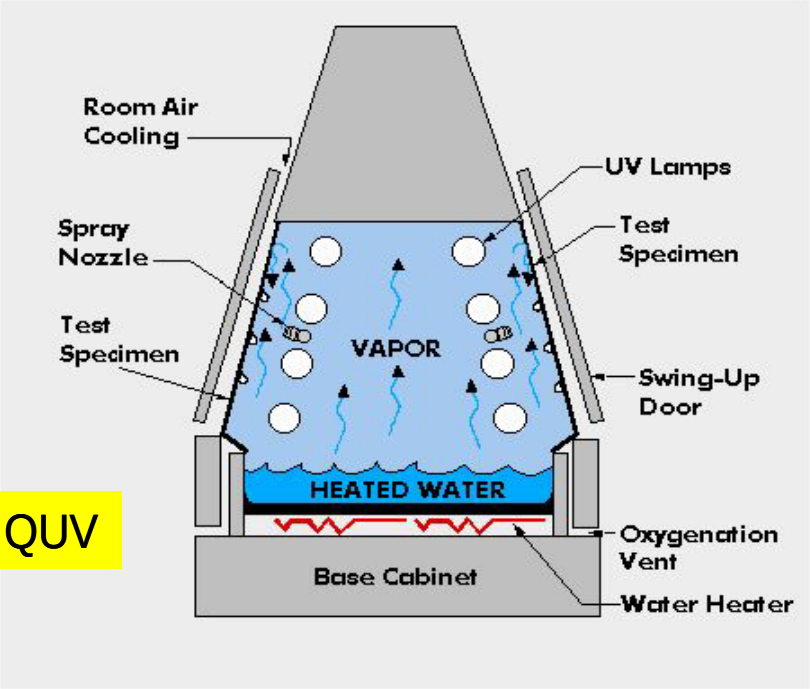


Annual irradiated energy isocurves in “kLy”; where 1 kLy = 1 kcal/cm^2;
ref. Van Wijk and Stoezer, 3IGC, Vienna, 1986

Option “B” –Time-Temp Superposition; then Arrhenius

ASTM D4355, Xenon

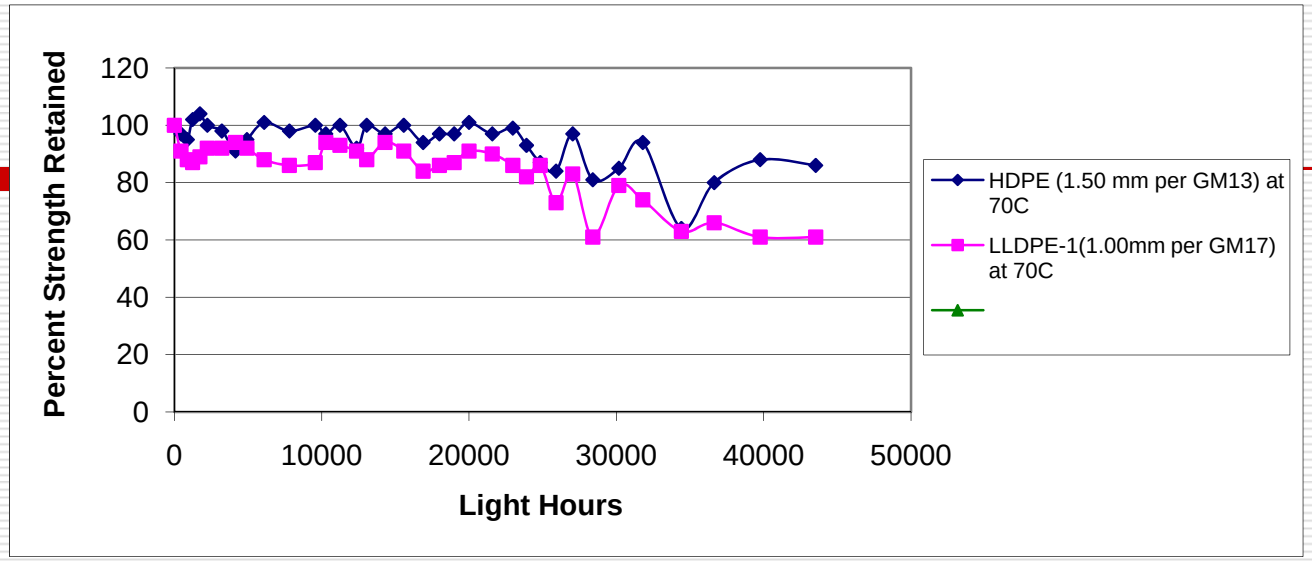
ASTM D7238, QUV

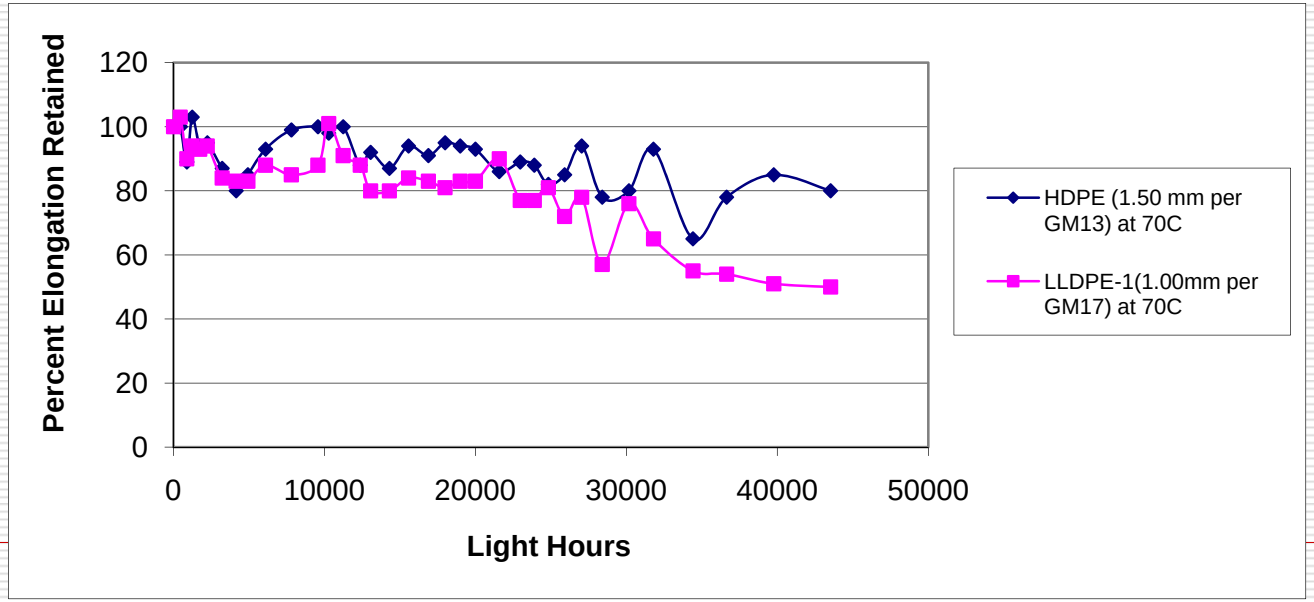


Option “C” – Correlation to Field Failure Samples

- requires actual sample(s) which failed in known time in the field
- incubate archived samples in weatherometer until failure occurs
- obtain correlation of lab to field times
- use correlation to predict other locations

Polyethylene Weatherometer Data





Exposed Lifetime Prediction Results of Selected Geomembranes to Date

Type	Specification	Prediction Lifetime in Texas, USA
HDPE-1	GRI-GM13	> 42+ years
LLDPE-1	GRI-GM17	36 years
EPDM-1	GRI-GM21	34 + years
PE-R-1	GRI-GM22	~ 17 years
fPP-1	GRI-GM18	33 years

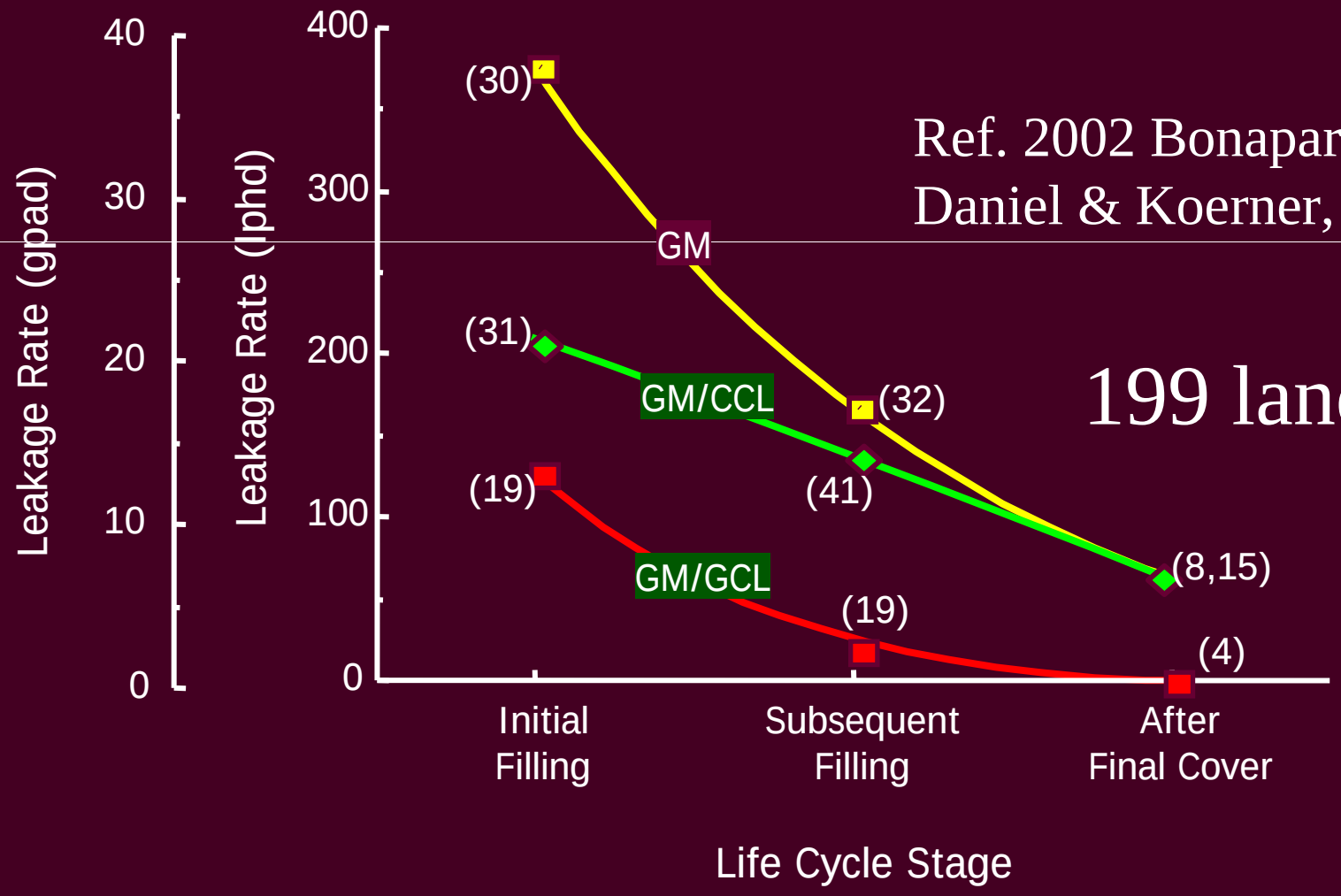
Geomembrane Buried Cover Performance

60mil HDPE, 24” cover soil, strain >100% GM = barrier

Geomembrane Exposed Cover Performance

60mil HDPE, 22 and 16 years, slight increase in density

Average Primary Leakage Rates

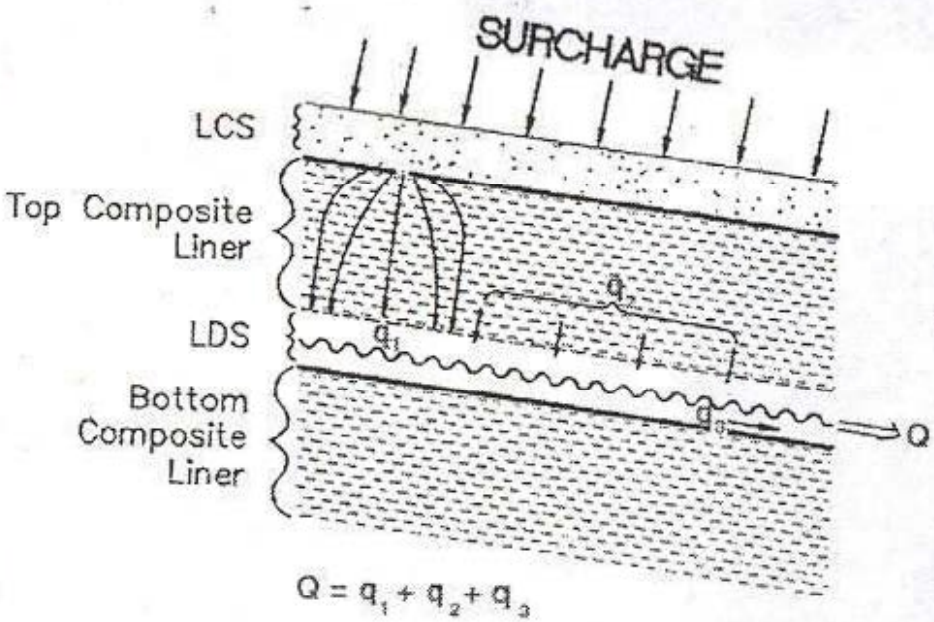


Ref. 2002 Bonaparte, Daniel & Koerner, USEPA

199 landfills

How Well Are New York State's Double-Lined Landfill Designs Working ?

Top Composite Liner Performance Monitoring



From 2005 Annual Reports

(data on 34 Landfills)

Primary LCRS Flows:

Max: 10,746 gpad; Min: 262.2 gpad; Mean: 1,341 gpad

Max: 107,460; Min 2,622 & Mean 13,410 lphd

Secondary LCRS Flows:

Max: 26.8 gpad; Min: 0.50 gpad; Mean: 7.2 gpad

Max: 268; Min 5 & Mean 72 lphd

Upper Liner System Efficiency:

Max: 99.95 %; Min: 93.72 %; Mean: 99.10 %

Summary and Recommendation

- GM-13 geomembranes work well
- Buried lifetime 100's of years, exposed GM lifetime 40 years plus
- Need comprehensive system approach, (design, raw material, GM-13, QC/QA, LIS and maintenance)
- regulators, owners, consultants require answers
- Perhaps a double composite cap is in order (GM/GCL-GN-GM/GCL)?