Sustainable Use of Recycled HDPE for Stormwater Drainage

AMERICA'S OVERALL GRADE

2017

INFRASTRUCTURE REPORT CARD

$3,900,000,000,000

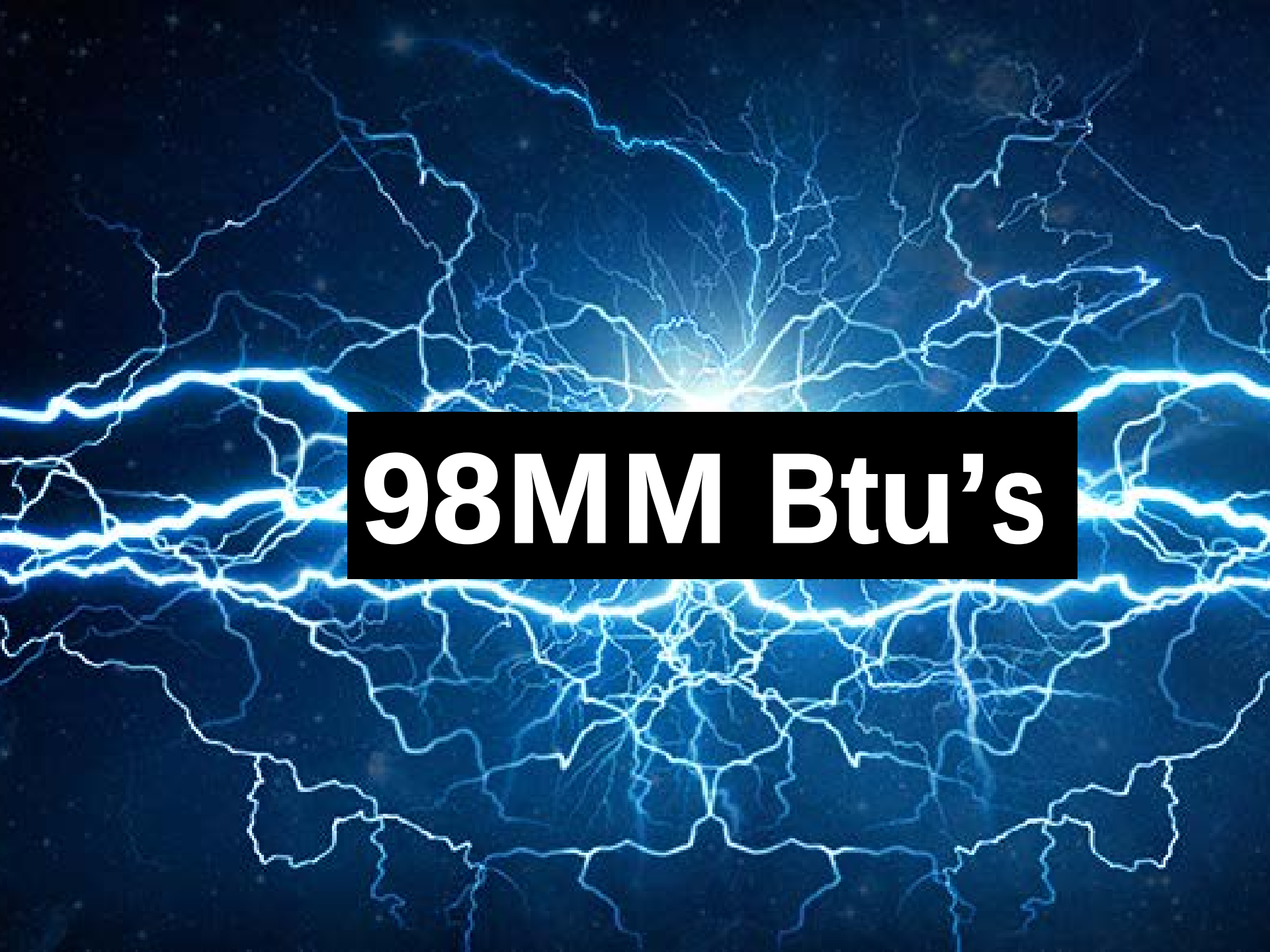
https://www.huffingtonpost.com/entry/plastic-waste-oceans_us_58fed37be4b0c46f0781d426

https://www.npr.org/2017/12/09/568797388/recycling-chaos-in-u-s-as-china-bans-foreign-waste


1 Ton

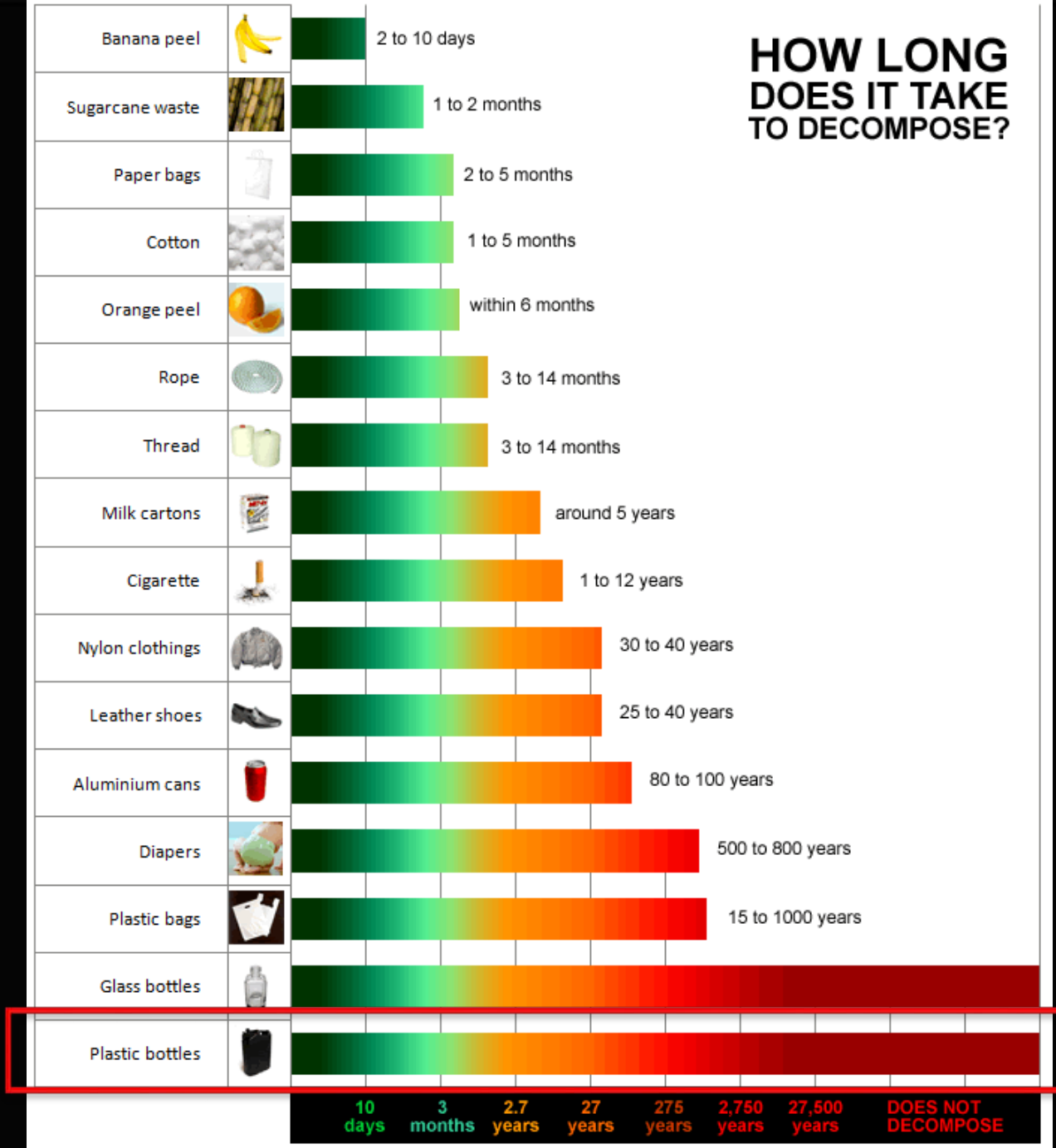

5,774kWh


685 Gal


98MM Btu’s


30 CY

HOW LONG DOES IT TAKE TO DECOMPOSE?



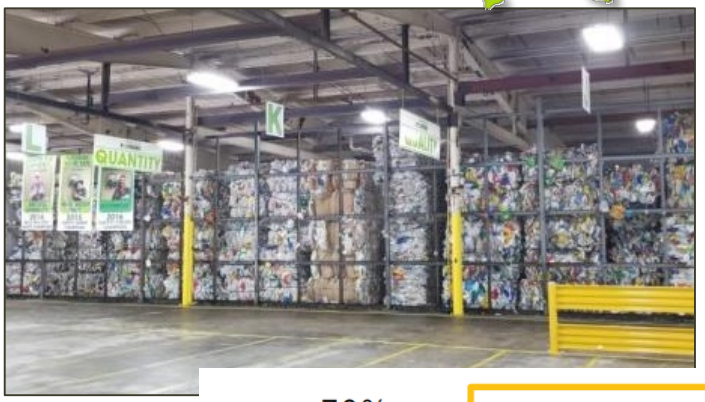
Source: http://socyberty.com/issues/strange-trash-facts/

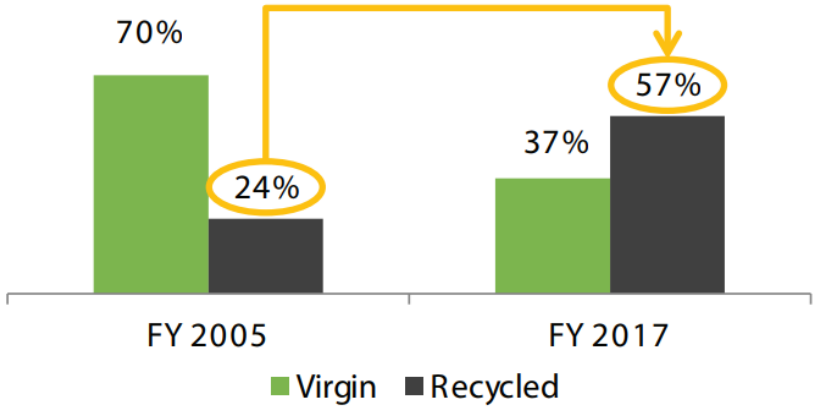

Purex
Purex

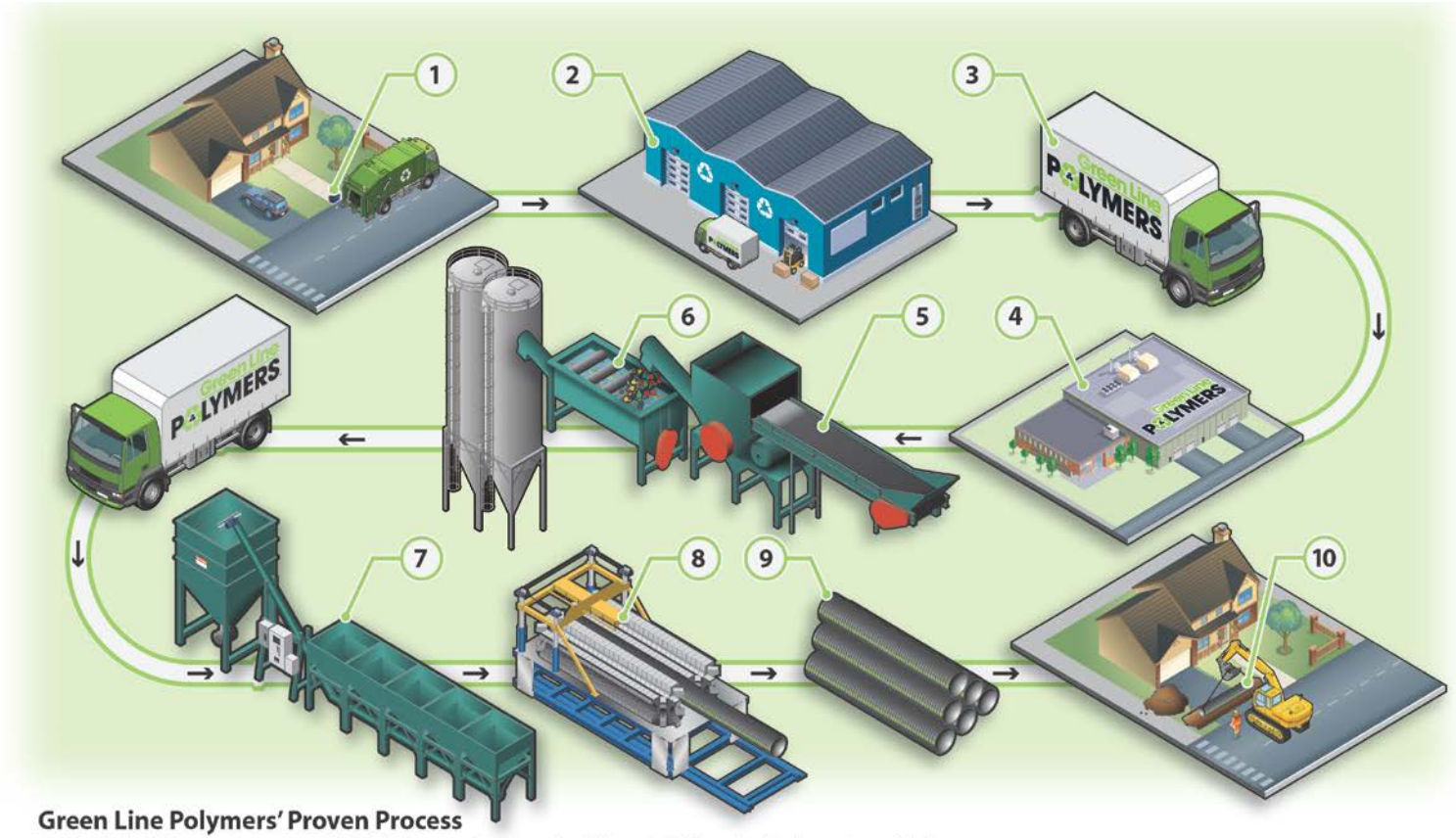
Green Line POLYMERS

255 million pounds post-consumer plastic + 170 million pounds post-industrial plastic

high performing pipe





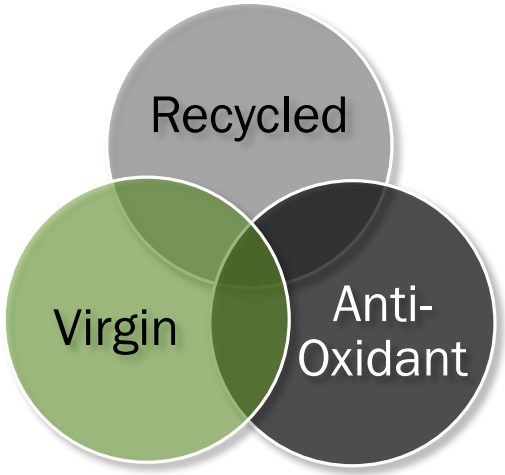


Green Line Polymers' Proven Process

1. Post-industrial and post-consumer HDPE plastic scrap is collected by your local recycling facility.
2. Green Line Polymers sources large quantities of HDPE material which is packed into bales and loaded for transport.
3. Green Line Polymers has a full-service logistics department ready to meet your needs. Our large fleet allows us to pay a competitive price for scrap HDPE while managing the increasing costs of transportation.
4. Green Line Polymers processes a wide variety of reusable HDPE material which is used in the manufacturing of products like N-12® MEGA GREEN® pipe.
5. Once the baled material arrives to the facility, it is sorted and ground into the desired flake size.
6. Flake material is washed to rinse off any debris or contaminants, ensuring a clean material for production.
7. The clean flake is dried and blended proportionately to create the desired resin quality.
8. The mixture is then extruded into corrugated molds to create top quality, uniform pipe.
9. Green Line Polymers allows for your post-industrial and post consumer HDPE material to be recycled directly into environmentally-friendly products rather than a landfill.
10. From beginning to end, Green Line Polymers' complete recycling process provides sustainable solutions and quality products for your project.

Green Line POLYMERS™

Recycled HDPE Pellets



Virgin HDPE Pellets

Carbon Black Pellets

NCHRP Project 4-32 – *Performance of Corrugated Pipe Manufactured with Recycled Content*

- $350,000
- Completed in 2011 and published in NCHRP Report 696

NCHRP Project 4-39 – *Field Performance of Corrugated HDPE Pipes Manufactured with Recycled Materials*

- $600,000
- Completed in 2016 and published in NCHRP 870

Evaluation of Corrugated HDPE Pipes Manufactured with Recycled Materials in Commuter Railroad Applications

- PhD Dissertation, published by Michael Pluimer, PhD in 2016

NCHRP
NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

TRI
TRI ENVIRONMENTAL, INC

CROSSROADS
ENGINEERING SERVICES

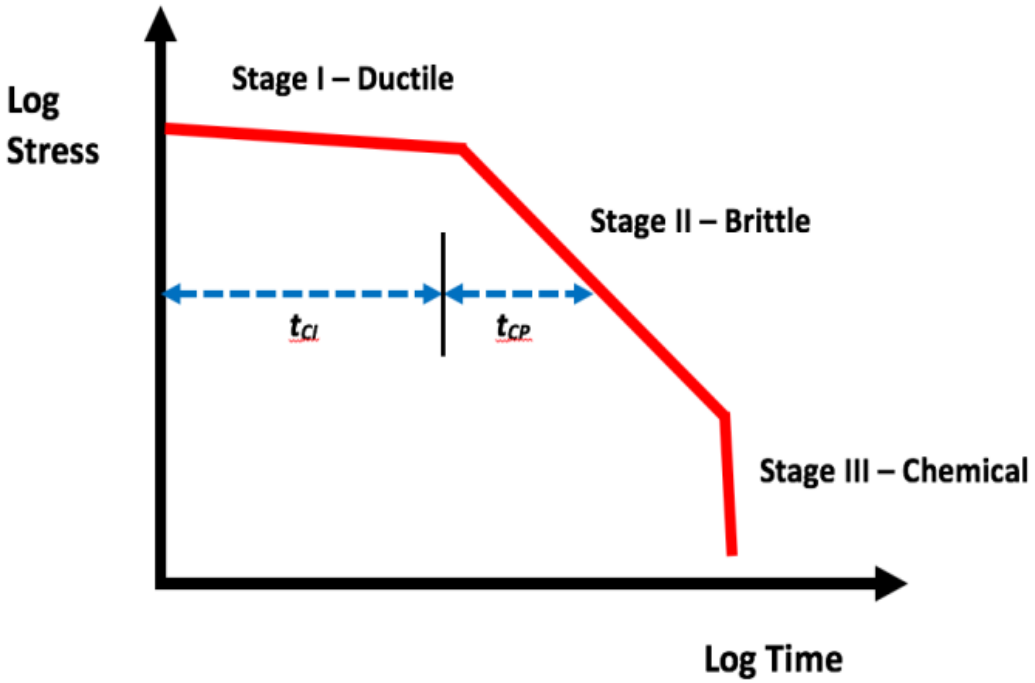
V

Highlights of Research

- Recommendations to include recycled HDPE content in pipe manufactured per AASHTO M294
- Must meet or exceed current virgin resin requirements
- Criteria to ensure 100-year service life established

AASHTO
THE VOICE OF TRANSPORTATION

Service Life

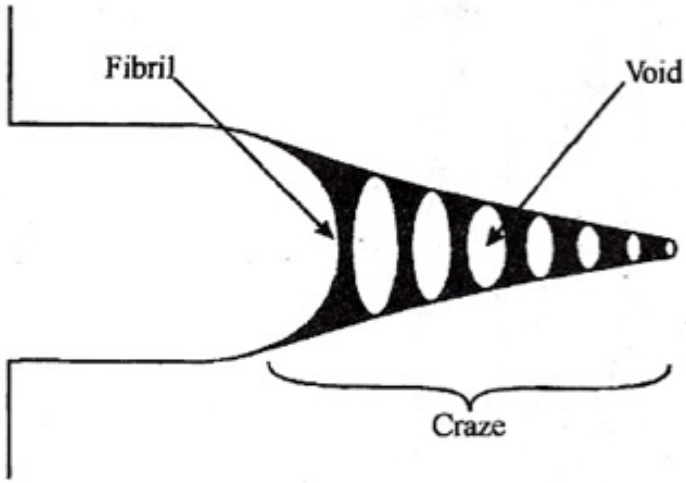


Creep

$$t_{CCG} = t_{CI} + t_{CP}$$

Fatigue

$$N_{FCG} = N_{CI} + N_{CP}$$



Notched Tests

$$t_{SCG} = t_{CI} + t_{CP}$$

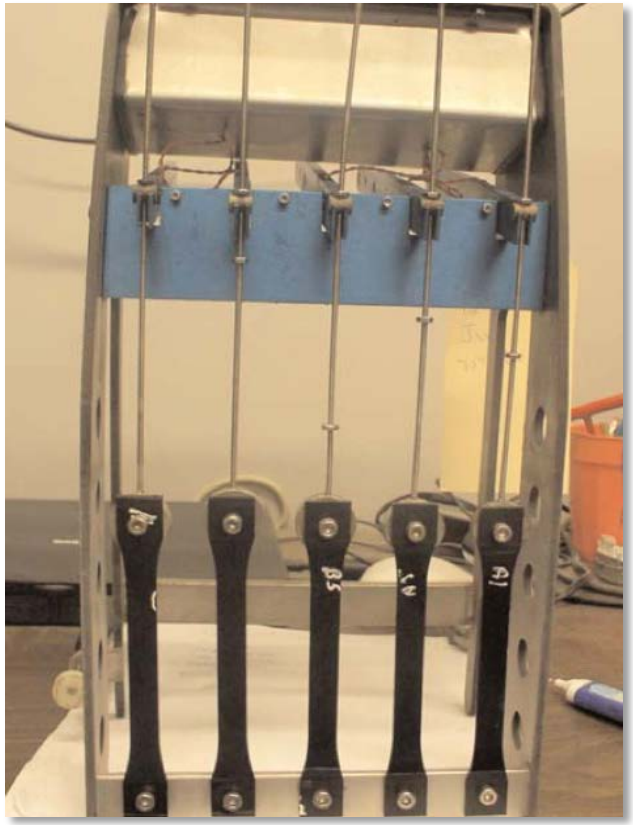
where

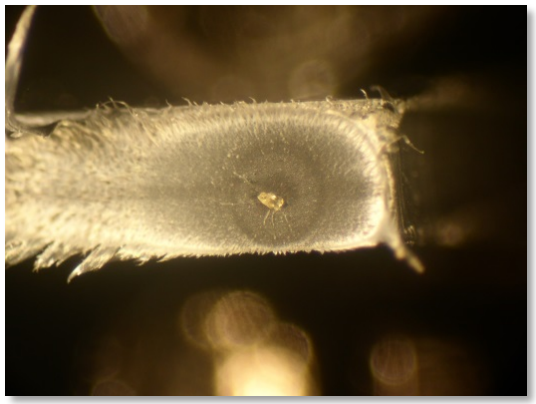
t_{SCG} = total time for slow crack growth
t_{CI} = time for crack initiation
t_{CP} = time for crack propagation

Designation: F3181 – 16

Standard Test Method for The Un-notched, Constant Ligament Stress Crack Test (UCLS) for HDPE Materials Containing Post- Consumer Recycled HDPE[1]

This standard is issued under the fixed designation F3181; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.





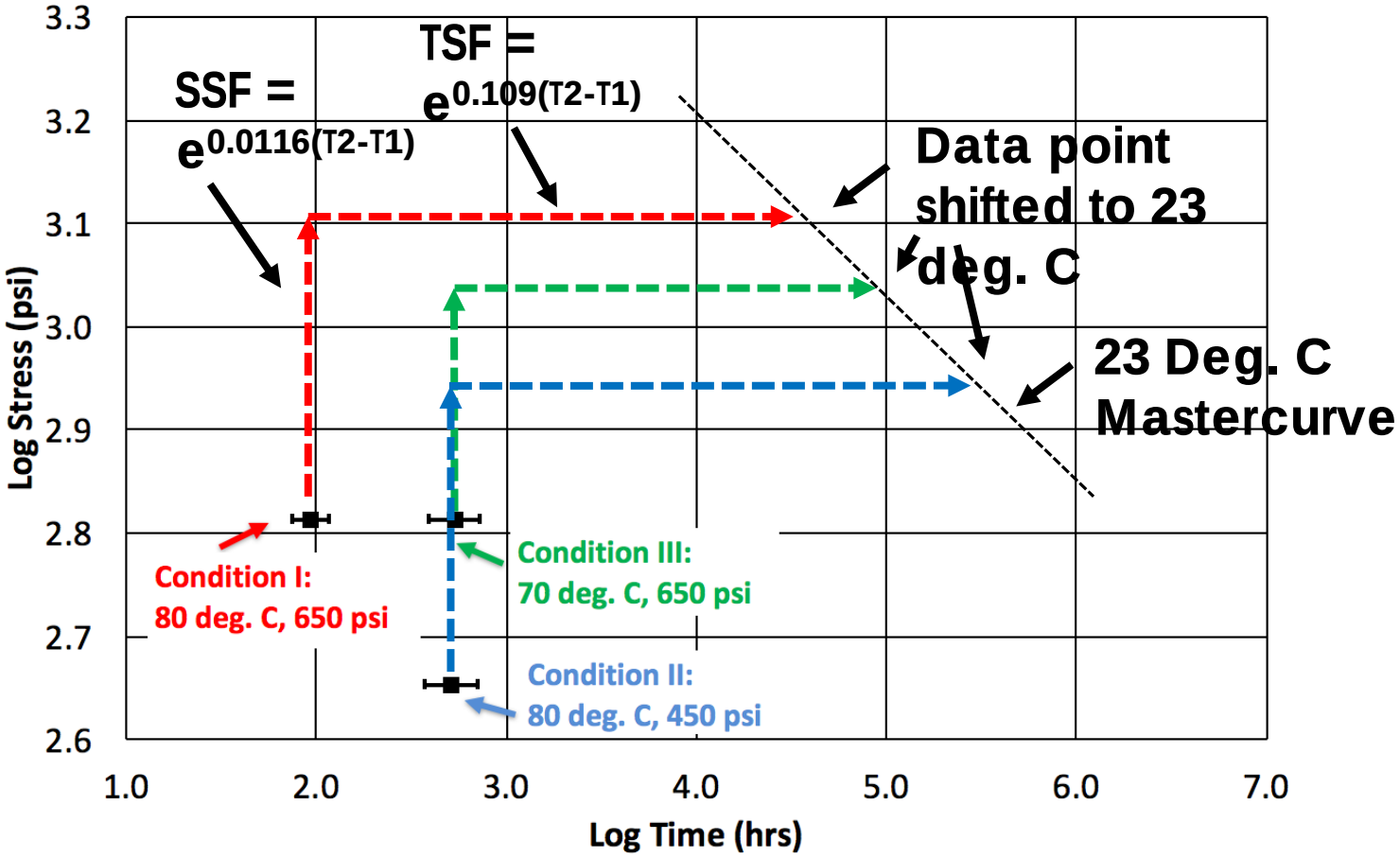
Popelar Shift Method:

Stress Shift Factor = e $^{0.0116(T2-T1)}$

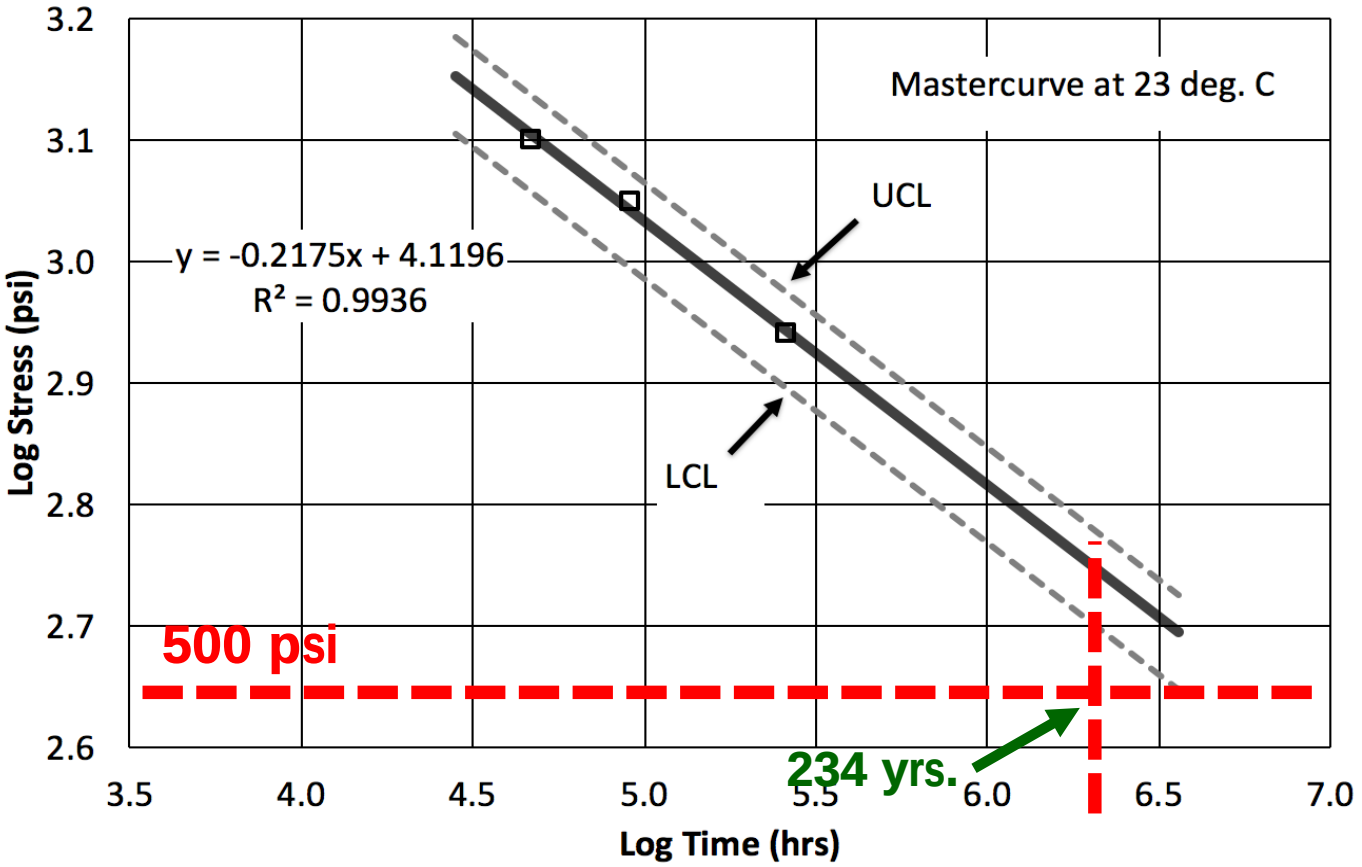
Time Shift Factor = e $^{0.109(T2-T1)}$

Rate Process Method:

$$\log t = A + \frac{B}{T} + \frac{C \log S}{T}$$


SSF = e^0.0116(T2-T1)
TSF = e^0.109(T2-T1)
Data point shifted to 23 deg. C
23 Deg. C Mastercurve
Condition I: 80 deg. C, 650 psi
Condition III: 70 deg. C, 650 psi
Condition II: 80 deg. C, 450 psi
Log Stress (psi)
Log Time (hrs)
3.3
3.2
3.1
3.0
2.9
2.8
2.7
2.6
1.0
2.0
3.0
4.0
5.0
6.0
7.0

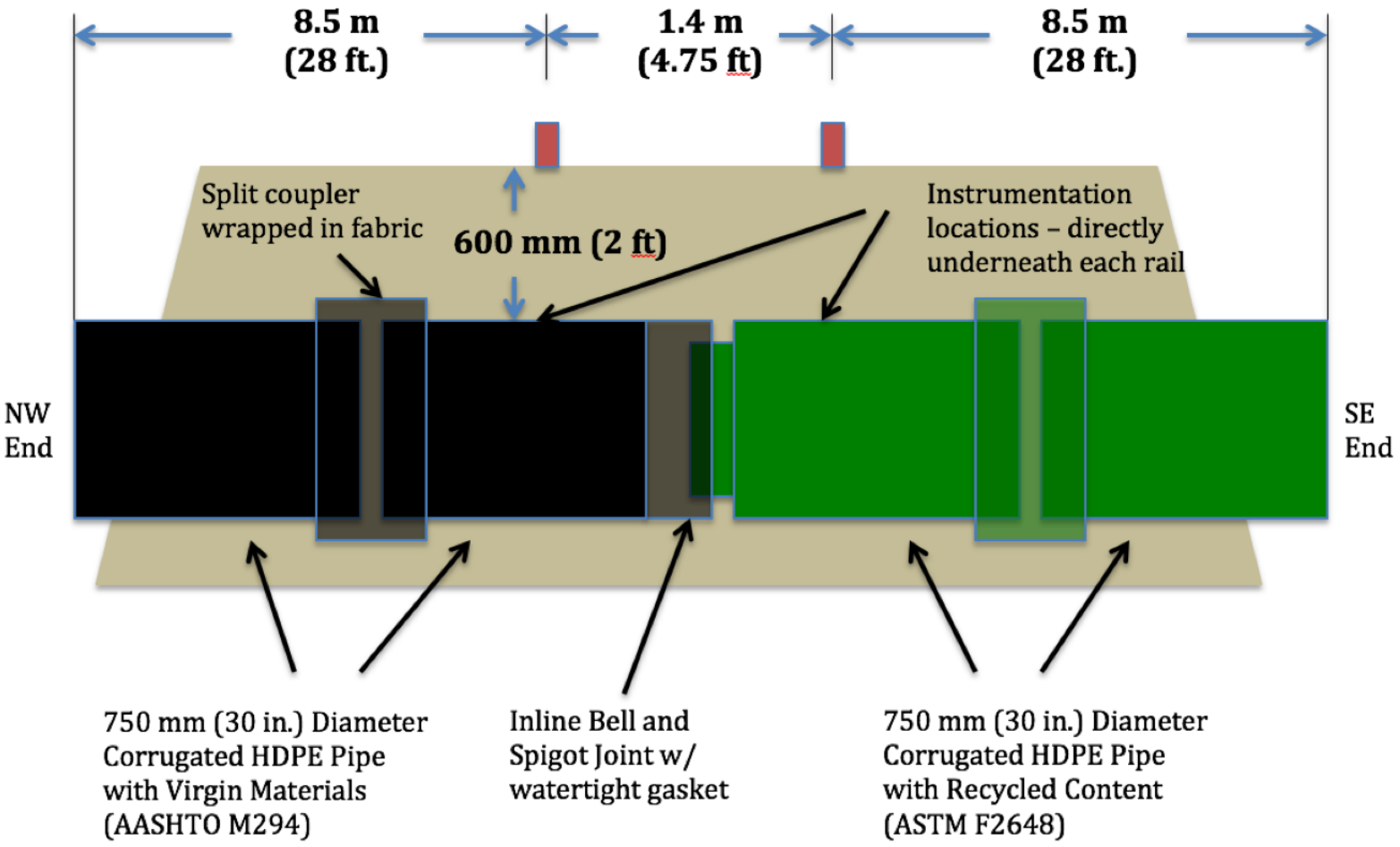
Service Life Prediction Illustration

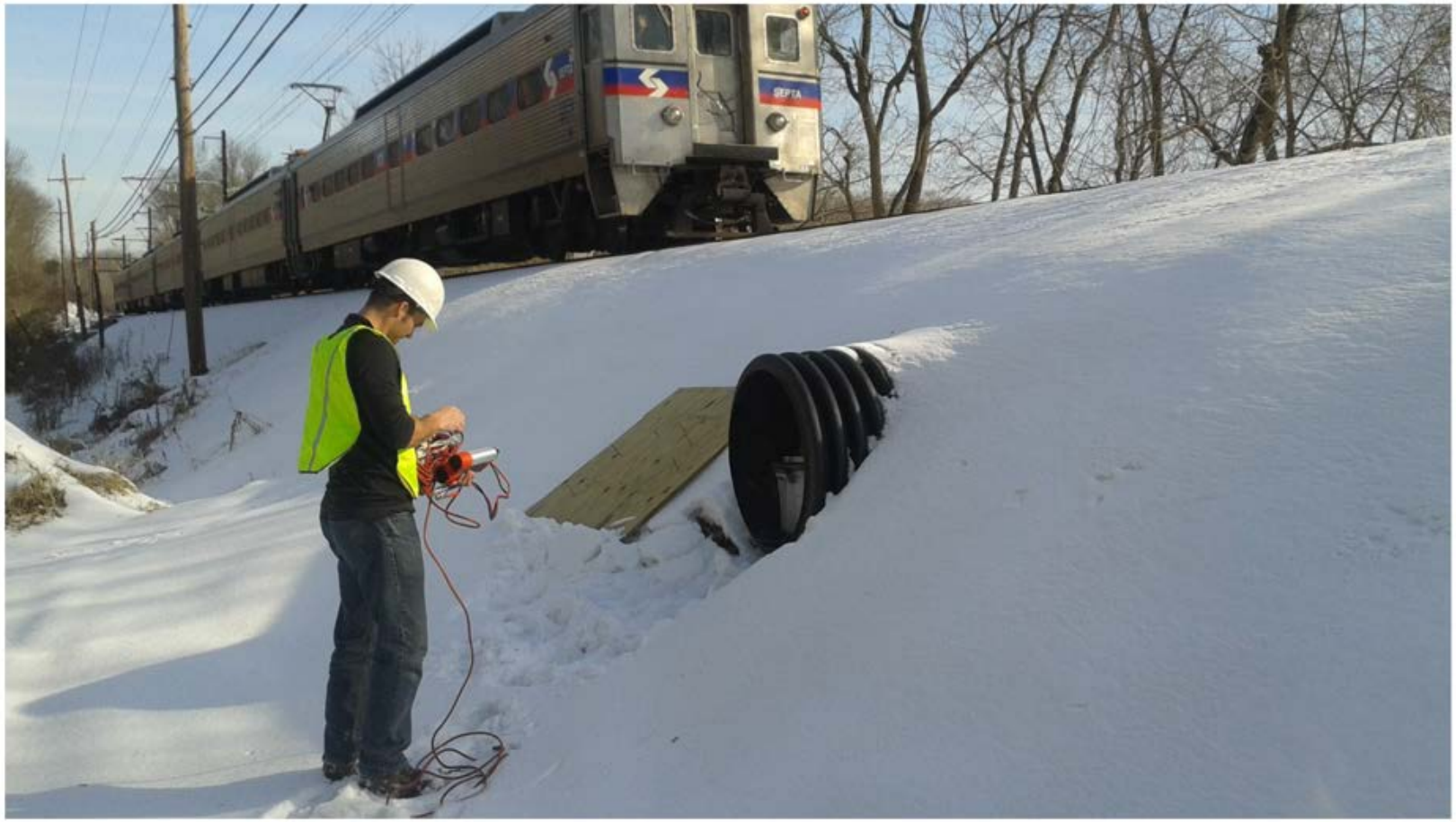


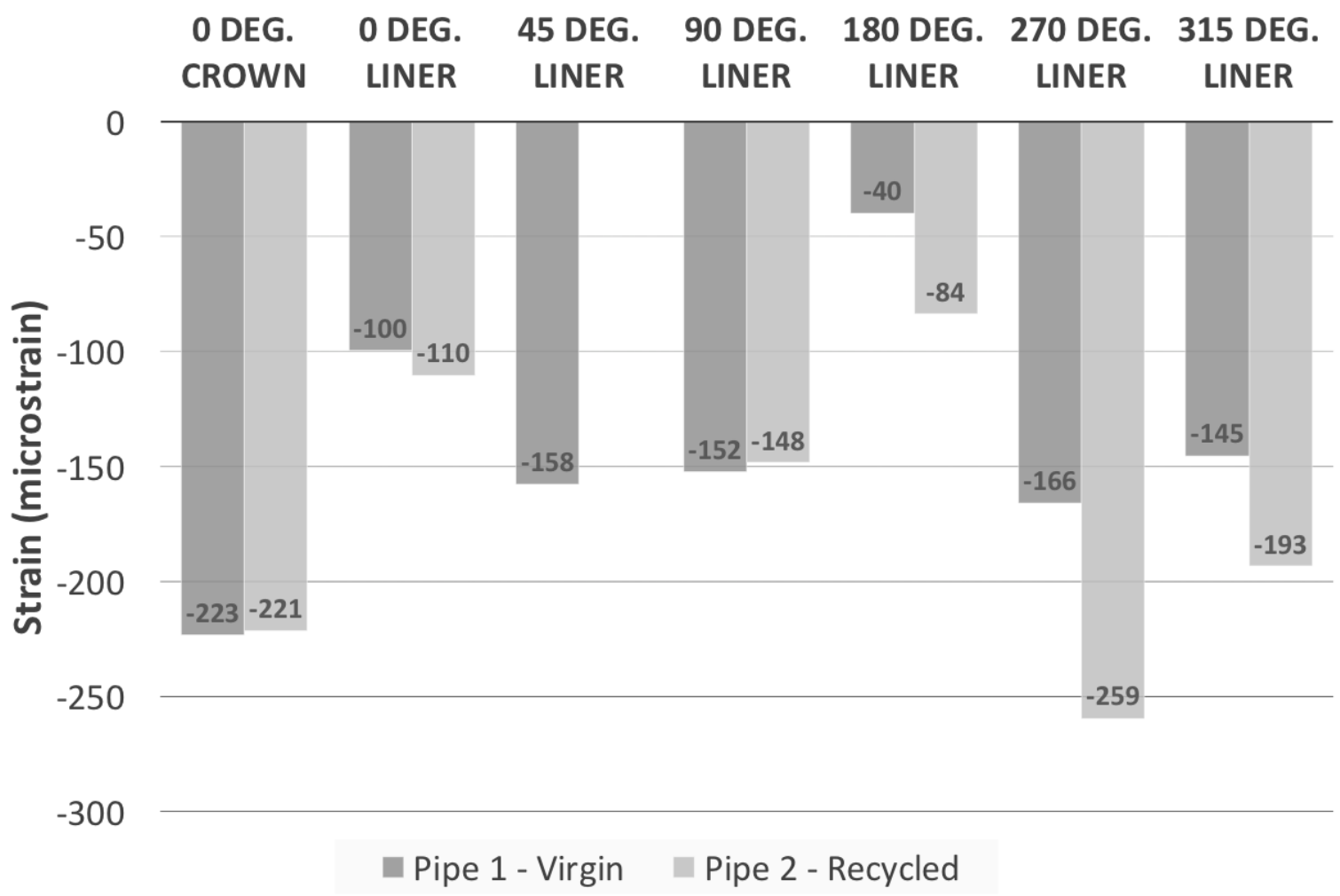
Lab Constant Stress
(Ohio University)

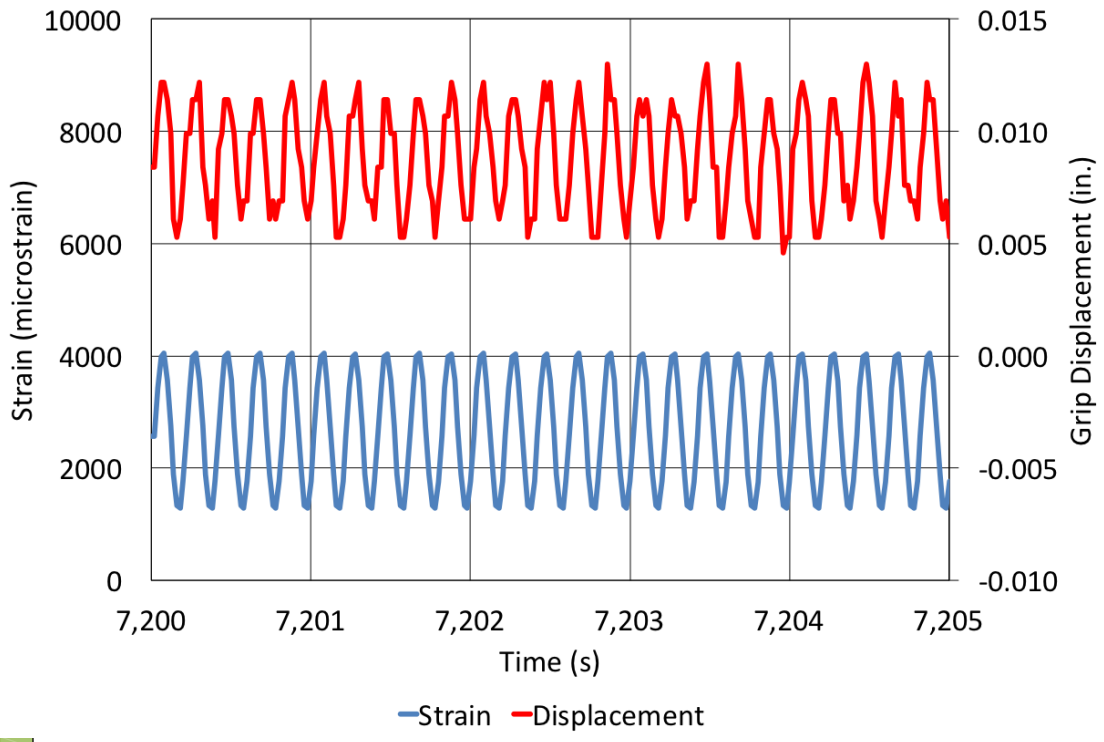
Simulated Field Installation
(TRI Load Cell)

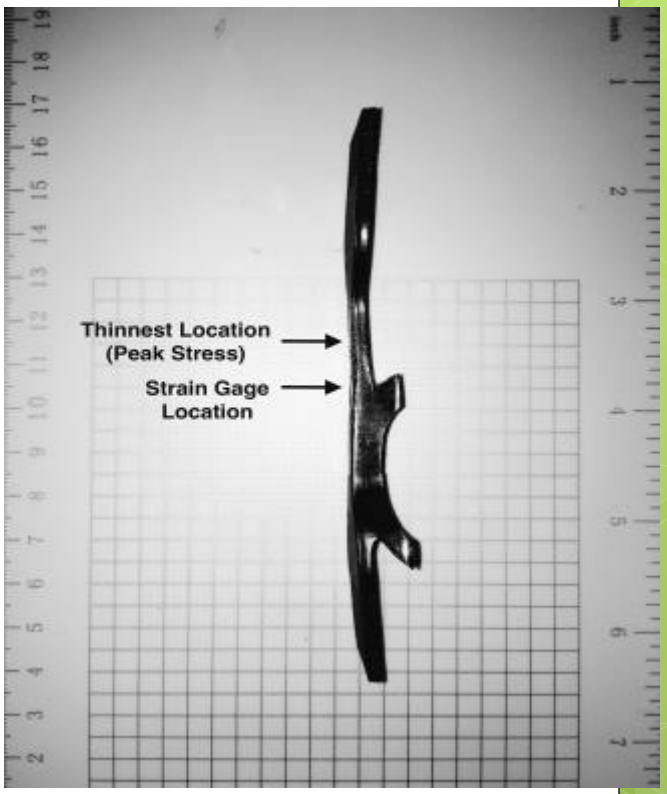
Pipe	Description	PCR	Predicted Time to Cracking	Actual Time to First Cracking
Pipe 1	30 in. M294 pipe	0%	> 2 yrs.	> 1 yr. - No cracks
Pipe 2	30 in. F2648 pipe	49%	> 2 yrs.	> 1 yr. - No cracks
Pipe 3	30 in. Custom pipe	98%	58 – 148 days	101 days
Pipe 4	30 in. F2648 pipe	49%	1.4 – 3.1 yrs.	> 1 yr. - No cracks
Pipe 5	30 in. M294 pipe	0%	> 2 yrs.	> 1 yr. - No cracks
Pipe 6	30 in. Custom pipe	98%	71 – 220 days	185 days
Pipe 7	30 in. Custom pipe	98%	73 – 172 days	185 days
Pipe 8	30 in. F2648 pipe	54%	203 - 578 days	> 306 d - No cracks
Pipe 9	30 in. F2648 pipe	59%	139 – 357 days	300 days


8.5 m
(28 ft.)
1.4 m
(4.75 ft)
8.5 m
(28 ft.)
Split coupler
wrapped in fabric
600 mm (2 ft)
Instrumentation
locations – directly
underneath each rail
NW
End
SE
End
750 mm (30 in.) Diameter
Corrugated HDPE Pipe
with Virgin Materials
(AASHTO M294)
Inline Bell and
Spigot Joint w/
watertight gasket
750 mm (30 in.) Diameter
Corrugated HDPE Pipe
with Recycled Content
(ASTM F2648)


SEPTA


0 DEG. CROWN
0 DEG. LINER
45 DEG. LINER
90 DEG. LINER
180 DEG. LINER
270 DEG. LINER
315 DEG. LINER
Strain (microstrain)
0
-50
-100
-150
-200
-250
-300
-223
-221
-100
-110
-158
-152
-148
-40
-84
-166
-259
-145
-193
Pipe 1 - Virgin
Pipe 2 - Recycled


10000
8000
6000
4000
2000
0
Strain (microstrain)
0.015
0.010
0.005
0.000
-0.005
-0.010
Grip Displacement (in.)
7,200
7,201
7,202
7,203
7,204
7,205
Time (s)
Strain
Displacement


Thinnest Location
(Peak Stress)
Strain Gage
Location

Pipe	Spec	PCR, %	Dynamic Grip Displacement, mm (in.)	Peak-Peak Dynamic Strain, microstrain	Number of Cycles, millions	Results
1	1-1	0	+/- 0.05 (0.002)	1200	1.0	No cracking
2	2-1	49	+/- 0.05 (0.002) +/- 0.13 (0.005)	1200 – 1st million 2700 – 2nd million	2.0	No cracking
4	4-1	49	+/- 0.05 (0.002)	1200	6.4	No cracking
	4-1	49	+/- 0.05 (0.002)	1200	10.0	No cracking

Standard Recommended Practice for

Service Life Determination of Corrugated HDPE Pipes Manufactured with Recycled Materials

AASHTO Designation: M xxx-yy[1]

Technical Section: No., Name

Release: Group n (Month yyyy)

AASHTO

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Thank You

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