ADS
ADVANCED DRAINAGE SYSTEMS, INC.

Plastic Corrugated HDPE Drainage Pipe with Recycled Content

Joe Babcanec, PE

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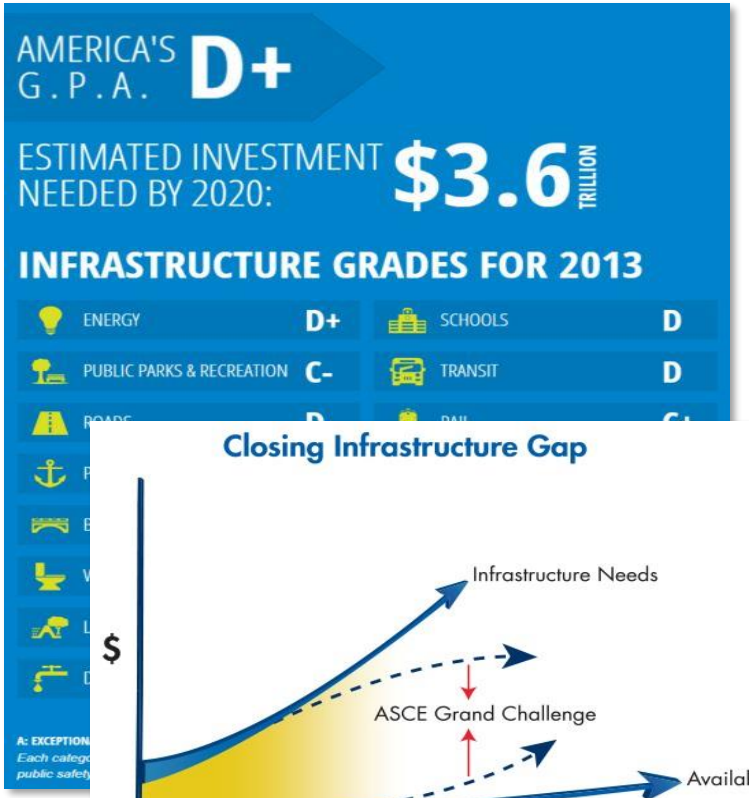
Recycled Materials for Public Storm Pipe

Infrastructure Challenge



Sustainable & Resilient Solutions

How Our Recycling Process Works

In fiscal 2020, we consumed

29%

of the recycled pigmented HDPE bottles in the United States.

The amount of recycled plastic we consumed in fiscal 2020 reduced our Greenhouse Gas emissions by over 730 million pounds, which amounts to taking

70,000

cars off the road.

In fiscal 2020, we consumed 29% of the recycled pigmented HDPE bottles in the United States.

These bottles as well as other plastics and recyclable materials are picked up through curbside recycling programs and taken to recycling centers.

At the recycling centers, materials are sorted and packed into bales. The bales are then taken to our recycling facilities.

We sort, shred and wash the material, turning it into clean plastic flakes. We test all plastic material for quality assurance.

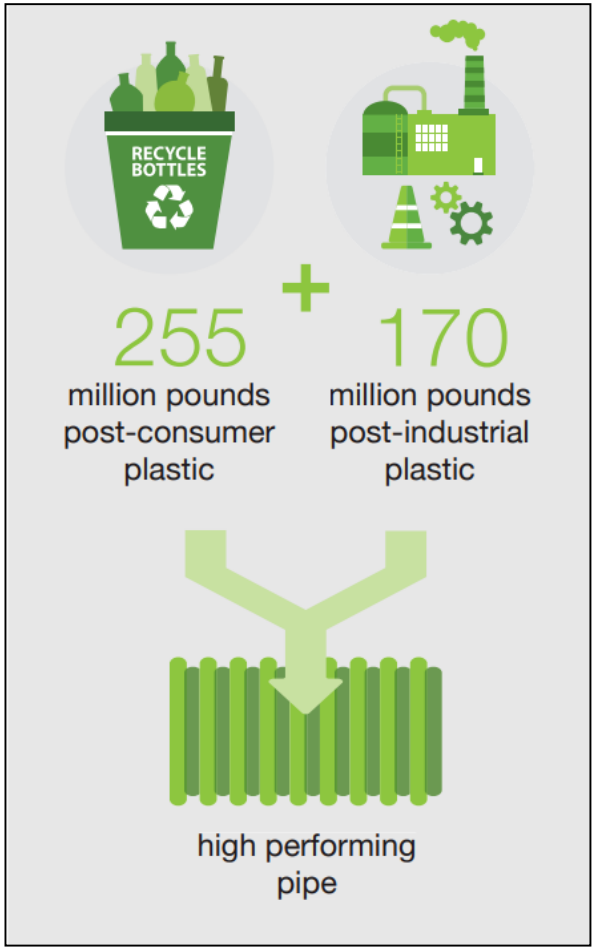
Flake may be further pelletized and is then used in the manufacturing process.

ADS pipe products are installed in stormwater systems that are designed to last over 100 years

ADS' Commitment to Sustainability

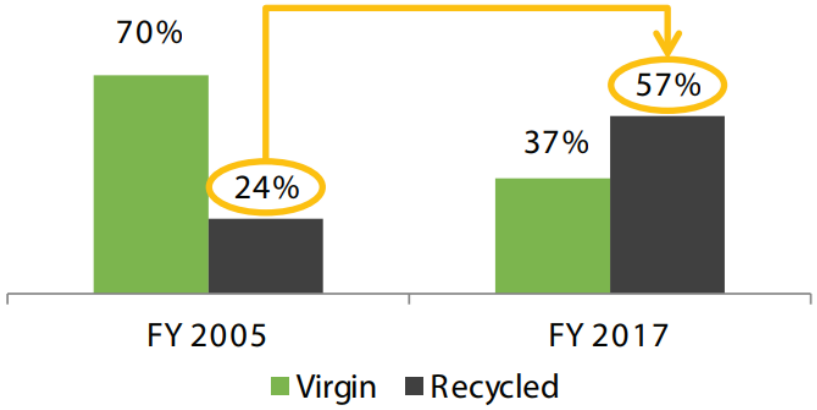
Green Line POLYMERS

HDPE Material Recycled Annually



Eight (8) Recycling Locations

Sustainable Product Evolution



https://www.ads-pipe.com/

The Perfect Outlet

- Drainage pipe is the ideal outlet for recycled HDPE
  - Colored flake can be used since end product is black
  - Blending allows for use of materials with a wide range of properties
  - Odors remaining in the plastics are not a concern
  - Short service life products are removed from a closed tight loop recycling chain and put it into service for 50-100 years

Research Overview

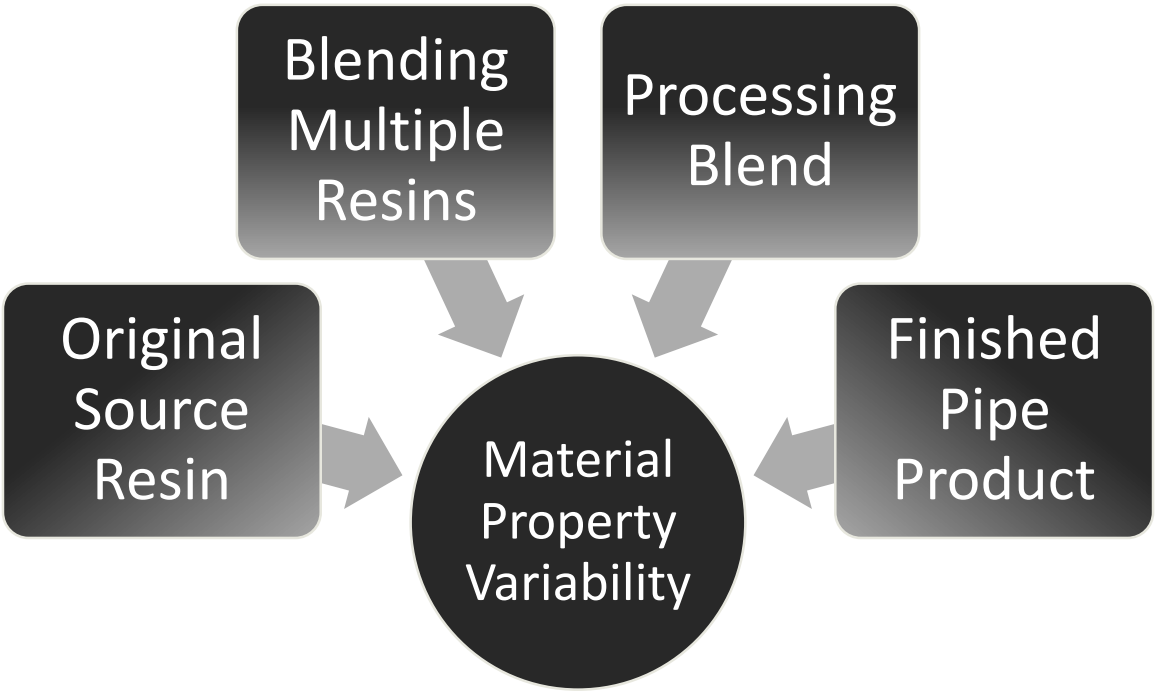
Key Recycled HDPE Research Projects

- NCHRP Project 4-32 – *Performance of Corrugated Pipe Manufactured with Recycled Content*
  - $350,000 project, TRI was prime contractor
  - 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 3-year project built on Project 4-32; TRI and Crossroads Engineering Services were Principal Investigators
  - Completed in 2016 and will be published in NCHRP Report 870
- *Evaluation of Corrugated HDPE Pipes Manufactured with Recycled Materials in Commuter Railroad Applications*
  - PhD Dissertation, published by Michael Pluimer, PhD in 2016

AASHTO M294 Now Includes Recycled Materials

- Pipes manufactured with recycled materials must meet all of the requirements of pipes manufactured with virgin materials
  - Same cell classification, NCLS criteria, structural properties, pipe stiffness, etc.
- In addition, pipes manufactured with recycled materials must also meet the following criteria:
  - Average UCLS failure time must exceed a minimum calculated value to ensure that service life exceeds 100 years
  - Minimum OIT of 20 minutes (ensures resistance to Stage III chemical failure)
  - Elongation at break must exceed 150% (redundant contaminant test)

Project Goals



https://www.ads-pipe.com/

Nomenclature

- Post-Consumer HDPE
  - General public recycling
  - Milk jug, detergent containers, food & product packaging
  - Includes commercial and industrial products that have served its purpose
- Post-Industrial HDPE
- Flake
- Salt & Pepper Blending
- Pellets & Pelletizing

Recycled HDPE Bales

Nomenclature

- Post-Consumer HDPE
- Post-Industrial HDPE
  - Excess or rejected bottles, crates, drums dunnage
- Flake
- Salt & Pepper Blending
- Pellets & Pelletizing

Post-Industrial HDPE

Nomenclature

- Post-Consumer HDPE
- Post-Industrial HDPE
- Flake
  - Original production, shredded plastic; washed
- Salt & Pepper Blending
- Pellets & Pelletizing

Recycled HDPE Flake

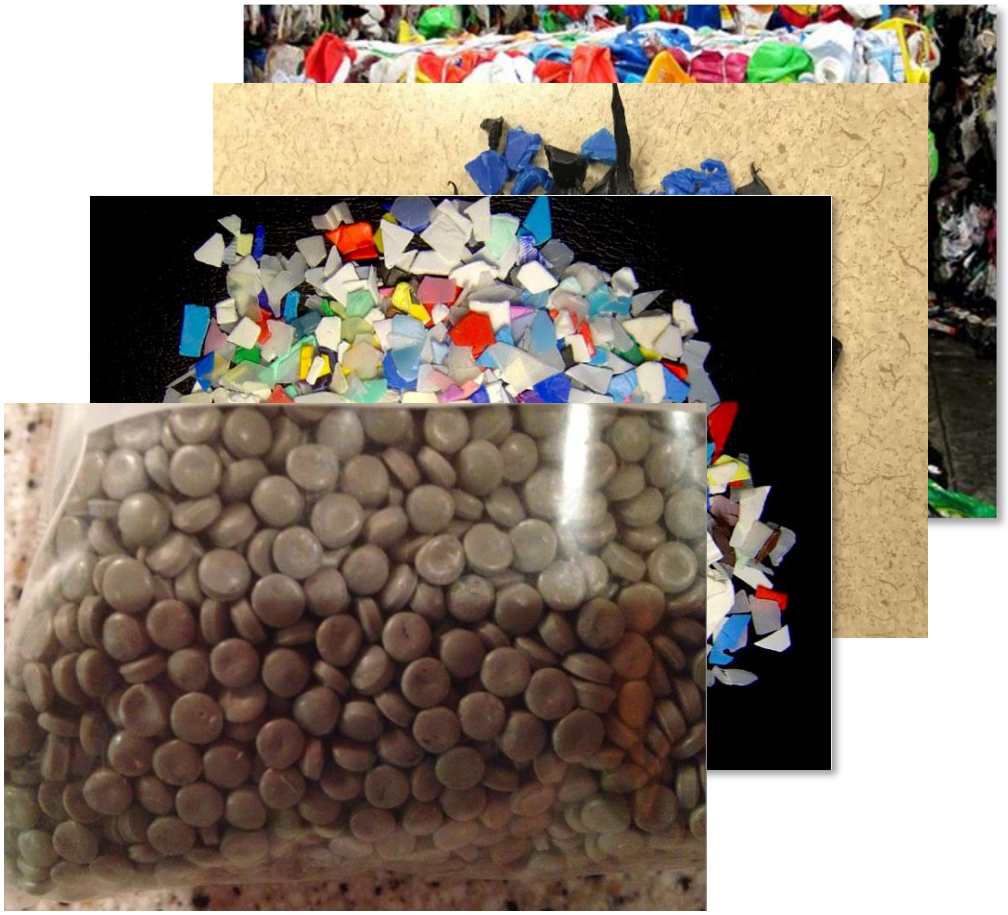
Nomenclature

- Post-Consumer HDPE
- Post-Industrial HDPE
- Flake
- Salt & Pepper Blending
  - Mechanical blending of 2+ components
- Pellets & Pelletizing

Recycled HDPE Flake

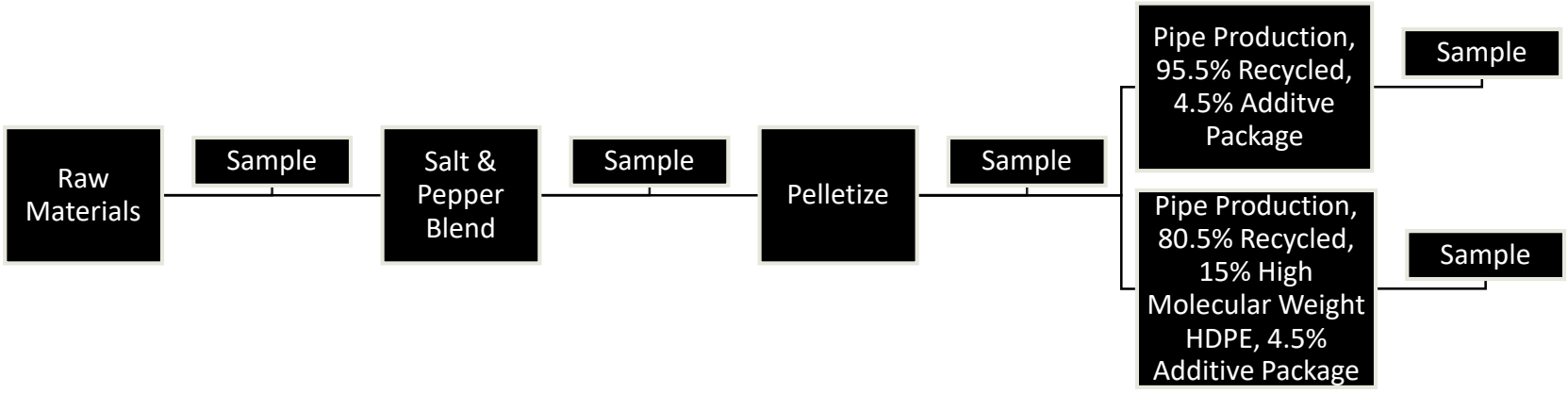
Nomenclature

- Post-Consumer HDPE
- Post-Industrial HDPE
- Flake
- Salt & Pepper Blending
- Pellets & Pelletizing
  - Melt, blend, filter process
  - Extruded into thin, cylindrical pellets



Recycled HDPE Pellets

Experiment


Raw Materials
Sample
Salt & Pepper Blend
Sample
Pelletize
Sample
Pipe Production, 95.5% Recycled, 4.5% Additve Package
Sample
Pipe Production, 80.5% Recycled, 15% High Molecular Weight HDPE, 4.5% Additive Package
Sample

Experiment

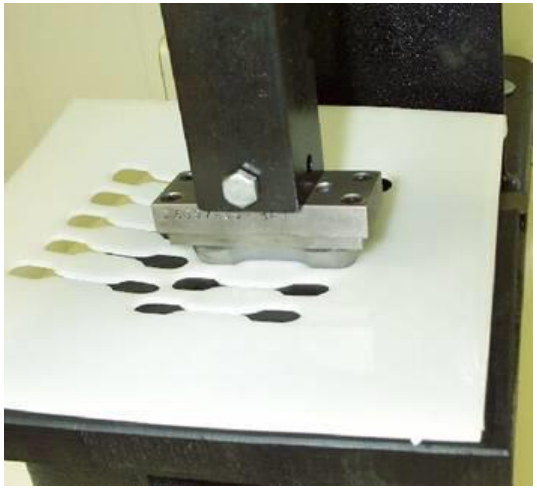
- 45,000lbs total material
  - 45% “Z” (post-industrial flake)
  - 25% “6” (post-consumer flake)
  - 15% “X” (post-industrial blow molding flake)
  - 10% “V” (post-industrial film)
  - 5% “Y” (post-industrial pellet)
- 95.5% recycled content, 4.5% additive to meet ASTM F2648 requirements
- 80.5% recycled content, 15% high molecular weight HDPE, 4.5% additive to meet AASHTO M294 requirements

Tested Properties

- Notched Constant Ligament Stress, per ASTM F2136
  - Initiated crack, time to failure
  - Stress crack resistance

Standard Specification	Melt Index [ASTM D1238]	NCLS [ASTM F2136], hrs	UCLS [ASTM F3181], hrs
ASTM F2648 Private land drainage	<0.15	Avg >16, Min >12	N/A
AASHTO M294 Surface and subsurface drainage	<0.15	Avg ≥24	Avg >34, Min >18

Finished pipe requirements; not raw material



Tested Properties

- Un-notched Constant Ligament Stress, per ASTM F3181
  - Crack propagation, time to failure
  - Presence of contaminant

Standard Specification	Melt Index [ASTM D1238]	NCLS [ASTM F2136], hrs	UCLS [ASTM F3181], hrs
ASTM F2648 Private land drainage	<0.15	Avg >16, Min >12	N/A
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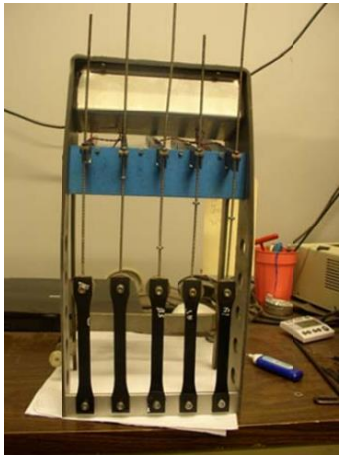
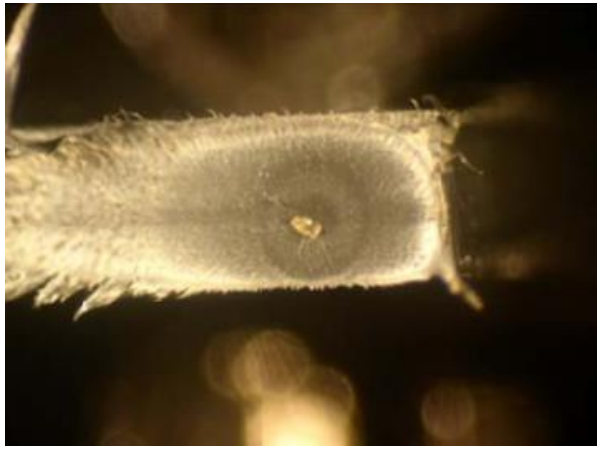
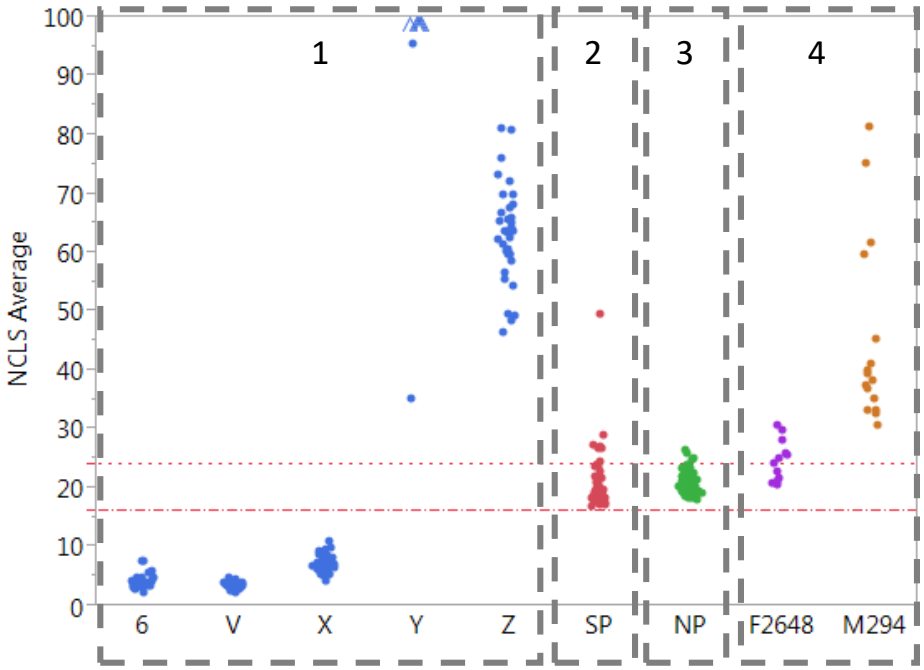




Results

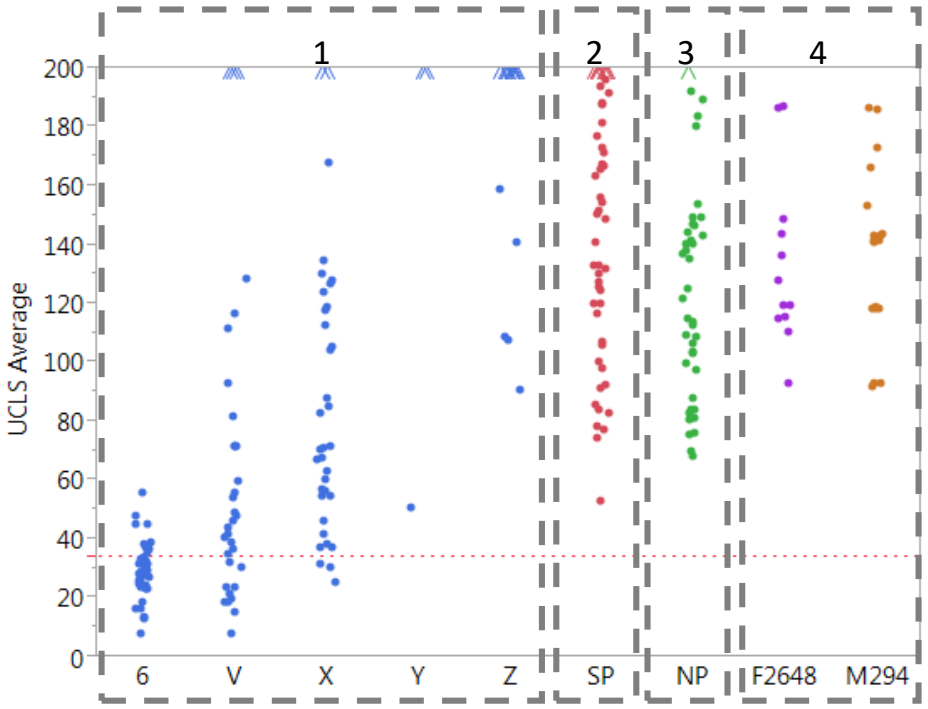


NCLS

1. Raw material wide distribution
2. Mechanical blending some homogenization
3. Pelletizing (melt-filter) further homogenization
4. Pipe product extrusion
    1. Addition of virgin HDPE increased failure time

Dotted line is minimum average failure time per AASHTO M294
Dashed line is minimum average failure time per ASTM F2648
Arrows at top of chart indicate results exceeding the scale shown

Results



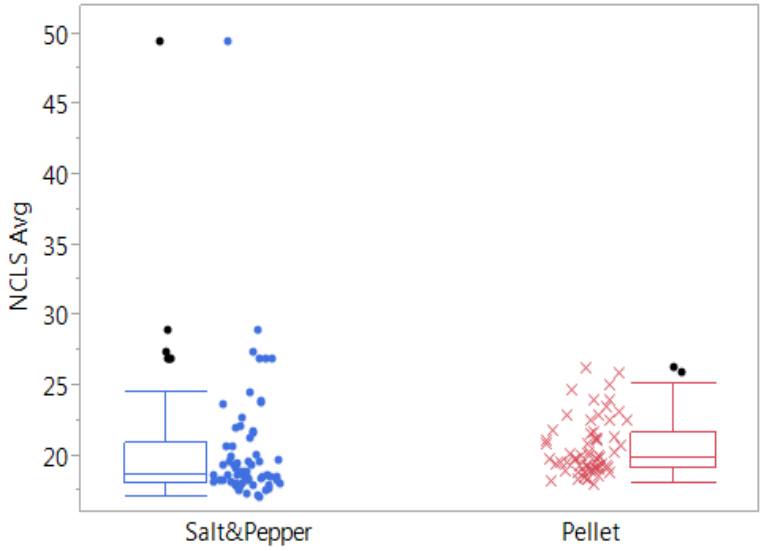
UCLS

1. Raw material wide distribution
2. Mechanical blending some homogenization
3. Pelletizing (melt-filter) some homogenization
4. Pipe product extrusion

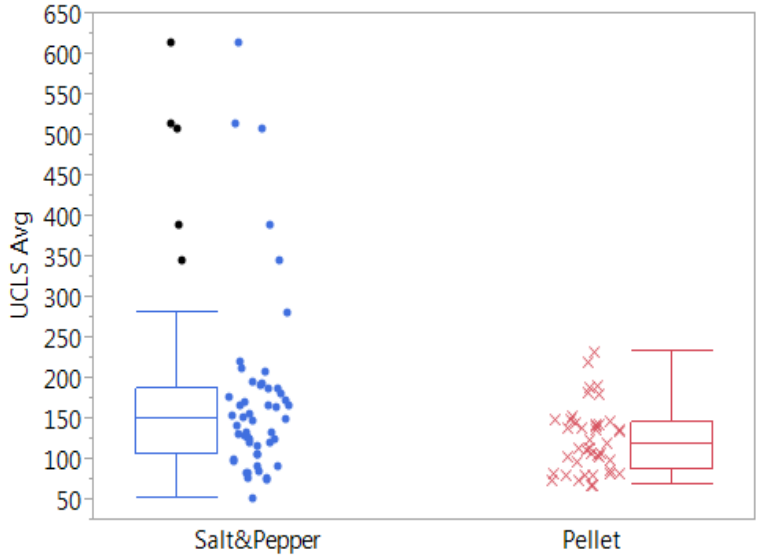
Dotted line is minimum average failure time per AASHTO M294
Arrows at top of chart indicate results exceeding the scale shown

Significance of Pelletizing to Variability

NCLS



UCLS



Conclusions

- Raw material testing alone does not predict final product performance
- Mechanical blending facilitates homogenizing the blend
- Statistically significant reduction in variability with pelletizing salt & pepper (mechanical) blend
- Significant increase in stress crack resistance with 15% high molecular weight HDPE addition to meet AASHTO M294
- Recycled-content HDPE for corrugated pipe production is viable and will meet performance & service life requirements

Special Thanks!

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ADS plant production and laboratory personnel

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