Plastics Forming Enterprises LLC

Laboratory Report #C102

Phase 1

PET Color

Contamination Study

Plastics Forming Enterprises, LLC

Plastics Consulting, Research, and Engineering

General Overview

Plastics Forming Enterprises (PFE) is conducting a multi-phase study to identify the most significant effects of contaminants on the quality of the PET recycling stream. As a leading contributor to the advancement of plastics recycling for over forty years, PFE is responding to ongoing challenges faced by PET reclaimers related to contamination. Contaminants can reduce the quality of PET for end-market products, damage equipment during reprocessing, and decrease the volume of recyclable material. This three-phase study aims to take a closer look at the known contaminants present in the PET recycling stream and analyze their impact on the performance of end-market products.

Through this data-driven approach, PFE seeks to establish a foundational understanding of contaminant thresholds that significantly affect PET color properties, reduce process efficiency, and lower reclaim yield. The resulting data will inform best-practice recommendations for brands, packaging designers, and material specifiers to support design-for-recyclability standards. In parallel, the findings will assist PET reclaimers by guiding improvements in feedstock quality controls and process parameters critical to maintaining rPET quality and maximizing throughput.

Phase 1 Overview

Phase 1 of this case study focuses on evaluating the impact of color contamination on the PET recycling stream, specifically assessing how colored PET materials affect visible quality and processing efficiency. A key objective is to characterize the influence of both common and emerging color contaminants on critical recycling metrics, including resin clarity, color uniformity, and reprocessing compatibility factors that directly impact product quality and yield throughout the PET value chain.

To achieve this, a controlled series of tests was conducted using a defined set of known colored PET contaminants frequently found in the PET reclaim stream. These included Light Blue, Clear Blue, Opaque Blue, Black, White, Amber, Green, Exotic Transparent, and Exotic Opaque. Each contaminant was blended into a single heat history, extruded virgin clear PET at defined concentrations (measured in parts per million, PPM), simulating realistic contamination scenarios based on average allowances from industry specification data.

Colorimetric data were collected and analyzed using 3 mm amorphous plaques, with color and haze measured through transmission methods. This analysis quantified changes in lightness (L*), chromaticity red/green (a*), hue yellow/blue (b*), and haze, enabling a precise assessment of each contaminant's optical impact on the PET matrix. While the primary focus of this study is the PET recycling stream, the findings also have relevance for challenges within the polyolefin stream. Based on the results, colored PET does not pose a significant risk to the PET stream at the levels evaluated. However, PFE does not support the indiscriminate use of colored PET in either the clear PET stream or in colored polyolefin streams.

Next Steps

This colored PET contamination study represents Phase 1 of a three-phase initiative focused on known PET contaminants that PFE is actively addressing within the industry. Phases 2 and 3 will focus on polyolefin contamination and other critical non-PET materials, including PVC, polystyrene, PLA, EVOH, nylon, and adhesives, respectively. PFE is currently seeking collaborators for Phases 2 and 3. If you are interested in participating in future studies, please contact us directly.

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Materials:
- Control – Virgin Indorama 1101 PET Pellets
- PET Contaminates
    - 1A-1C – Light blues
    - 2A and 2B – Dark blues
    - 3A – Cobalt
    - 4A – Black
    - 5C – White
    - 6A and 6B – Amber
    - 7A – Green
    - 8A – 8F – Exotic transparents
    - 9A – 8G – Exotic opaques
- Theoretical Blends
    - 10A (max contamination levels without blue contamination)
        - 15 ppm Black
        - 50 ppm White
        - 40 ppm Amber
        - 800 ppm Green
        - 150 ppm Exotic Transparent
        - 15 ppm Exotic Opaque
    - 10B (max contamination levels with blue contamination)
        - 829 ppm Light Blue, Dark Blue, and Cobalt
        - 15 ppm Black
        - 50 ppm White
        - 40 ppm Amber
        - 800 ppm Green
        - 150 ppm Exotic Transparent
        - 15 ppm Exotic Opaque
    - 10C (double max contamination levels, without blue contamination)
        - 30 ppm Black
        - 100 ppm White
        - 80 ppm Amber
        - 1,600 ppm Green
        - 300 ppm Exotic Transparent
        - 30 ppm Exotic Opaque
    - 10D (double max contamination levels, with blue contamination)
        - 1,628 ppm Light Blue, Dark Blue, and Cobalt
        - 30 ppm Black
        - 100 ppm White
        - 80 ppm Amber
        - 1,600 ppm Green
        - 300 ppm Exotic Transparent
        - 30 ppm Exotic Opaque

Conclusions

- None of the blends showed a significant increase in extrusion pressure or screen build-up, as all materials were PET.
- Tests 3A, 4A, and 9D all fail the industry standard guidelines for b* colors, which is less than a 1.5-unit difference from the control. 3A is the cobalt sample, 4A is the black, 9D is the exotic opaque green.
- Tests 9A and 9B fail the industry standard guidelines for a* colors, which is less than a 1.5-unit difference from the control. 9A is the exotic opaque red, and 9B is the exotic opaque orange
- None of the test materials fail for L* or haze percentage.
- This study suggests that colored PET does not pose a significant risk in the PET stream.
    - Even at a 2000PPM contamination level, representing 11 bottles (assuming a bottle weight of 10 grams) in a standard bale of 1,200 pounds, the material would still meet the industry standard guidelines compared to a control bottle.
    - An example of white flake being added in at 20x compared to the reclaimers acceptable limit still produced results within the industry standards.
- The theoretical blends were based on the maximum reported acceptable contamination levels from multiple PET reclaimers. These values were then doubled to show an extreme case of reclaimer contamination. The maximum blue contamination level was not achievable.
- All theoretical blends meet the industry standard guidelines for color and haze.
- **Because the material was sourced from an end-market retailer, the final parts per million are calculated based on the weight of the package, not the weight of the inks or colorants in the products, because the composition is unknown.**

Contaminate Category	Maximum Accepted Reclaimer Contamination (ppm)
Blue	50,000*
Black	15
White	50
Amber	40
Green	800
Exotic Transparent	150
Exotic Opaque	15

Disclaimer: While the conclusions above state that colored PET does not pose a significant risk in the PET stream at the levels evaluated, PFE does not condone the negligent use of colored PET in either the clear PET stream or in colored polyolefin streams.

Individual Color Contaminate Summary*

Color	Variable	L* Average	a* Average	b* Average	Haze Average
Clear	Control	90.05	-0.59	2.16	5.68
Light Blue	1A	89.94	-0.50	2.27	6.61
	1B	90.22	-0.48	2.00	5.88
	1C	90.30	-0.53	1.93	5.36
Dark Blue	2A	89.74	-1.28	1.55	6.20
	2B	89.85	-0.75	1.73	6.57
Cobalt	3A	88.02	-1.41	-0.08	7.41
Black	4A	87.15	-0.07	3.75	7.14
White	5A	87.20	-0.12	3.39	14.48
Brown	6A	89.83	-0.70	3.26	5.96
	6B	89.75	-0.71	3.38	5.97
Green	7A	90.09	-0.92	2.41	5.89
Exotic Transparent	8A	89.98	-0.15	1.97	5.95
	8B	89.90	-0.41	2.79	6.32
	8C	90.10	-0.53	2.31	6.02
	8D	89.67	-0.88	1.87	6.09
	8E	90.02	-0.32	1.88	5.89
	8F	89.91	-1.65	4.64	6.20
Exotic Opaque	9A	88.45	3.44	3.54	7.46
	9B	88.28	1.78	3.31	2.09
	9C	87.87	-0.34	2.81	5.35
	9D	89.74	-2.05	5.19	0.31
	9E	87.70	-1.54	0.71	2.84
	9F	87.83	0.79	1.75	2.12
	9G	87.48	-0.01	2.84	12.90

All plaques represent a 2,000-ppm blend of individual color contamination.

APR PET Guidelines: The L* value cannot be less than 82, the a* and b* values cannot be more than 1.5 times different from the control, and the haze cannot differ by more than 10%. The control haze value cannot exceed 9.5%, and b* must be below four.

Theoretical Blends Summary

Variable	L* Average	a* Average	b* Average	Haze Average
Control	90.05	-0.59	2.16	5.68
10A	89.31	-1.25	1.32	6.51
10B	90.04	-0.71	2.21	5.41
10C	89.79	-0.91	1.81	5.74
10D	89.91	-0.84	2.52	5.84

APR PET Guidelines: The L* value cannot be less than 82, the a* and b* values cannot be more than 1.5 times different from the control, and the haze cannot differ by more than 10%. The control haze value cannot exceed 9.5%, and b* must be below four.

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Material Preparation Overview

The material was purchased from a retailer after being identified as PET by the resin code. After purchasing, the materials were sorted by colors commonly identified by PET reclaimers as contaminants. The purchased items were thoroughly cleaned of any contents, the caps removed, and the body material hand-cut, avoiding any labels or printing.

The cut material was then ground and blended with the second heat-extruded control at varying percentages, then blended down, again with the second heat control, to 2,000 ppm during injection. **Because the material was sourced from an end-market retailer, the final parts per million are calculated based on the weight of the package, not the weight of the inks or colorants in the products, because the composition is unknown.**

The theoretical blends are based on PET reclaimer feedback and their allowable tolerance. These blends were created with and without blue; blue was unable to achieve the higher level of PPM's listed by the reclaimers due to limitations created within this study from the initial PPMs tested. PFE also doubled the contamination levels to test the limits and ran them with and without the blue contamination.

Granulation

References:
PET-P-03

Test Summary:
Granulate incoming articles to the required grind size.

Procedure:
Articles are manually fed into a grinder with screen holes ranging from 9.5 to 12 mm in diameter.

1st Heat PET Control Extrusion

References:
PET-P-06

Test Summary:
Add a heat history to the control material for later processing.

Procedure:
Crystallized, extrusion material is prepped in a dryer for four to six hours until a moisture level of below 50 is reached. PET material is extruded at a target melt temperature of 280°C using a suggested screen pack of 20/40/150/40/20. The extruder is purged, and the screen pack is changed between each test innovation. Pressure and melt temperature are recorded throughout the run.

Operating Conditions:

Zone 1 Temperature (°C)	Zone 2 Temperature (°C)	Zone 3 Temperature (°C)	Zone 4 Temperature (°C)	Zone 5 Temperature (°C)	Clamp Temperature (°C)	Die Temperature (°C)
271	271	271	277	277	282	282

2nd Heat APR PET Extrusion

References:
PET-P-06

Test Summary:
Add a heat history to the material, homogenize blends, and filter out contamination.

Procedure:
Crystallized, extrusion material is prepped in a dryer for four to six hours until a moisture level of below 50 is reached. PET material is extruded at a target melt temperature of 280°C using a suggested screen pack of 20/40/150/40/20. The extruder is purged, and the screen pack is changed between each test innovation. Pressure and melt temperature are recorded throughout the run.

Operating Conditions:

Zone 1 Temperature (°C)	Zone 2 Temperature (°C)	Zone 3 Temperature (°C)	Zone 4 Temperature (°C)	Zone 5 Temperature (°C)	Clamp Temperature (°C)	Die Temperature (°C)
271	271	271	277	277	282	282

3rd Heat PET Injection

References:
PET-P-08
ASTM D1003
Within PFE's scope of ISO 17025 accreditation, certificate number AT-3210.

Test Summary:
Injection mold 3mm plaques and measure the color values L*, a*, b*, and haze. The data is designed to be correlated to the production of reproduced bottles.

Procedure:
Injection material is prepped in a dryer until the moisture content is below 50 ppm. PET is injection molded at a target melt temperature of 275°C. The injection unit is purged between each test innovation. The color analyzing equipment is set up on transmittance and calibrated using pure white and black standards. The molded plaque is inserted into the testing location, and the equipment runs the color test.

Operating Conditions:

Zone 1 Temperature (°C)	Zone 2 Temperature (°C)	Zone 3 Temperature (°C)	Nozzle Temperature (°C)
265	266	266	275

Light Blue PET Flake, Pellet, and Plaques

Variable	Incoming Material	Extruded Pellet	Injection Molded Plaque
1A			
1B			
1C			

Light Blue PET Plaque Colors

Variable	L* Values	a* Values	b* Values	L* Average	a* Average	b* Average	Haze	Haze Average
Control	90.08	-0.58	2.08	90.05	-0.59	2.16	5.71	5.68
	89.99	-0.62	2.32				5.78	
	90.06	-0.59	2.15				5.61	
	90.07	-0.58	2.11				5.64	
	90.06	-0.59	2.12				5.68	
1A	89.74	-0.53	2.59	89.94 (-0.11)	-0.50 (-0.09)	2.27 (0.11)	6.96	6.61 (0.93)
	90.05	-0.49	2.10				6.22	
	89.70	-0.47	2.45				7.21	
	90.11	-0.49	2.04				6.18	
	90.09	-0.50	2.16				6.48	
1B	90.21	-0.48	2.02	90.22 (0.17)	-0.48 (0.11)	2.00 (-0.16)	5.98	5.88 (0.20)
	90.21	-0.48	2.01				5.94	
	90.23	-0.48	1.99				5.76	
	90.21	-0.48	1.99				5.91	
	90.23	-0.47	1.98				5.79	
1C	90.43	-0.59	1.80	90.30 (0.25)	-0.53 (0.06)	1.93 (-0.23)	4.81	5.36 (-0.32)
	90.29	-0.52	1.95				5.35	
	90.34	-0.55	1.86				5.15	
	90.25	-0.50	2.02				5.83	
	90.18	-0.49	2.04				5.68	

APR PET Guidelines: The L* value cannot be less than 82, the a* and b* values cannot be more than 1.5 times different from the control, and the haze cannot differ by more than 10%. The control haze value cannot exceed 9.5%, and b* must be below four.

Dark Blue, Cobalt and Black PET Flake, Pellets and Plaques

Variable	Incoming Material	Extruded Pellet	Injection Molded Plaque
2A			
2B			
3A			
4A			

Dark Blue, Cobalt, and Black Plaque Colors

Variable	L* Values	a* Values	b* Values	L* Average	a* Average	b* Average	Haze	Haze Average
Control	90.08	-0.58	2.08	90.05	-0.59	2.16	5.71	5.68
	89.99	-0.62	2.32				5.78	
	90.06	-0.59	2.15				5.61	
	90.07	-0.58	2.11				5.64	
	90.06	-0.59	2.12				5.68	
2A	89.74	-1.27	1.60	89.74 (-0.31)	-1.28 (0.69)	1.55 (-0.61)	6.12	6.20 (0.52)
	89.72	-1.29	1.57				6.21	
	89.75	-1.30	1.53				6.07	
	89.75	-1.28	1.57				6.40	
	89.74	-1.28	1.50				6.19	
2B	89.85	-0.75	1.73	89.85 (-0.20)	-0.75 (-0.15)	1.73 (-0.42)	6.29	6.57 (0.88)
	89.85	-0.76	1.78				6.25	
	89.87	-0.73	1.67				6.39	
	89.82	-0.74	1.80				7.27	
	89.85	-0.75	1.69				6.63	
3A	87.84	-1.41	0.06	88.02 (-2.03)	-1.41 (-0.82)	-0.08 (-2.24)	7.46	7.41 (1.73)
	88.07	-1.42	-0.44				7.35	
	88.14	-1.41	-0.39				7.23	
	87.93	-1.44	0.52				7.55	
	88.10	-1.37	-0.16				7.48	
4A	87.46	-0.10	3.42	87.15 (-2.90)	-0.07 (0.52)	3.75 (1.59)	6.43	7.14 (1.46)
	86.88	-0.07	4.18				7.76	
	86.47	0.07	4.28				8.65	
	87.48	-0.13	3.44				6.34	
	87.44	-0.10	3.41				6.53	

APR PET Guidelines: The L* value cannot be less than 82, the a* and b* values cannot be more than 1.5 times different from the control, and the haze cannot differ by more than 10%. The control haze value cannot exceed 9.5%, and b* must be below four.

White, Amber, and Green PET Flake, Pellets, and Plaques

Variable	Incoming Material	Extruded Pellet	Injection Molded Plaque
5A			
6A			
6B			
7A			

White, Brown, and Amber Plaque Colors

Variable	L* Values	a* Values	b* Values	L* Average	a* Average	b* Average	Haze	Haze Average
Control	90.08	-0.58	2.08	90.05	-0.59	2.16	5.71	5.68
	89.99	-0.62	2.32				5.78	
	90.06	-0.59	2.15				5.61	
	90.07	-0.58	2.11				5.64	
	90.06	-0.59	2.12				5.68	
5A	87.14	-0.11	3.43	87.20 (-2.85)	-0.12 (0.47)	3.39 (1.23)	14.64	14.48 (8.80)
	87.11	-0.11	3.37				14.64	
	87.23	-0.12	3.39				14.38	
	87.21	-0.11	3.41				14.51	
	87.30	-0.15	3.37				14.22	
6A	89.81	-0.70	3.28	89.83 (-0.22)	-0.70 (-0.11)	3.26 (1.10)	5.94	5.96 (0.28)
	89.83	-0.69	3.25				5.87	
	89.84	-0.70	3.27				5.91	
	89.85	-0.70	3.28				6.02	
	89.80	-0.70	3.24				6.08	
6B	89.72	-0.70	3.41	89.75 (-0.30)	-0.71 (-0.12)	3.38 (1.22)	6.05	5.97 (0.29)
	89.74	-0.71	3.43				5.92	
	89.73	-0.71	3.45				6.08	
	89.80	-0.70	3.27				5.88	
	89.76	-0.71	3.35				5.91	
7A	90.09	-0.92	2.39	90.09 (0.04)	-0.92 (-0.33)	2.41 (0.25)	6.11	5.89 (0.21)
	90.10	-0.91	2.40				5.77	
	90.08	-0.91	2.41				5.92	
	90.10	-0.93	2.42				5.86	
	90.09	-0.92	2.42				5.78	

APR PET Guidelines: The L* value cannot be less than 82, the a* and b* values cannot be more than 1.5 different from the control, and the haze cannot differ by more than 10%. The control haze value cannot exceed 9.5%, and b* must be below four.

Exotic Transparent PET Flake, Pellet, and Plaques

Variable	Incoming Material	Extruded Pellet	Injection Molded Plaque
8A			
8B			
8C			
8D			

Variable	Incoming Material	Extruded Pellet	Injection Molded Plaque
8E			
8F			

Exotic Transparent Plaque Colors

Variable	L* Values	a* Values	b* Values	L* Average	a* Average	b* Average	Haze	Haze Average
Control	90.08	-0.58	2.08	90.05	-0.59	2.16	5.71	5.68
	89.99	-0.62	2.32				5.78	
	90.06	-0.59	2.15				5.61	
	90.07	-0.58	2.11				5.64	
	90.06	-0.59	2.12				5.68	
8A	90.01	-0.14	1.92	89.98 (-0.07)	-0.15 (0.44)	1.97 (-0.19)	5.90	5.95 (0.27)
	89.93	-0.18	2.13				5.93	
	90.00	-0.13	1.93				5.96	
	90.01	-0.14	1.92				5.93	
	89.93	-0.16	1.97				6.01	
8B	89.97	-0.40	2.65	89.90 (-0.15)	-0.41 (0.18)	2.79 (0.63)	6.10	6.32 (0.64)
	89.99	-0.37	2.45				6.36	
	89.77	-0.46	3.17				6.51	
	89.86	-0.45	2.97				6.45	
	89.93	-0.39	2.71				6.20	
8C	90.06	-0.53	2.34	90.10 (0.05)	-0.53 (0.06)	2.31 (0.15)	6.69	6.02 (0.34)
	90.23	-0.50	1.99				5.79	
	90.02	-0.55	2.50				6.03	
	90.12	-0.53	2.32				5.69	
	90.05	-0.53	2.40				6.23	
8D	89.68	-0.88	1.88	89.67 (-0.38)	-0.88 (-0.29)	1.87 (-0.29)	6.06	6.09 (0.41)
	89.67	-0.89	1.84				6.02	
	89.68	-0.87	1.87				6.03	
	89.64	-0.87	1.89				6.22	
	89.69	-0.87	1.86				6.11	
8E	90.06	-0.31	1.85	90.02 (-0.03)	-0.32 (-0.27)	1.88 (-0.28)	5.90	5.89 (0.21)
	90.08	-0.32	1.85				5.82	
	89.97	-0.33	1.93				5.90	
	89.98	-0.33	1.93				5.88	
	89.99	-0.32	1.84				5.97	
8F	89.91	-1.66	4.56	89.91 (-0.14)	-1.65 (-1.06)	4.64 (2.48)	6.25	6.20 (0.52)
	89.93	-1.71	4.77				6.14	
	89.95	-1.58	4.58				6.11	
	89.91	-1.66	4.71				6.26	
	89.87	-1.66	4.57				6.25	

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Exotic Opaque PET Flake, Pellets, and Plaques

Variable	Incoming Material	Extruded Pellet	Injection Molded Plaque
9A			
9B			
9C			
9D			

Variable	Incoming Material	Extruded Pellet	Injection Molded Plaque
9E			
9F			
9G			

Exotic Opaque PET Plaque Colors

Variable	L* Values	a* Values	b* Values	L* Average	a* Average	b* Average	Haze	Haze Average
Control	90.08	-0.58	2.08				5.71	
	89.99	-0.62	2.32				5.78	
	90.06	-0.59	2.15	90.05	-0.59	2.16	5.61	5.68
	90.07	-0.58	2.11				5.64	
	90.06	-0.59	2.12				5.68	
9A	88.49	3.49	3.48				7.32	
	88.44	3.43	3.48				7.37	
	88.39	3.47	3.59	88.45 (-1.60)	3.44 (4.03)	3.54 (1.38)	7.69	7.46 (1.78)
	88.53	3.40	3.45				7.28	
	88.39	3.39	3.69				7.64	
9B	88.30	1.72	3.31				9.50	
	88.29	1.78	3.30				9.54	
	88.19	1.86	3.33	88.28 (-1.77)	1.78 (2.37)	3.31 (1.15)	9.86	2.09 (-3.59)
	88.31	1.74	3.28				9.45	
	88.30	1.78	3.33				9.42	
9C	87.95	-0.32	2.76				12.58	
	87.78	-0.34	2.87				12.92	
	87.84	-0.34	2.83	87.87 (-2.18)	-0.34 (0.25)	2.81 (0.65)	12.99	5.35 (-0.33)
	87.93	-0.34	2.77				12.72	
	87.87	-0.34	2.81				12.82	
9D	89.78	-2.02	5.05				7.67	
	89.80	-2.04	4.99				7.68	
	89.62	-2.03	5.47	89.74 (-0.31)	-2.05 (-1.46)	5.19 (3.03)	7.88	0.31 (-5.37)
	89.73	-2.07	5.26				7.86	
	89.76	-2.08	5.17				7.75	
9E	87.69	-1.55	0.70				10.33	
	87.70	-1.55	0.70				10.45	
	87.71	-1.53	0.73	87.70 (-2.35)	-1.54 (-0.95)	0.71 (-1.45)	10.20	2.84 (-2.84)
	87.72	-1.54	0.71				10.28	
	87.70	-1.53	0.72				10.26	
9F	87.83	0.74	1.98				9.52	
	87.91	0.77	1.66				9.43	
	87.81	0.82	1.62	87.83 (-2.22)	0.79 (1.38)	1.75 (-0.41)	9.64	2.12 (-3.56)
	87.82	0.83	1.64				9.66	
	87.79	0.79	1.83				9.67	
9G	87.47	0.01	2.83				12.99	
	87.53	-0.01	2.77				12.77	
	87.40	0.00	2.90	87.48 (-2.57)	-0.01 (0.58)	2.84 (0.68)	13.16	12.90 (7.22)
	87.54	-0.03	2.85				12.63	
	87.48	0.00	2.84				12.97	

APR PET Guidelines: The L* value cannot be less than 82, the a* and b* values cannot be more than 1.5 different from the control, and the haze cannot differ by more than 10%. The control haze value cannot exceed 9.5%, and b* must be below four.

Theoretical Blends Injection Molded Plaque Pictures

Variable	Injection Molded Plaque
10A	
10B	
10C	
10D	

Theoretical Blends Injection Molded Plaque Colors

Variable	L* Values	a* Values	b* Values	L* Average	a* Average	b* Average	Haze	Haze Average
Control	90.08	-0.58	2.08	90.05	-0.59	2.16	5.71	5.68
	89.99	-0.62	2.32				5.78	
	90.06	-0.59	2.15				5.61	
	90.07	-0.58	2.11				5.64	
	90.06	-0.59	2.12				5.68	
10A	89.32	-1.26	1.28	89.31 (-0.74)	-1.25 (-0.66)	1.32 (-0.84)	6.43	6.51 (0.83)
	89.23	-1.25	1.32				6.64	
	89.34	-1.23	1.34				6.50	
	89.28	-1.26	1.35				6.57	
	89.37	-1.25	1.32				6.41	
10B	90.11	-0.71	2.23	90.04 (-0.01)	-0.71 (-0.12)	2.21 (0.05)	5.27	5.41 (-0.27)
	90.09	-0.73	2.16				5.36	
	89.96	-0.70	2.20				5.41	
	90.02	-0.71	2.25				5.39	
	90.00	-0.69	2.20				5.64	
10C	89.79	-0.92	1.81	89.79 (-0.26)	-0.91 (-0.32)	1.81 (-0.35)	5.77	5.74 (0.06)
	89.80	-0.89	1.78				5.71	
	89.75	-0.92	1.84				5.83	
	89.78	-0.93	1.85				5.73	
	89.81	-0.90	1.76				5.68	
10D	89.93	-0.81	2.47	89.91 (-0.14)	-0.84 (-0.25)	2.52 (0.36)	5.77	5.84 (0.16)
	89.9	-0.87	2.55				5.93	
	89.92	-0.84	2.47				5.83	
	89.91	-0.86	2.59				5.74	
	89.89	-0.84	2.51				5.92	

APR PET Guidelines: The L* value cannot be less than 82, the a* and b* values cannot be more than 1.5 times different from the control, and the haze cannot differ by more than 10%. The control haze value cannot exceed 9.5%, and b* must be below four.

Report Statements

ANAB
ANSI National Accreditation Board
A C C R E D I T E D
ISO/IEC 17025
TESTING LABORATORY
Certificate Number: AT-3210

Conformance Statements

Plastics Forming Enterprise (PFE) is an ISO 17025-accredited laboratory whose management system conforms to all standard requirements; all testing within the scope is identified. Results stated in the report are only relevant to the items tested and the test performed. All testing was completed at PFE's New Hampshire laboratory unless otherwise noted. All sampling was done using random selection, by experienced technicians unless otherwise noted.

As required, test specimens are conditioned at $23 \pm 2°C$ and $50 \pm 10\%$ relative humidity for at least 40 hours by the ASTM D618 procedure A. Additional information and results are available upon request. PFE will retain available hard copies of records related to this project for at least one year from its completion and available digital copies of documents for a minimum of three years.

Conclusions Statements

Experienced staff members do any interpretations of data with a good knowledge of the materials used during testing. All interpretations or conclusions about data can be found in the conclusions section of the report, unless noted. Opinions, interpretations, or statements of conformity included are based on results for which accreditation is held. Opinions, interpretations, or statements of conformity outside the scope of accreditation but based on those results for which a disclaimer identifies accreditation.

Report Authorizations

Report Written by	Report Approved by	Report Approved on

Date of Amendment	What was Amended?	Reason for Amendment	Amendment Performed by	Amendment Approved by

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