

Plastic Pellet Color Measurement



Industry Need, Justification & the HunterLab Agera® L2 Solution

Plastics Industry Applications Dossier

Proven across Alpek Polyester • Americas Styrenics • Amcor Rigid Packaging • and many more



1. The Application Need: Color Control in Plastic Pellets

Plastic pellet color is not simply an aesthetic parameter—it is a critical quality attribute that directly impacts product acceptance, brand consistency, and downstream processing performance.

Across injection molding, extrusion, film, and fiber production, manufacturers must ensure that raw materials and compounded resins meet tight color tolerances before entering production. Once processed, color deviations are costly, often irreversible, and amplified across high-volume manufacturing.

The industry has steadily moved away from subjective visual inspection toward objective, instrument-based measurement. This shift is driven by increasing material complexity, especially recycled content and UV-reactive additives—and the need for globally consistent quality decisions.

1.1 Who Measures Pellet Color – and Why It Matters

Color measurement is essential across a wide range of plastic pellet applications:

- **Virgin & Recycled Pellets (rPET, rHDPE, etc.)**
Color variation signals contamination, degradation, or feedstock inconsistency
- **Masterbatch & Additives**
Small color shifts propagate through entire production batches
- **Packaging Materials (Preforms, Bottles, Films)**
Brand-critical appearance and clarity requirements
- **Engineering Plastics & Automotive Components**
Tight tolerances for visual uniformity and part matching
- **Consumer Goods & Appliances**
Visual consistency across multi-component assemblies

A deviation detected early prevents scrap, rework, and customer rejection. A deviation missed early becomes a production-scale problem.

2. The Cost of Getting It Wrong: Color as a Production Risk

IMPORTANT NOTE:

The cost ranges presented below are based on typical production scenarios and publicly available industry benchmarks. Variability should be expected depending on process configuration, pellet value, regional cost structures, and operational efficiency. These values are intended to provide directional insight into cost-of-quality exposure rather than precise financial prediction.

Color variation in plastic pellets is not an isolated quality issue—it is a multiplier of operational cost. A typical out-of-spec condition can result in:

Typical Financial Exposure Per Event

Cost Category	Manufacturing Impact
Scrap & Regrind	Lost material value and added processing (\$4K - \$5K)
Production Downtime	Line stoppage for investigation or correction (\$15K - \$25K)
Rework / Reformulation	Additional labor and material usage (\$8K - \$10K)
Customer Rejection	Returns, penalties, and reputation damage (\$30K - \$40K+)

Total Risk Range:

- 👉 \$10,000 - \$45,000+ per event (internal)
- 👉 \$30,000 - \$100,000+ when customer-facing

2.1 Production Risk Financial Examples – Plastic Pellets

Scenario Context (used across all examples):

- Production line: 25,000 lbs/hour
- Resin value: \$1.20/lb (typical PET / engineered resin range \$0.90-\$2.00)
- Batch size (shift or lot): 50,000 - 100,000 lbs

2.1.1. Scrap & Regrind

Lost material value and added processing

Example Scenario:


A color deviation (ΔE out of tolerance) is detected after pelletizing.

- Off-spec material: **8% of 75,000 lb batch = 6,000 lbs**
- Scrap (unrecoverable): **2,000 lbs**
- Regrind (recoverable but downgraded): **4,000 lbs**

Financial Impact:

Component	Calculation	Cost
Scrap Loss	2,000 lbs × \$1.20	\$2,400
Production Downtime	4,000 lbs × \$1.20 × 30%	\$1,440
Regrind Value Loss (30%)	~\$0.10/lb × 4,000 lbs	\$400

 **Total Impact:** \$4,000 - \$5,000 per event

 **Hidden impact:** Regrind increases variability in future batches → compounds risk

2.1.2 Production Downtime

Line stoppage for investigation or correction

Example Scenario:

Color drift triggers a production stop to investigate:

- Duration: **2 hours**
- Line rate: **25,000 lbs/hour**

Financial Impact:

Component	Calculation	Cost
Lost Production	50,000 lbs × \$1.20 margin impact (\$0.20-\$0.40 typical)	\$10,000 - \$20,000
Labor Idle Time	Operators + supervisors	\$1,000 - \$2,000
Restart Loss (purge, off-spec startup)	3,000-5,000 lbs	\$3,600 - \$6,000

 **Total Impact:** \$15,000 - \$25,000 per event

 **Critical insight:** Most cost is not labor—it's lost throughput + restart waste

2.1.3. Rework / Reformulation

Additional labor and material usage

Example Scenario:

Batch is corrected by adding pigment / blending:

- Batch size: **50,000 lbs**
- Additional masterbatch: **2% addition**
- Masterbatch cost: **\$4.00/lb**

Financial Impact:

Component	Calculation	Cost
Additional Material	1,000 lbs × \$4.00	\$4,000
Reprocessing Cost	\$0.08/lb × 50,000 lbs	\$4,000
Labor & Handling	Operators, QC	\$1,000 - \$2,000

 **Total Impact:** \$8,000 – \$10,000 per event

 **Hidden impact:**

- Overcorrection risk → second rework
- Material property drift (mechanical / optical)

2.1.4. Customer Rejection

Returns, penalties, and reputation damage

Example Scenario:

A shipment of pellets fails customer color spec:

- Shipment size: 80,000 lbs
- Selling price: \$1.30/lb

Financial Impact:

Component	Calculation	Cost
Return Freight	Trucking + handling	\$3,000 – \$7,000
Downgrade Loss (20%)	$80,000 \times \$1.30 \times 20\%$	\$20,800
Reprocessing / Disposal	\$0.10/lb	\$8,000


Total Direct Cost: \$30,000 – \$40,000+

Even small ΔE deviations, especially in light or translucent materials, can trigger rejection or require costly adjustments.

 **Hidden / Strategic Costs (often larger):**

- Lost customer trust
- Increased incoming inspection requirements
- Reduced pricing leverage

- Potential loss of future contracts

 **Real-world truth:** One rejection can cost more than the entire measurement system

In plastic pellet production, the cost of color variability is not theoretical—it is measured in tens of thousands of dollars per event. The real risk is not just bad material, but bad decisions driven by unreliable measurement.

The challenge is not only detecting color differences, but doing so consistently, repeatably, and in alignment with human visual perception.

3. The Measurement Challenge: Why Plastic Pellets Are Difficult

Plastic pellets present unique measurement challenges that standard approaches often fail to address.

3.1 Low Signal in Dark or Translucent Materials

- Dark pellets reflect very little light → low signal-to-noise ratio
- Small variations appear as large ΔE shifts
- Measurement instability increases

3.2 Pellet Geometry and Surface Variability

- Pellets create voids and inconsistent surfaces
- Measurement depends heavily on presentation
- Small positioning changes affect results

3.3 Fluorescence and UV Sensitivity

- rPET and brightened materials contain optical brighteners
- Appearance changes under different lighting conditions
- Measurements without proper UV control do not match visual perception

3.4 Non-Uniform Composition

- Recycled content introduces variability
- Additives and regrind create localized color differences

👉 Result: Without a measurement system designed for these realities, data becomes inconsistent, non-repeatable, and disconnected from visual appearance.

4. The Solution: HunterLab Agera L2



The Agera L2 is designed specifically to address the real-world challenges of plastic pellet color measurement—delivering reliable, repeatable results that align with how materials are actually seen.

4.1 0°/45° Circumferential Geometry – Measuring Like the Human Eye

The Agera L2 uses a directional 0/45° circumferential optical geometry. The sample is illuminated simultaneously from all directions:

- Measures reflected light the way humans perceive color
- Minimizes effects of texture, gloss, and surface variation
- Provides strong correlation to visual evaluation

👉 Impact: Color decisions made by the instrument match decisions made in the real world.

4.2 True CIE Calibrated D65 Illumination with Calibrated UV – Critical for Modern Plastics

Plastic pellets increasingly rely on UV-reactive additives and recycled content.

The Agera L2 provides:

- True CIE calibrated D65 daylight illumination (visible + near UV)
- Calibrated and controlled UV energy for consistent measurement
- Accurate detection of fluorescence effects

 **Impact:**

- rPET and brightened materials are measured correctly
- Visual vs. instrument disagreement is eliminated
- Batch-to-batch UV variation is detected early

Performance Benchmark

Under controlled measurement conditions, the Agera L2 demonstrates instrument repeatability ($s_r \leq 0.03 \Delta E^*$).

When applied to heterogeneous materials such as plastic pellets and compounded resins, total observed variation includes both instrument and sampling effects. In these conditions, properly controlled measurement procedures (e.g., multiple readings, rotation, or averaging) yield effective measurement uncertainty in the range of 0.05-0.10 ΔE .

This performance supports statistically reliable pass/fail decisions at common industrial tolerances ($\Delta E \leq 0.3-0.5$), maintaining a clear separation between measurement noise and true material variation.

4.3 Controlled UV Measurement – Understanding Material Behavior

The ability to evaluate materials under different UV conditions provides critical insight:

- Detects fluorescent variability
- Identifies additive inconsistencies
- Explains visual mismatches

 **Key Insight:** A material can pass numerically but fail visually if UV behavior is not controlled.

4.3.1 D65 UV400 Compare Mode – Detecting Optical Brighteners and Fluorescent Additives

Modern plastic pellets, recycled materials, and compounded formulations increasingly contain optical brightening agents (OBAs) and fluorescent additives designed to improve perceived whiteness and visual brightness under daylight conditions. These materials can create significant visual differences that are not always obvious in standard color measurements unless UV behavior is specifically evaluated.

The Agera L2 with Essentials L2 includes **D65 UV400 Compare Mode** designed specifically to identify the presence of OBAs and fluorescent behavior quickly and objectively.

How D65 UV400 Compare Works

The workflow is intentionally simple:

1. The sample is placed on the measurement port
2. Two consecutive measurements are automatically performed:
 - **First measurement:** full D65 spectrum including near UV (360–700 nm)
 - **Second measurement:** visible-only measurement with UV removed (400–700 nm)
3. Essentials L2 automatically calculates and displays the ΔE difference between the two measurements

Interpretation of Results

- Minimal or no ΔE difference:
 - Indicates little to no fluorescent response
 - OBAs are likely not present
- Significant ΔE difference:
 - Indicates UV-reactive behavior
 - OBAs or fluorescent additives are present in the material

Why This Matters

Optical brighteners absorb UV energy and re-emit visible blue light, increasing perceived whiteness and brightness. As a result:

- Materials may appear different under different lighting conditions
- Visual appearance may shift between production sites
- Recycled content may introduce unexpected fluorescence variability
- Instrument agreement with visual evaluation becomes difficult without controlled UV measurement


The D65 UV400 Compare feature provides a fast and intuitive way to identify this behavior without requiring detailed spectral interpretation.

Improvement Over Previous 420 nm Compare Method

Previous workflows relied on a 420 nm compare approach. While effective for trained users reviewing spectral plots, the resulting ΔE values were often difficult to interpret directly, requiring operators to analyze spectral curves manually to determine whether fluorescent additives were present.

The new D65 UV400 Compare workflow simplifies this process significantly by:

- Providing a more meaningful ΔE comparison
- Using a full UV-inclusive vs UV-excluded measurement approach
- Allowing operators to identify fluorescent behavior immediately
- Reducing dependence on spectral expertise

 **Impact:** The D65 UV400 Compare feature enables faster detection of optical brighteners, improved troubleshooting of visual mismatches, and more reliable evaluation of recycled and UV-reactive plastic materials in real-world production environments.

4.4 Extra Large Area View (XLAV) – Reducing Pellet-to-Pellet Variation

Pellet-based materials require averaging across multiple surfaces.

The Agera L2 offers:

- Large 2-inch (55.8 mm) measurement area
- Reduced sensitivity to individual pellet variation
- Improved repeatability across samples

 **Impact:** More stable ΔE values and higher confidence in results.

4.5 Integrated Imaging – Seeing What You Measure

The built-in camera provides:

- Visual documentation of the measurement area
- Detection of contamination or defects
- Traceability for quality investigations

 **Impact:** Measurement data is supported by visual evidence.

4.6 Standardized Workflows with Essentials L2 & Quality Central

The Agera L2 integrates seamlessly into modern QC environments:

On-Instrument (Essentials L2):

- Guided workflows
- Pass/fail decisions
- Reduced operator variability

Enterprise-Level (EasyMatch Quality Central):

- Standardized methods across sites
- Centralized tolerances and data
- SPC trending and traceability

 **Impact:** Consistent color control from lab to global production.

4.7 Integrated 60° Gloss Measurement –From Pellets to Pressed Plaques

Color alone does not fully define the visual appearance of plastic materials. Surface characteristics—particularly gloss—play a critical role in how color is ultimately perceived, especially in finished or formed parts.

While pellet measurement is essential for process control, many plastic manufacturers also produce pressed plaques to confirm the final color and appearance of a formulation under conditions that more closely represent the end-use product. These plaques introduce surface-related variables—such as gloss, texture, and flow effects—that are not present in loose pellet measurements.

Agera L2 addresses this by integrating a **true 60° specular gloss sensor**, compliant with ASTM D523 and ISO 2813, enabling direct evaluation of both **color and surface appearance** within a single platform.

Why Pressed Plaques Matter




*Fig. 1: Pellets define the formulation—but plaques define the appearance.
Gloss measurement bridges the gap between the two.*

Pressed plaques are commonly used to:

- Simulate molded or extruded part appearance
- Validate formulation performance before production
- Resolve discrepancies between pellet color and finished part appearance
- Support customer approvals and visual sign-off

In these cases, gloss becomes a critical variable:

- Two plaques may match in ΔE but appear different due to surface finish
- Processing conditions (temperature, cooling, mold surface) influence gloss
- Additives and flow behavior can alter surface reflectance

 **Impact:** By combining color measurement of pellets with gloss evaluation of plaques, the Agera L2 enables:

- More accurate prediction of final product appearance
- Faster root-cause analysis of visual differences
- Reduced risk of customer rejection due to surface-driven appearance issues
- Improved alignment between QC data and real-world perception

5. Method Standardization – The Key to Reliable Results

The effectiveness of any measurement system depends on consistent execution.

This standardized method ensures:

- Uniform sample preparation
- Controlled UV conditions
- Repeatable measurement procedures

Key elements include:

- Consistent pellet packing and presentation
- D65 illumination with UV included
- Multiple replicate measurements
- Defined acceptance criteria (ΔE , L^* , a^* , b^*)

 **Result:** Reduced variability, improved confidence, and better decision-making.

6. Summary: Need, Justification, and Solution

The case for precision pellet measurement in the chemical industry rests on three interlocking realities:

The Need	Plastic pellet color must be controlled early and consistently to prevent costly downstream issues. Modern materials, especially recycled and UV-reactive pellets, require more advanced measurement approaches.
The Justification	<p>Traditional or uncontrolled measurement methods cannot reliably handle:</p> <ul style="list-style-type: none"> • Pellet variability • Low reflectance materials • UV-sensitive behavior <p>Without proper control, measurements become inconsistent and misleading.</p>
The Solution	<p>The HunterLab Agera L2 delivers:</p> <ul style="list-style-type: none"> • Visual correlation through 0°/45° geometry • True D65 illumination with calibrated UV • Reliable measurement of fluorescent materials • Reduced variability through large area averaging • Standardized workflows for consistent QC <p>By combining proper instrumentation with standardized methods, manufacturers can:</p> <ul style="list-style-type: none"> • Reduce scrap and rework • Improve batch consistency • Detect issues earlier in the process • Ensure alignment between visual and instrumental color

7. Standards Compliance – Defending Every Certificate of Analysis

In the global plastics market, a color measurement is only as defensible as the standard it is measured against. The Agera L2 operates in full conformance with the recognized international standards that govern liquid color measurement.

7.1 Core Color Measurement & Calculation Standards

ASTM International Standards

ASTM E1164	<p>Standard Practice for Obtaining Spectrometric Data for Object-Color Evaluation</p> <p>→ Foundation for reflectance measurements (used in plastics, coatings, etc.)</p>
ASTM E308	<p>Standard Practice for Computing the Colors of Objects by Using the CIE System</p> <p>→ Converts spectral data into CIE L*a*b*, etc.</p>
ASTM E313	<p>Standard Practice for Calculating Yellowness and Whiteness Indices</p> <p>→ Critical for plastics, especially natural, white, and rPET materials</p>

ISO (International Organization for Standardization) Standards

ISO 11664 (CIE Colorimetry Series)	<p>→ Defines:</p> <ul style="list-style-type: none"> • CIE standard observers • Illuminants (D65, etc.) • Color spaces (L*a*b*)
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7.2 Plastics-Specific Color Standards

ASTM International Standards

ASTM D2244	<p>Standard Practice for Calculation of Color Tolerances and Color Differences</p> <p>→ Defines ΔE calculations (critical for QC pass/fail)</p>
ASTM D6290	<p>Standard Practice for Color Determination of Plastic Pellets</p>

	<p>→ Specifically addresses:</p> <ul style="list-style-type: none"> • Pellet presentation • Measurement approach • QC consistency
ASTM D1925	<p>Standard Test Method for Yellowness Index of Plastics</p> <p>→ Legacy method still referenced in industry</p>
ASTM D523	<p>Specular Gloss</p> <p>→ Gloss influences perceived color</p>

7.3 Illumination & Visual Correlation Standards

ISO (International Organization for Standardization) Standards

ISO 23603	<p>CIE daylight simulator evaluation (D65 validation)</p> <p>→ Critical for UV + daylight accuracy</p>
ISO 3664	<p>Viewing conditions for color evaluation</p> <p>→ Defines light booth conditions</p>

7.3.1 Opacity – The Relevant Appearance Metric for Reflective Plastics

While haze and transmittance are critical for transparent materials, most plastic resins, pellets, and compounded polymers measured with the Agera L2 are opaque or semi-opaque, making opacity—not haze—the more relevant optical property.

Opacity describes a material’s ability to block light transmission and reflect incident light, directly influencing:

- Visual brightness (L*)
- Color saturation

- Hiding power and uniformity

Why Opacity Matters in Plastic Pellets

Opacity is affected by:

- Pigment loading and dispersion
- Filler content (e.g., TiO₂, calcium carbonate)
- Recycled content variability
- Additive distribution and processing conditions

Changes in opacity can create:

- Apparent color differences without formulation change
- Variability in brightness or whiteness
- Inconsistent visual appearance across batches

Measurement Relevance with Agera L2

The Agera L2 measures reflected light using 0°/45° geometry, making it ideally suited to evaluate opacity-driven appearance differences through:


- **L* (lightness)** as a proxy for brightness and hiding
- **Y (tristimulus value)** for reflectance-based opacity indication
- **Whiteness/Yellowness indices (ASTM E313)**
- **Consistent geometry and illumination for comparative evaluation**

Unlike transmission-based instruments, the Agera L2 evaluates how materials appear in real-world viewing conditions, where opacity governs perception.


Standards Context

While opacity itself is not always reported as a single standardized value in reflectance color measurement, it is inherently captured through:

- ASTM E1164 – Reflectance measurement
- ASTM E308 – Color computation
- ASTM E313 – Whiteness/Yellowness (opacity-influenced)

 **Impact:** By focusing on **opacity-driven reflectance behavior**, the Agera L2 enables:

- Better control of brightness and hiding characteristics
- Detection of formulation or dispersion issues
- Improved consistency in opaque and semi-opaque materials
- More accurate alignment with customer visual expectations

 **Key Insight:** For opaque plastics, appearance is governed by how light is reflected—not transmitted. Measuring opacity-driven behavior ensures color data reflects what the customer actually sees.

7.4 How This Comes Together

For plastic color QC, most real-world workflows rely on:

- Measurement: ASTM E1164 / ISO 7724
- Color Calculation: ASTM E308 / ISO 11664
- Color Difference: ASTM D2244
- Plastics-Specific Practice: ASTM D6290
- Whiteness/Yellowness: ASTM E313 / D1925
- Opacity (ASTM E1164 / ASTM E308/ ASTM E313)

8. Proven in Real-World Applications

The Agera L2 is deployed across industries where plastic color consistency is critical:

- Pellets, resins and polymers
- Packaging and bottling (including rPET)
- Consumer products and appliances
- Automotive interiors and components
- Industrial and engineering plastics

These environments demand:

- Reliable detection of small color differences
- Consistency across operators and sites

- Alignment between instrument data and visual evaluation

9. Proven at Scale: A Global Customer Record

The Agera L2's performance in plastics resin, pellet and polymer measurement is not a specification promise – it is a matter of record. HunterLab instruments are the trusted solution for plastic color quality control at many of the world's largest and most demanding chemical producers. These organizations have selected HunterLab not because it was the least expensive option, but because the measurement accuracy, instrument reliability, and data traceability it provides protect their product quality, their customer relationships, and their bottom line.

Alpek Polyester	Formosa Plastics	Liberty Packing
Amtor Rigid Packaging	Indorama Ventures Xylenes	Equistar Chemicals LP
Americas Styrenics	Ingomar Packing	Certainteed
Firestone Building Products	Magnera Film Products	Mitsubishi Polyester Film

These represent a fraction of HunterLab's global plastics industry installed base. From single-laboratory quality control to multi-site enterprise standardization, the Agera L2 platform has proven its capability across the full breadth of plastic color measurement applications.

Bottom Line


- There is no single “plastic color standard”—it’s a stack of complementary standards
- The critical requirement is consistency across geometry, illumination, and sample presentation
- The biggest failures in the field are not lack of standards—but inconsistent implementation of them

Plastic pellet color is a critical quality variable that directly impacts production efficiency, product acceptance, and brand consistency. As materials become more complex—especially with the rise of recycled content and UV-reactive additives—traditional or inconsistent measurement approaches introduce significant risk. As shown throughout this dossier, color variability can result in **\$10,000–**

\$45,000+ per internal event and \$30,000-\$100,000+ in customer-facing scenarios, driven not only by material issues but by unreliable or inconsistent measurement practices.

The HunterLab Agera L2 addresses these challenges by combining **0°/45° geometry aligned with human vision, true D65 illumination with calibrated UV, large-area averaging for pellets, and standardized workflows**, enabling accurate, repeatable, and visually relevant color measurement. The result is **earlier detection of process variation, reduced scrap and rework, and confident, defensible color decisions across global operations**.

If color consistency impacts your production efficiency, scrap rates, or customer acceptance, now is the time to evaluate your measurement approach. Request a sample evaluation or correlation study with the HunterLab Agera L2 to quantify variability in your current process and demonstrate how improved measurement can reduce cost and risk. For enterprise operations, explore standardized workflows with Essentials L2 and EasyMatch Quality Central to align color decisions across sites.

 **Contact your HunterLab representative** or visit www.hunterlab.com to schedule a demo, request application guidance, or begin a validation study.