Automating Plastic Extrusion Color Control

Eliminating the 'Black Magic'

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color Process Automation Technology

In Partnership with

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The world's true measure of color HunterLab

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Color Process Automation Technology (cPAT) introduces best practices and solution tools to help plastics manufacturers achieve greater performance by moving from a philosophy of time-interval based color QC to a more dynamic approach of continuous monitoring, closed-loop color control, and automated defect containment. Color process automation technology allows organizations to measure, analyze, control and document the color of extruded plastic in real-time through the measurement of Critical Color Process Parameters (CCPP) which affect Critical Color Quality Attributes (CCQA).

A man went to his doctor telling him “Doctor, it hurts when I touch my chin and it hurts when I press on my sternum, and it even hurts when I palpate my lower left abdomen. The pain radiates throughout my body every time I touch these areas. What could possibly be wrong with me”? The doctor looked at the man and said “well, it is simple, you have a broken finger”!

This analogy, though humorous, is used to illustrate the non-humorous way in which one critical but broken step in a dynamic process can cause systemic pain throughout that process. In business, this is all too common as variable outcomes cause frustration with customers and employees who routinely waste time ‘fire fighting’ instead of producing more quality products. A more representative illustration can be found in color control for plastic extrusion processing.

Today’s plastic extrusion process is a bit of ‘black magic’ when it comes to color control. Readings are taken every 30 minutes or longer, and adjustments are made based on these static results. This does not give a close enough view of the process or process stability to know its baseline, what its true variation is, or how much the process can be improved. The process is not very controllable, predictable or often times even understandable. And in today’s competitive environment where efficiency is critical, the pains that can result manifest as high scrap and regrind costs, high labour costs, high material costs, increased costs of quality and poor customer satisfaction. All of these are a direct result of a broken color quality control process. A remedy to fix a broken finger would typically include a splint and possibly some pain medication. A remedy for fixing a broken color quality control process in plastic extrusion processing should include state of the art Color Process Automation Technology.

Color process automation technology takes the ‘black magic’ out of the process and makes it something that operators can control, predict and troubleshoot. The result is improvements in efficiency, productivity and profitability stemming from Quality and Customer Satisfaction improvements, process and yield improvements, material cost reductions, operator efficiency improvements, and enhancements to an organizations green initiative and carbon footprint reduction.

Quality and Customer Satisfaction

There is no price that can be put on a customer losing faith in a product or a company. Poor quality, long lead times, missed deliveries, and returns and rework are all quality costs that can significantly impact customer satisfaction and bottom line profitability. In plastic extrusion processing, color quality claims are typically segmented into two categories; manufacturing claims and policy claims. Manufacturing claims are real color issues where the product shipped out of spec from the factory. Policy claims are claims in which the product is in color specification, but operator 'A' produced product at the high end of the color specification, typically measured in L* colorimetric value, and operator 'B' ran the product at the low end of the specification, and the customer receives product from both batches. In this case, the color is within specifications, but noticeably different. Policy claims are the claims that really cost you, because you did everything 'right'. You spend the money to do the quality checks and ensure quality control, but when, in the case of vinyl siding for example, you throw it on the house and two or three panels or two or three boxes are off color, the product is completely torn off. The initial cost to assess the complaint can be as much as $3,000, not to mention the $15,000 to $20,000 cost once the claim is accepted.

Process and yield Improvements

On a perfect day, the average plastics extrusion plant might see 98% efficiency. This number never goes higher because 2% of material is lost in quality checks, tear offs, nail slots, cutter slugs and other variables that are part of the process. Most 'efficient' plants run at around 94% efficiency. Raising this yield just 1% can result in a few hundred thousand dollars per year in scrap and other savings. To look at the big picture, a plant that can raise its efficiency from 94% to 98% can see potential savings in the millions of dollars. Implementing good color process automation technology can yield improvements of 1.5% to 2%, with improvements in color changeovers of 5%-10%. These improvements are realized with the most skilled operators, and significantly more with less skilled workers. This is because color process automation technology forces all operators to do things the same way. It tells them when color is stable based on predetermined rules they set, when to take a reading, and when to package product. It also enables automated sorting of saleable product from defective product downstream. And with real-time process data collection, operations managers can work to a plan. If the data says that at 3,000 pounds per hour and each color change taking 15 minutes, the result will be 750 pounds of regrind, no more, no less. This is the number that can be expected. This ability to predict what the color change is going to do combined with the knowledge that 2% will be scrapped from known process variables gives a plant the ability plan their events and schedule accordingly, rather than setting hypothetical targets to shoot for in hopes of achieving them.

Material Savings

The past several years have seen significant plastic price increases, making the job of producing plastics products challenging to say the least. With oil discovery peaking in the mid-1960s and declining at a rate of 8% per year, and with the world extracting more oil than it can find and consuming 2% more each year, there is compelling evidence that the pricing situation will worsen over time. The price of plastics and resins that use oil feedstocks will continue to trend upward, and moulders must continue to seek innovative ways to keep costs in check in order to remain competitive. Having a few resin options for any project can help, and resin buying options in the primary and secondary resin markets can provide some leverage for price improvement. More direct and predictable solutions that can contribute to significant cost reductions include using less pigment to color the product, consistently running the product at the top end of the color specification, and elevating the use of outsourced regrind and recycled material. Color process automation technology provides the ability to monitor and control the topcoat as regrind material is increased on the backcoat, ensuring that color quality is not sacrificed as regrind material use is increased. The result can be a realization in pigment savings of as much as 20 to 30 percent. Added to the savings in pigment use are the savings that can be realized from using recycled material vs. virgin which can be as much as 40 cents per pound. From an efficiency standpoint, this can also help to consolidate to a lower number of backcoat colors.

Changes in Workforce Dynamics

Since the 1980's, reductions in force, retirements, and industry consolidation have made keeping up the chain of knowledge about plant processes difficult and problematic. The pool of people with the process and technical knowledge of a plant or even its processes is shrinking. Younger workers do not have the science, mathematics or mechanical skills, on average that the workers they are replacing had when they started. The modern operator has evolved into a multi-faceted employee, which has drastically increased the role's responsibilities as a "generalist", solving problems in real time and not specifically being an expert in merely one section of the process. Today the operator is one of the key members of the team, and enhancing the efficiency of this role through improved operator response provides a critical advantage. No longer are operators simply working within their traditional functional boundaries with established guidelines and procedures to maintain status quo. They are increasingly expected to leverage their knowledge to make objective real-time decisions, which means they need a deeper understanding of the various factors that impact their operations and the ability to use that knowledge to improve planning and problem solving with more proactive measures. The latest color process automation technologies enable operators to better leverage information in both routine and critical conditions for optimal decision making, and provides the tools that enable operators to collect, connect, analyze and act upon vast amounts of real-time operations data supporting a more intelligent and engaged workforce

Green Initiatives

Manufacturers are getting on board with green initiatives and reviewing their carbon footprint for improvement. Sustainability however is more than reducing a plants carbon footprint. Properly done, it's about creating manufacturing processes that produce the highest profitability over the longest period of time, taking into consideration costs of materials, labour and energy. More efficient equipment and control methods in automation can improve the overall equation by reducing the energy cost per unit of output for any product. But this is not enough. What truly makes a product green is the amount of recycled material that can be used in it. Recycled product can be challenging to use because the color is not usually controlled very well, and this will influence the color of a capstock if the capstock becomes too thin. Color Process Automation Technology can resolve this by automatically varying the feeder along with the material to keep capstock color in spec as the percent of recycled content on the backside is increased. Reducing the cost per unit of output combined with the ability to increase the use of outsourced recycled material can significantly impact an organizations green initiatives while also helping to improve quality, reduce costs and improve profitability and competitive advantage.

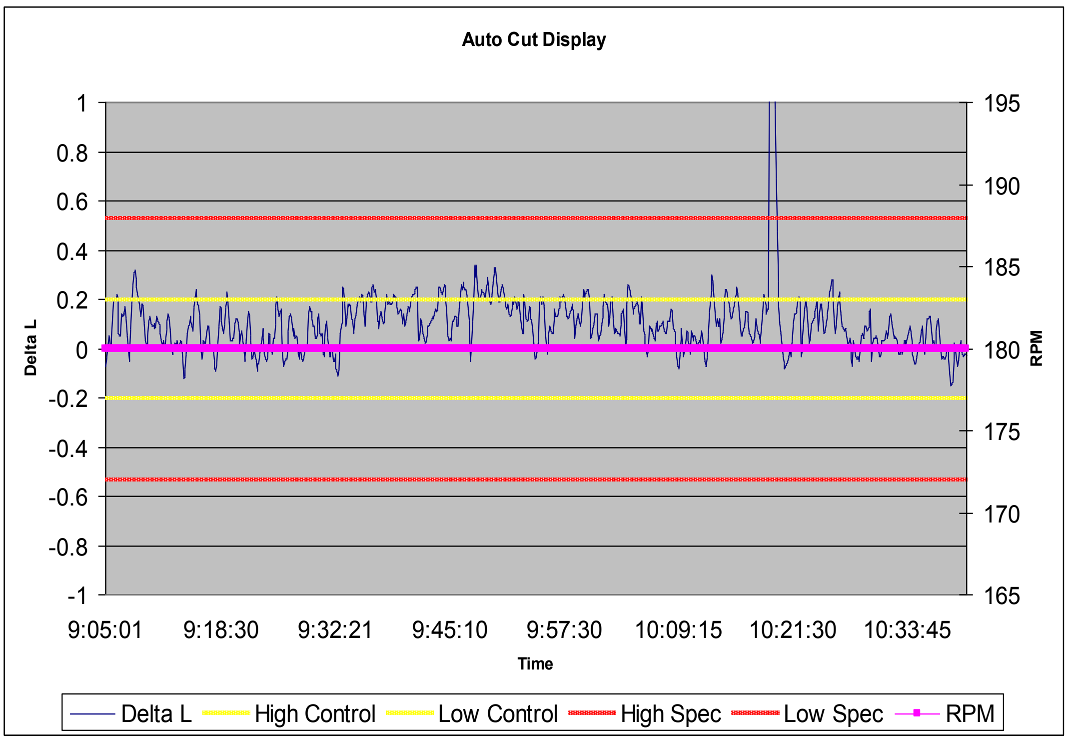
HunterLab and Plastore, Inc. through a strategic partnership have joined forces, lending their expertise in the fields of color measurement and plastic extrusion processing, to develop **cPAT – Color Process Automation Technology** - to specifically address todays color quality and control needs of the plastic extrusion industry. This new and innovative technology enables companies to achieve the improvements in efficiencies, productivity and profitability vital to their success and sustainability in today's competitive global market.

To learn more about cPAT, visit www.hunterlab.com, or www.plastore.com.

<u>**CASE STUDY**</u>

QUALITY TOOL – Auto-cut benefit Example

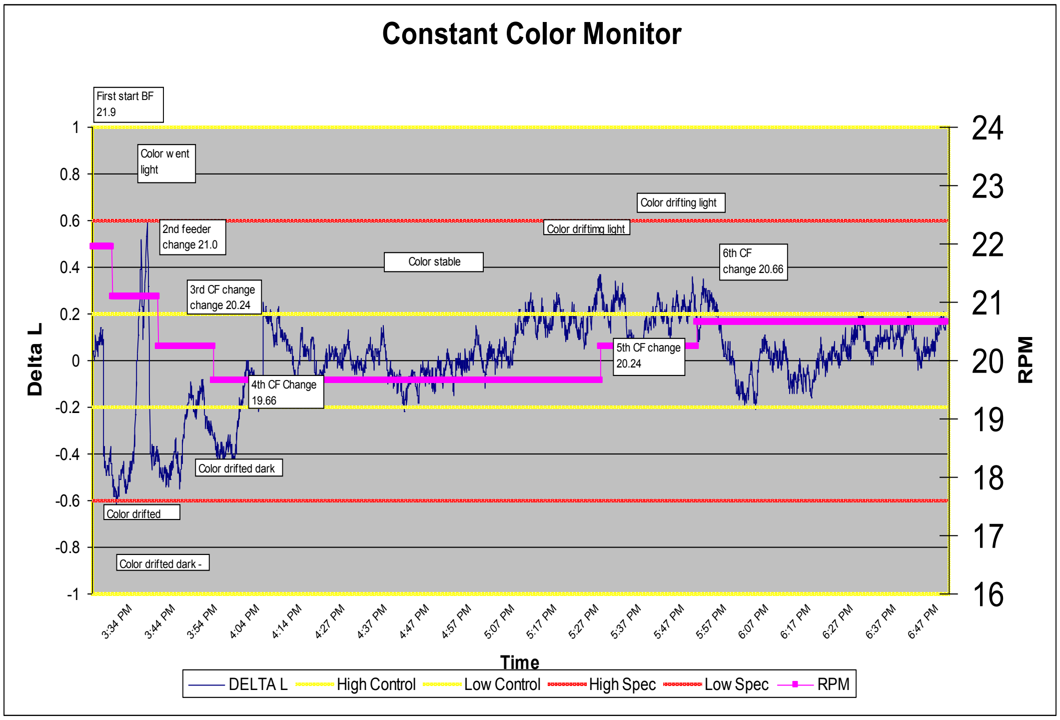
- QC picked up a check at 10:30 a.m. and found the color was 1.68 DL. Skid was put on hold and 6 boxes were discarded
- QC just happened to pick up at the only time during this run that the color was out of spec (see color scan data)
- The color spiked out of spec for 7 five second reads and then went back into spec. range
- All color checks were taken on time and if not for QC's timing this could have been a claim
- Auto-cut would have prevented losing 144 pieces of siding, and only lost 12 panels
- Eliminates potential color claims from field



QUALITY TOOL – Constant Color Checks

Ability to continuously monitor for color shifts

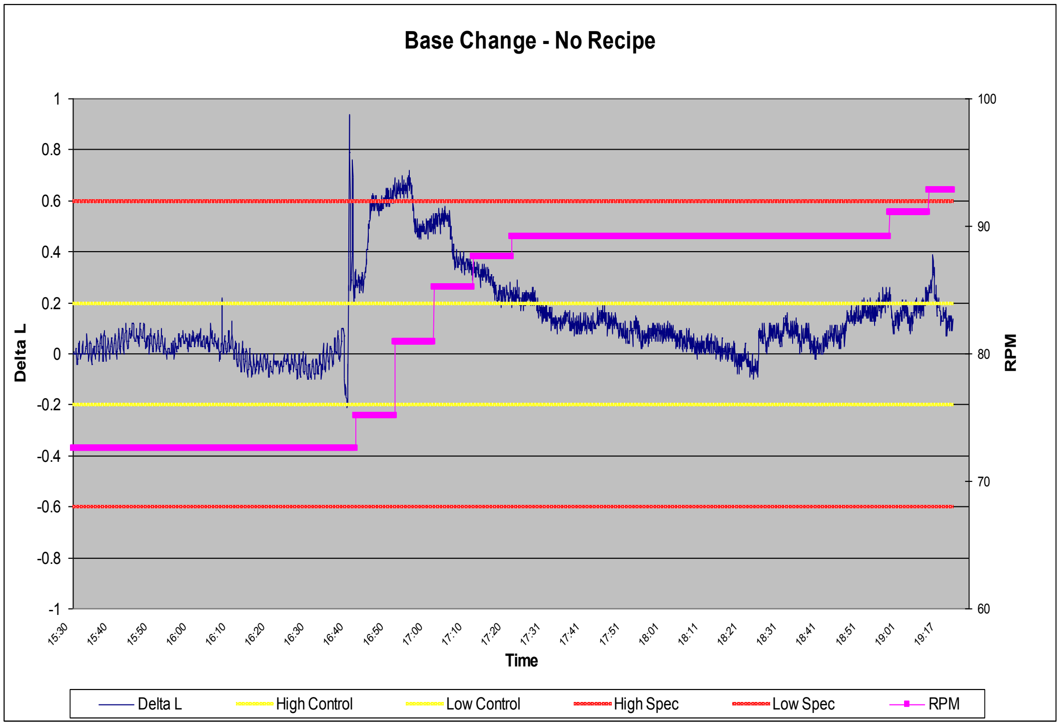
- Color change line from Light Gray to Medium Gray: Color feeder started at 21.9 and after 6 CF changes it ended up at 20.66, 3hr and 15 min later. This change was done by the cPAT® solution, totally automatic
- If operator would have taken a check after color change and began to box product, then waited until his next check 30 min later, there is a high level of certainty that the color would have been far out of the spec range and product would have had to be unboxed and scrapped
- 4 color feeder changes were made in the first 30 min after product started to be boxed
- Medium Gray is a 3.0 ASA color, known for taking a while for color to stabilize after a change
- This time appears to change depending on what the previous color was prior to the color change
- The cPAT® system constantly monitors color and makes the necessary feeder changes at the correct times
- The cPAT® system eliminates any delayed operator response, and also eliminates a color shift that would go undetected until a color check would be performed at 30 min intervals, having to back track and scrap product



PROCESS TOOL– Recipe Error

Why did the run shift light?

- Records shows that at 16:38 the co base feeder was changed from 35 to 39 causing the color to go light
- This was caused because operator loaded D5 recipe but it was for 3.0 ASA. There was not a .5 recipe. This line did not usually run .5 colors
- This explains the color shift and also shows how the cPAT® system brought color back to nominal making several changes because the increased base feed reduced the regression accuracy causing the CF changes to move the DL* less



Process Tool – Regression Checks and Correction

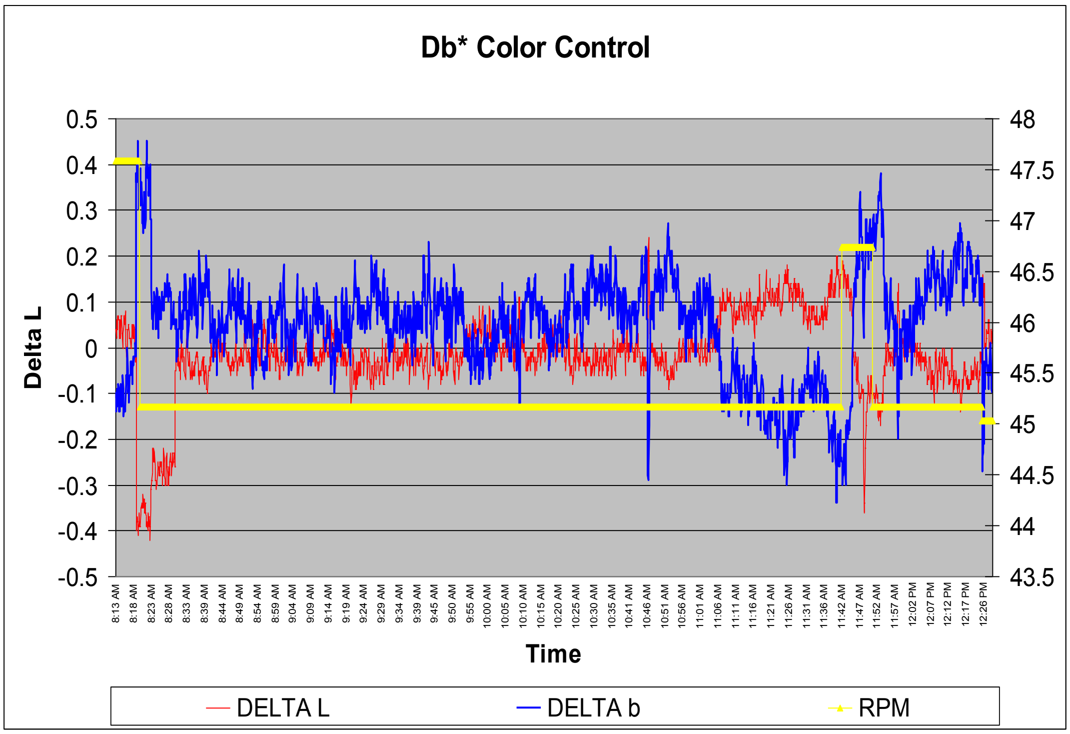
The regression for this color was off, as you can see by the graph

- Recording the feeder changes along with DL* movement will give the actual regression for any concentrate, improving CCS performance. (Assuming Base Feed Rate remains constant)
- Can better predict residence time in extruder
- Time difference between feeder change and actual start of color shift

Process Tool – Studying How Db* Controlled Color works

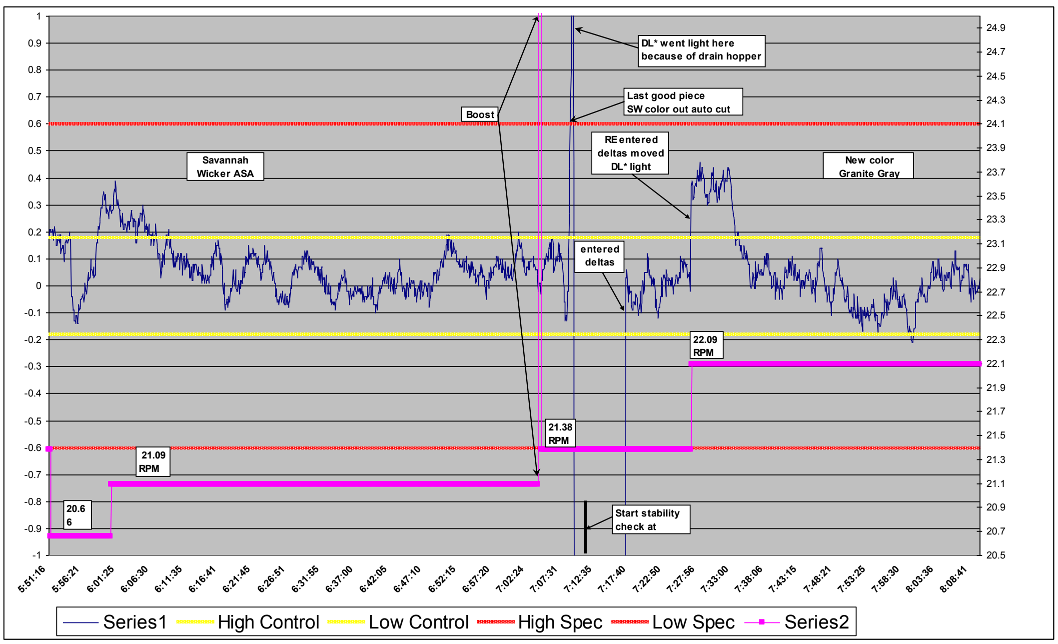
Ability to monitor Db* Controlled colors and watch interactions between other functions

- Can better train on color control for b* scale colors
- Can assist in establishing better adjustments to concentrates

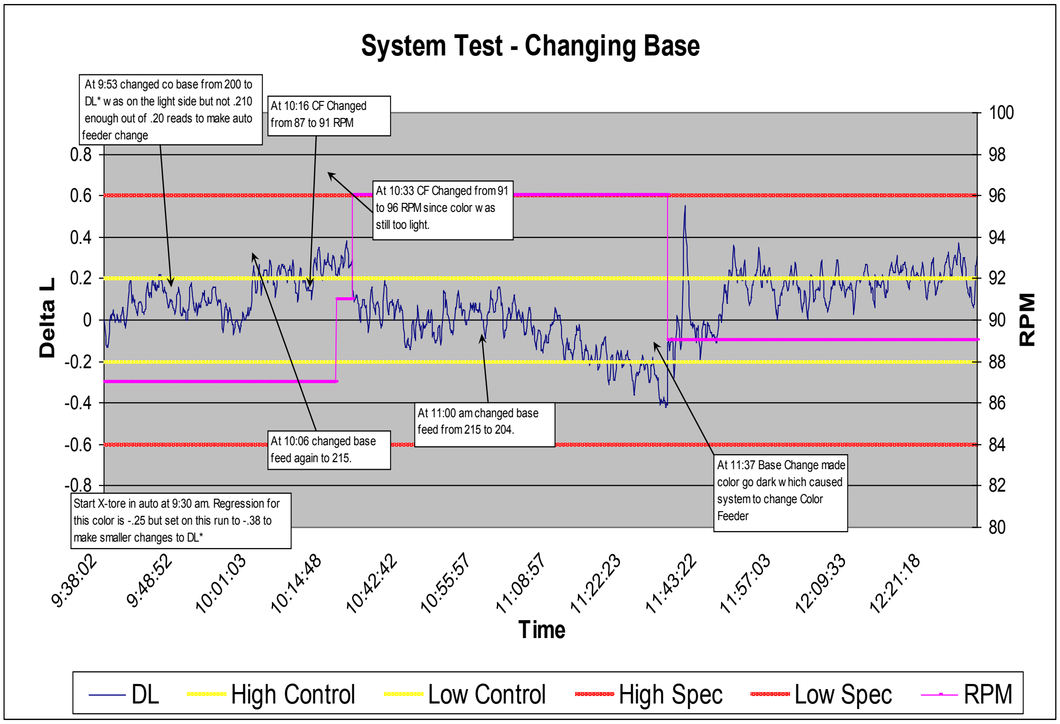


Process Tool – Color Change Tool

- Allows all Color Changes to be the same
    - Mirrors Current Procedure
    - Assists Last Piece Checks
- Stability Check
    - Improves Color Change Time
    - Provides better data for CCS



Changing Base



SYSTEM LOG DATA (example)

Date	Time	RECIPE ID	TARGET L*	TARGET a*	TARGET b*
10/22/2013	8:37:49	52	55.75	3.47	12.71
10/22/2013	8:37:52	52	55.75	3.47	12.71
10/22/2013	8:37:55	52	55.75	3.47	12.71
10/22/2013	8:37:58	52	55.75	3.47	12.71

ACTUAL L*	ACTUAL a*	ACTUAL b*	DELTA L*	DELTA a*	DELTA b*	DELTA E
53.87	2.59	12.91	-2.22	-0.88	0.4	2.42
53.66	2.67	12.88	-2.06	-0.89	0.29	2.27
53.69	2.64	13.31	-2.06	-0.88	0.33	2.26
53.95	2.53	12.7	-2.04	-0.87	0.29	2.24

L TOL HI	L TOL LO	L WARN HI	L WARN LO	a TOL HI	a TOL LO	a WARN HI	a WARN LO	b TOL HI	b TOL LO	b WARN HI	b WARN LO	REGRESSION
0.4	-0.4	0.2	-0.2	0.4	-0.4	0.2	-0.2	0.4	-0.4	0.2	-0.2	-0.2
0.4	-0.4	0.2	-0.2	0.4	-0.4	0.2	-0.2	0.4	-0.4	0.2	-0.2	-0.2
0.4	-0.4	0.2	-0.2	0.4	-0.4	0.2	-0.2	0.4	-0.4	0.2	-0.2	-0.2
0.4	-0.4	0.2	-0.2	0.4	-0.4	0.2	-0.2	0.4	-0.4	0.2	-0.2	-0.2

MOTOR RPM	CONTROL VAR	CONTROL MODE	SCANS TO AVE	SAMPLE INTERVAL	BAD SCANS ALLOW	SCAN RESULT	TOTAL SCANS
46	1	0	5	3	10	2	424617
46	1	0	5	3	10	2	424618
46	1	0	5	3	10	2	424619
75	1	0	5	3	10	2	424620