Applying Science to the Art of Powder Coating

Robyn Aiken
BTD Paint Engineer
Is this in your facility?

• Multiple painters painting at one time
• Paint defects found at end of process or at customer
• Pair new painter with seasoned painter
• “Best” painter is the one doing it the longest
• Lack of organized training program for painters
• No baseline skill assessment for growth and promotion
Why This method?

- Individual painter assessment
- Pin point techniques and habits
- Develop a painting skills baseline
- Training program and continuing education
- Improve first pass yield
- Improve productivity
- Reduce rework, scrap and corrective actions to your customers
- Build confident painters
Test Concept & Background

- My experience as a paint department manager and paint engineer, I was plagued with...
  - Defects
  - Painter turnover
  - Arguments of where the defect came from
  - Didn’t know who my SMEs were
  - Had 4-5 English as a second language painters at any one time
  - Pressure from leadership or customers to improve the metrics
  - **AND THE SCIENCE WASN’T UNDERSTOOD!**

I had to
Test Set Up Check List

1. Part Selection
2. Hanging Plan
3. Painter Preparation
4. Video
5. Preparing the Spreadsheet
6. Scheduling the event
Part Selection

Select something that represents the problems that you see on your line. Try quantifying the defect so you can measure improvements in the future.

• 1-2 parts
• Flats and faradays
• 5 - 15 each

*Note – you can be flexible with number but I have found that too many parts make it timely to measure, but too few don’t give enough data points.
Part Selection

Flat, simple

Complex, fardays
Part Selection

- Large with cutouts
- Small, complex, fardays
Part Selection

- Remember the purpose is to present a **NEW** scenario to the painter to assess how they respond.
- Your painter should know the science to apply their skills appropriately to any situation.

Not just the familiar
Hanging Plan

Plan how you will hang the parts in a drawing. This will help visualize, communicate and keep you organized.

- Breadth and depth
- Racks or hooks
- Hawthorn affect on the painter
Hanging Plan

“Drops” with movement direction identified

Part placement & numbering
Hanging Plan

On racking

BTD

12 11
13
15 14

7 6
8
10 9

2 1
3
5 4
Preparation

Preparing the painter is important but you don’t want to tell them everything. This should be as organic to your process as possible and people often get nervous when put in the spotlight.

TELL THEM:
- Purpose of the assessment
- How the assessment will work and how long it will take
- They will videoed
- They will be given feedback to improve their skills – like a top performing athlete!

PRACTICE THE PLAYS
Recording the Video

You want to capture what the painter is focusing on and how they move through the paint zone.

- Capture their gun setting (can write this down)
- Position yourself close to the same level. If they are on a platform higher than you, stand on a ladder
- Observe how they are waiting for the part to move into the painting zone (if on moving line). You want to see...
  - if they are testing the powder flow
  - where they start painting – in the lead-in space or directly on the part
  - where they start in the zone – high/low
- Try not to move around too much
- Stay zoomed out as much as possible – looking for habits through entire painting zone
- Record each painter individually – makes it easier to review
What are you looking for?

You want to see how the painter is moving.

- Are they tweerky or jittery? Or are their movements fluid and smooth?
- Are they struggling with their size- too short, too tall, too fat? j/k
- Do they have physical obstructions like half doors or pits that forces them to contort into difficult positions.
- How much time are they spending on each part. Too much at first and lose valuable time for the rest.
- Gun to part distance?
- Are they “working the cloud”? 
- Do they have a rhythm?
Recording the Video

Dawsonville - painter 1

Dawsonville - painter 6
Preparing the Spreadsheet

Organization is key. 5-6 painters will take quite a bit of time to get through.

• Use Excel – used widely and easy to format
  • Tab 1 – At a Glance
  • Tab 2 - Observations
  • Tab 3 - Measurements/Data
  • Tab 4…. Charts if using Excel graphic – can use statistical programs like MiniTab or SPCExcel
## PAINTER COACHING USING VIDEO AND DATA

### Pre-painting steps

<table>
<thead>
<tr>
<th>Painter</th>
<th>Setting - checked or set</th>
<th>Powder inspected or purged</th>
<th>K.V. (Nordson recommends 15-25)</th>
<th>Flow Rate (Nordson recommends 20:30)</th>
<th>Atomizing Air (Nordson recommends 5:10)</th>
<th>Gun to part Distance</th>
<th>Fill recesses first</th>
<th>Gun to part Distance</th>
<th>Fill recesses first</th>
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<td>6-8&quot;</td>
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</table>

### Painting Techniques

| Painter | Adjusted | yes | 70 | n/a | 99 | 2 | Door closed | Off | 6-8" | yes | fast | short quick flutters | yes | 1.5-3.3 | 1.5-5.3 | 2.2 | 2.4 |
## Pre-painting steps

- **Checked the settings?**
- **Tested powder flow?**
- **kV setting**
- **uA setting**
- **Flow rate setting**
- **Air setting**

### Settings - checked or set

<table>
<thead>
<tr>
<th>Setting - checked or set</th>
<th>Inspected/inspected powder flow or purged</th>
<th>KV</th>
<th>Amps (µA)</th>
<th>Flow Rate</th>
<th>Atomizing Air</th>
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<td>70</td>
<td>n/a</td>
<td>99</td>
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</tbody>
</table>
# Painting Techniques

- Painter position
- Starting point
- Gun to part distance
- Fill recesses first?
- Painting speed
- Motion
- Consistency-part to part

<table>
<thead>
<tr>
<th>Painter Position (where standing in booth)</th>
<th>Starting point on/off part</th>
<th>Gun to part Distance</th>
<th>Fill recesses first</th>
<th>Painting Speed</th>
<th>Motion - fluid or twerky</th>
<th>Consistent technique - part to part movement</th>
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<tbody>
<tr>
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<td>yes</td>
<td>moderate</td>
<td>fluid</td>
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<td>moderate</td>
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<td>moderately fast</td>
<td>flutters more</td>
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<td>moderately fast</td>
<td>sweeping</td>
<td>illy yes, but not methodically</td>
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<td>quite fast</td>
<td>mostly sweeping</td>
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<td>fast</td>
<td>short quick flutters</td>
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Data at a glance

- Mil thickness range from all parts of painter
- Mil thickness averages per painter per part type

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<th>Bracket</th>
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<th>Bracket</th>
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<td>Mil thickness Consistency across part (Range) Goal: +/- .75 mil</td>
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<td>1.5-3.3</td>
<td>1.5-5.3</td>
<td>2.2</td>
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</table>
Data Collection

Collecting data can be time consuming & confusing, so plan wisely.

- **What to measure** – DFT (dry film thickness)
  - DFT will coincide with the Painter’s painting behavior
- **Who to involve** – call for help but be clear on how to measure and record. This will correlate to the Painter’s behavior.
- **Pulling parts off the line** - critical to pull off in certain order so you know exactly where it was hanging.
- **Labeling parts** – can write on part or use stickers.
Where to take measurements

- Flats spots and faradays
- Across flats
### Organizing Your Data

<table>
<thead>
<tr>
<th>PAINTER</th>
<th>PART TYPE</th>
<th>PART #</th>
<th>POINT 1</th>
<th>POINT 2</th>
<th>POINT 3</th>
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</tr>
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</table>

- The painter
- The Part Type
- The Part number
- The point number

*I like to add conditional formatting to highlight out of spec readings for a quick peek.*
Data Analysis

Graphing – I prefer using box plots, and surface charts more than Mini Tab or other statistical software. I feel its easier to discuss with someone who many not understand Xbar, moving R or histograms. 😊

- **MiniTab** – can be difficult to interpret and speak to
- **Box Plots** – pictorial to easily show pattern and comparison
- **Surface Charts** – elevation changes easy to see patterns
  1. Part to part comparison by painter - **individual**
  2. Painter to painter comparison by part - **systemic**
Mini-Tab Six Pack

Process Capability Sixpack of Hardness

Xbar Chart

R Chart

Normal Prob Plot

Capability Plot

Specifications
LSL  39
Target  41
USL  43

Within
StDev  0.969225
Cp  0.69
Cpk  0.44

Within
StDev  0.986873
Pp  0.68
Ppk  0.43
Cpm  0.54
Interpreting Boxes

- Trend Curves – point to point view on part type
- Thin or Thick – consistency of DFT on points for part type
- Whisker Stretch – min and max of DFT on certain point
Box Plots

Whiskers

Trend line

Thin

Thick

Jesus - Bracket

Eliseo - Bracket

#1
Surface Charts

Eliseo - Panel

Clemenico - Panel

Eliseo - bracket

Clemencio - Bracket
What does the Surface say

• Highlight with color heavy and light areas
• Can see from point to point – “All point 1’s are heavier than point 4’s”
• Can see how consistent the movement is as the painter paints the run.
• Can see ergonomic issues
• Can see fatigue
Surface Chart – by Painter

Part 3, point 3 was slightly heavier than the first 8 parts.

Painter was typically heavy on points 2 & 4 but light on 3. What could be happening?

The 4th “drop” of parts were a little lighter. What was the painter thinking/doing?
Surface – part vs part

• All the same as the painter vs. painter except can identify common struggles with all painters.

• Some issues could be-
  • Parts not hung properly
  • May have SOP that is restrictive
  • Bad habit that has been shared – moving too quickly
  • Could be ability to see out of PPE or within booth, ie; lighting or angles.
Surface – part vs part

Point 3 seemed to be light for everyone on part 8. Why could that be?

My last painter seemed to struggle on this part. What’s going on?
### Overall Observation Notes

<table>
<thead>
<tr>
<th>Movement over panels</th>
<th>Movement over brackets</th>
<th>Graphs</th>
<th>Doing well at</th>
<th>Recommendations</th>
</tr>
</thead>
</table>

**Raymundo**

- **Movement over panels**: Starts at top and sweeps across parts moving downwards. Mostly repeats movements across all parts with occasional skipping after inspections.
- **Movement over brackets**: Angling gun far perpendicular to faraday and moves up the line. As parts move, transitions to flat surface as he stays at the top flowing downward over the flat surfaces on 1st drop. Recovers a few sweeps and then checks faraday area on 1st position then moves to 2nd drop and touches faradays again bottom to top. Then returns to 1st drop and stays back faraday of 1st drop. At this point, starts to appear rushed and speeds his pace up and becomes less uniform in his pattern.
- **Graphs**: Bei plots show that though his wiskers are a bit wide, he’s consistent across parts and settles into a good movement that he maintains through the run. His little variation in dfh in Surface by Painter graphs which shows good balanced timing as he moves across the parts the parts moved through the zone.
- **Graphs**: Has very good awareness of timing and his body flow as the part pass by him. He’s relaxed and aware of when he needs to complete the first parts and move onto the next part.
- **Doing well at**: DFT is slightly below the 2.0 target. May want to adjust gun setting to allow more powder flow which may help narrow dfh span from point to point. When working with parts with faraday and flat areas, you seem to be a little tighter with the flat areas. This is partially due to the corona effect which you need to keep in mind and adjust to it.

**Recommendations**

- Be mindful of parts that are above your shoulders. You tend to not focus up high as much. Teach new or struggling painters your techniques. Show them what you are looking at and how to move.

**Samuel**

- **Movement over panels**: On panels: “Flutters” fan up and down then moves down the drop to next parts then sweep if back up the parts. Flutting is rapid but sweep is more fluid. Very consistent from part to part. DFT is slightly light but fairly even.
- **Graphs**: Uniquely starts at top then and travels down the drop. Fan is parallel to faraday flurrying quickly in the room. Quickly moves to flat portion on part and flutters from bottom up moving quickly. Though motions are quick powder cloud is full and airy. Can’t see through the cloud much providing good powder cloud.
- **Graphs**: Bee plots show little variability from part to part. Whiskers are close and medium is reasonably straight. Would say he’s #2 painter only because DFT is slightly lower to the 2.0 target. Surface charts interestingly shows heavier dfh on parts 3, 6, 9, 15 - which are all on bottom row. Indicates position or focus is at west high parts. However, not so much that outcome is a worriment.
- **Overall, great painter. Demonstrates that he truly understands how to assess and paint each part situation that passes him and can quickly determine where he will start and how he will move. Also know how to set gun to maximize powder to part.**

**Recommendations**

- Be mindful of parts that are above your shoulders. You tend to not focus up high as much. Teach new or struggling painters your techniques. Show them what you are looking at and how to move.

**Elio**

- **Movement over panels**: Before starting, was not quite plugged into air and parts were coming before being ready. Fast motion across part but sweep and does not “Flutter”. Starts at top and generally sweeps across and then top to bottom before moving to next part. Started at top of drop moving downward.
- **Graphs**: Initially started on middle part faraday then moved up and then down to bottom part. Found more consistent patterns on 2nd drop working from bottom to top. Painted front faraday first, flat areas and then moved to next drop, cycling back to previous drop to finish back faraday. Movement is quick and not a super set pattern but looks like he’s using the powder cloud and gathering movements to how cloud is working.
- **Graphs**: Bee plots on both panels and bracket has tight grouping and consistent median measures, coating each point on each part evenly. Statistically graphed as #1 painter.
- **Overall**: Shows a great understanding of how to set gun and use powder cloud work for him to allow more flexible movements in paint zone. Reacted very quickly when pressured as parts suddenly were in the paint zone.

**Recommendations**

- Watch other painters and mentor and coach on how to set gun and use powder cloud to their advantage. Give tips on what they should watch for as parts move into the zone. GOOD JOB!

**Kenseth**

- **Movement over panels**: Movements are very quick across parts and uniform in pattern. 2 sweeps horizontally and 3 sweeps vertically. Starts at bottom part moving upward coating each part completely before moving to next. As reaches top then transitions to next drop starting at top then moving downward. Once part passes painting zone, part is complete and no need to look back to touch up.
- **Graphs**: Starts on bottom part angling gun parallel to faraday. Makes a couple sweeps then moves to next part up, progressing to top part in same manner. Then turns vertically and sweeps side to side back down same faraday area for second pass. Then moves to flat portion of part on bottom with gun on horizontal plane flurrying up and down all 3 parts before moving to back faraday area repeating technique on front faraday. Movement is very fast and powder flow if heavy but trails on corona are even on edges and thinner in middle. Powder cloud is not uniform.
- **Graphs**: Bee plots on panels is very good. Tight wiskers but dfh is heavier and more varied on leading edge of part and then becomes as part moves through zone. Could be moving too quickly over the part and is little imbalance from front to back edges of part. Brisker wiskers are good but dfh measures are more sporadic. Indication of too quick of movements and not volumizing powder enough. Can’t see in green point which correlates to flat surface of part where trails of corona are blowing past surface due to the lighter amount of powder in the center of the corona.
- **Technically has a good pattern and is very confident. Manages time well as part moves through zone and keeps up pace with the line.**

**Recommendations**

- Two points: 1) Adjust powder down just a little and increase volumizing to get more uniform corona powder cloud. 2) Slow movements slightly to allow corona cloud to form around part and paint to adhere to metal.

**Crommer**

- **Movement over panels**: Starts with bottom part and “Flutters” gun very quickly up-down then left to right completing part before moving onto next part. Is somewhat of a shorter stature and leans heavily on door which causes him to be in an awkward position when trying to paint parts lower on the drop.
- **Graphs**: Begins painting on the bottom part and aims for the faraday area. But due to his height has to stretch over door in order to position the back of the gun down low enough to get the tip angle up under faraday. Motion is much like the panels with short & quick flutter strokes.
- **Graphs**: Bee plots are showing need for one or one training: for panels, lighter on edges and heavier dfh on center point. Brisker wiskers are all over the place showing need to hone in personal pattern and technique for more uniform movement. Seems to end coating before part completely passes missing opportunity apply more even coverage. Can clearly be seen in the erratic dfh measures across all brackets.
- **Recommendations**

  - First adjust powder setting for more uniform cloud of powder to allow powder to work better with technique. Then slow movements a little and be sure to create a regular pattern of movement from part to part to ensure more even coverage. Work with more experienced painters and observe techniques and try out for yourself.
## Pulling It All Together

### Movement over panels

<table>
<thead>
<tr>
<th>Samuel</th>
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<tbody>
<tr>
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</tbody>
</table>

### Movement over brackets

Uniquely starts at with the top part and then travels down the drop. Fan is parallel to faraday fluttering quickly in the crevis. Quickly moves to flat portion on part and flutters from bottom up moving quickly. Though motions are quick powder cloud is full and airy. Can't see through the cloud much providing good powder cloud.
Box plots show little variability from part to part. Whiskers are close and median is reasonably straight. Would say he's #2 painter only because dft is slightly lower to the 2.0 target. Surface charts interestingly show heavier dft on parts 3, 6, 9, 15 - which are all on bottom row. Indicates comfort or focus is at wait high parts. However, not so much that outcome is worrisome.

Overall, great painter. Demonstrates that he truly understands how to assess and paint each part situation that passes him and can quickly determine where he will start and how he will move. Also knows how to set gun to maximize powder to part.
Be mindful of parts that are above your shoulders. You tend to not focus up high as much. Teach new or struggling painters your techniques. Show them what you are looking at and how to move.
Giving Feedback

Some things to consider...

• What is the intention
• Group vs. Individual
• Language barriers
• Using graphs and video together
• Future plan
• Goal setting
Keeping it Simple

This was #1 painter
- Kv – 70
- Flow – 70
- Atomizing – 10

GOOD POINTS:
- Corona has enough powder (Flow)
- Powder is evenly distributed (Atomizing)
- Proper distance from part – (Kv)
- Painter works the cloud around part – not the gun

SUMMARY:
Painter has enough powder in his corona and the powder is evenly distributed. His gun is a good distance away to ensure particle carries the Kv charge and stick to part. He manipulates the powder cloud around the parts.
Keeping it Simple

PAINTER USED
- Kv – 70
- Flow – 99
- Atomizing – 2

LEARNING POINTS:
• Corona and cloud has heavy powder.
  DEFECT: Creates orange peel (Flow)
  CORRECTION: Dial down flow

• Powder is NOT evenly distributed. Heavier around edge of corona creating "striping" pattern. (Atomizing)
  DEFECT: inconsistent dft – even light in areas
  CORRECTION: turn atomizing UP

• Far distance from part – (Kv)
  DEFECT: powder will not hold Kv and not stick to part
  CORRECTION: use “hang-loose” rule of thumb.

SUMMARY: The painter has too much powder in cloud and didn’t atomize it enough. Too close to part, he creates orange peel, too far away from part, the Kv drops and particle loses its charge and ability to stick to part.
Moving Forward

Now that its all done, what to do next...

• If acceptable to all, post the information. This is a lot of information to take in. Let the painters review on their own time.

• Develop or incorporate into your training program. Can do every quarter, half year, annually to see how painters progress.

• Track painting defects and talk about daily/weekly. If you don’t use the training, they’ll lose it.

• Do classroom training after to teach the science and retest.
**BASICS OF POWDER COATING**

**GOAL:** A balance must be reached of each of these factors.

1. Minimum powder delivery needed to achieve the desired film thickness.
2. The maximum charge without back ionizing.
3. The best transfer efficiency and appearance.

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**CORONA CHARGING**

- Negative Free Ions
- Powder Spray Gun
- Voltage Cable
- Charging Electrode
- Electrical Lines of Force
- Powder Supply Hose
- Grounded Part
- Powder Particles

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**BASIC EQUIPMENT**

- Coating Unit
- Spray Gun
- Powder Pump
- Powder Hopper
- Compressed Air Input
Proof of work

Light & Heavy Paint 2017 - Feb 2018

- Painter assessment
- Started painter training
- Follow up training and posters put up.
Questions??