






Godfrey Hirst CARPET

# 6 Sigma

## Kuster Colour Variation

### Carpet Colour Measurement


**Jason Maher**

**Quality & Improvement Manager**


Godfrey Hirst offers a wide range of high quality residential and commercial carpets. Australasia's largest carpet supplier, we have operations in Australia, New Zealand and North America. Our range of modular carpet tiles and broadloom carpet is extensive and provides a variety of floor covering options. Nylon, triexta and wool carpets are all produced by Godfrey Hirst.

# What Makes a Good Lean Six Sigma Project?

- There is no known solution
- The root cause is not known
- The problem is complex and needs statistical analysis
- The problem is part of a process
- The process is repeatable
- A defect can be defined
- Project will take 3-6 months
- There is data available

# DMAIC **DEFINE**

**Project Name:**

Kuster Colour Variation Reduction

**Business Case**

Colour variation from the Kuster continuous dyeing operation drives the consumption of $650,000 of carpet greige per annum plus 6-8hrs/day of labour/machine time to complete production line sampling.

# DMAIC **DEFINE**

**Elements**

- Dyes & mixing variation – recipe calibration
- Yarn dye uptake variation – recipe calibration
- Process Control
- Recipe Management
- Carpet Colour Measurement

# DMAIC **DEFINE**

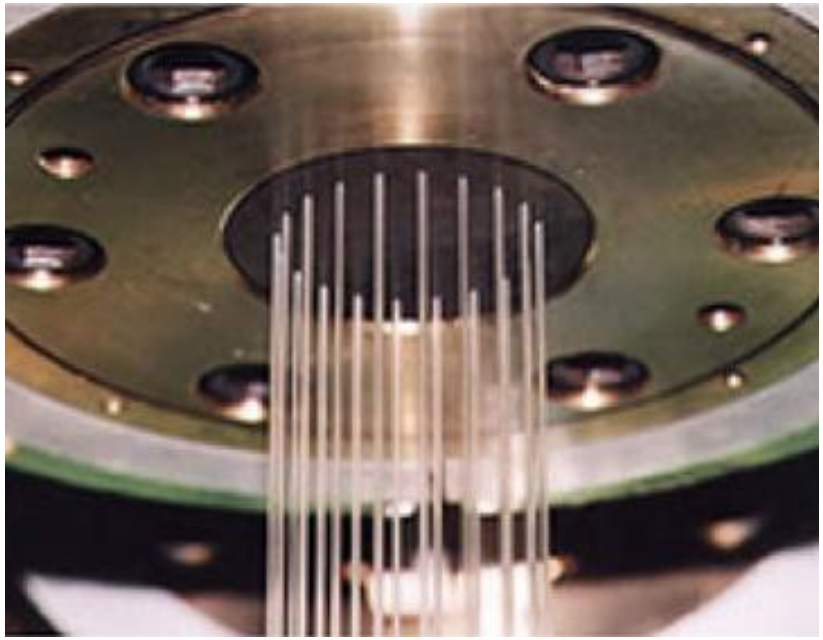
## Elements

Dyes & mixing variation – recipe calibration

# DMAIC **DEFINE**

## Elements

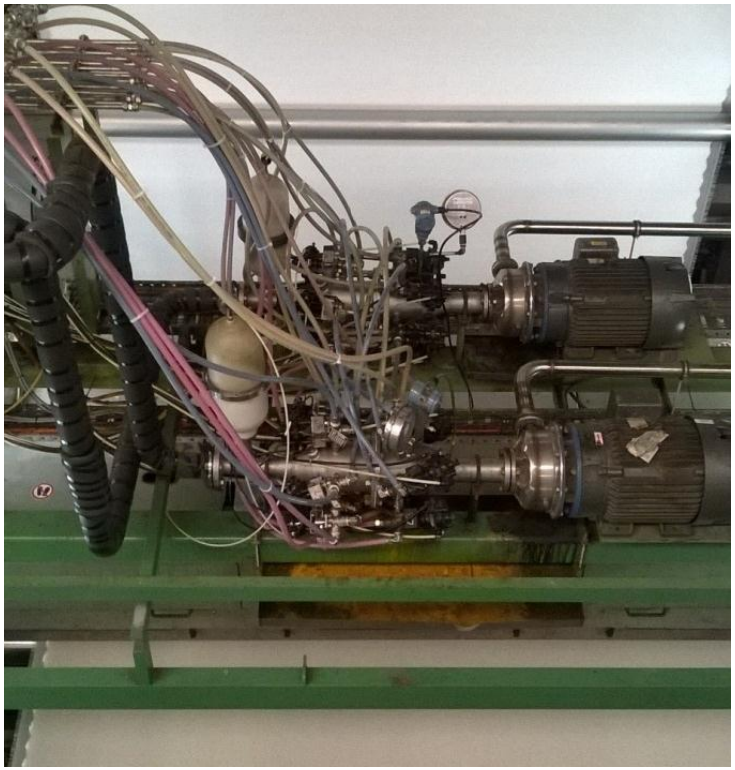
Yarn dye uptake variation – recipe calibration



# DMAIC DEFINE

## Elements

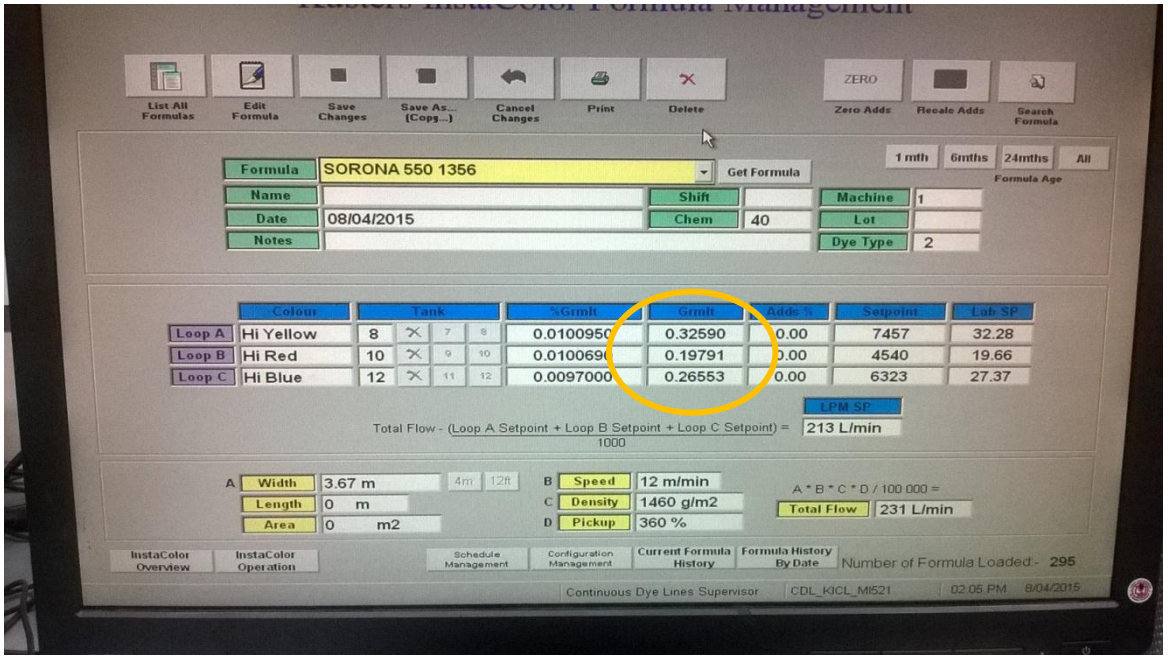
Process Control

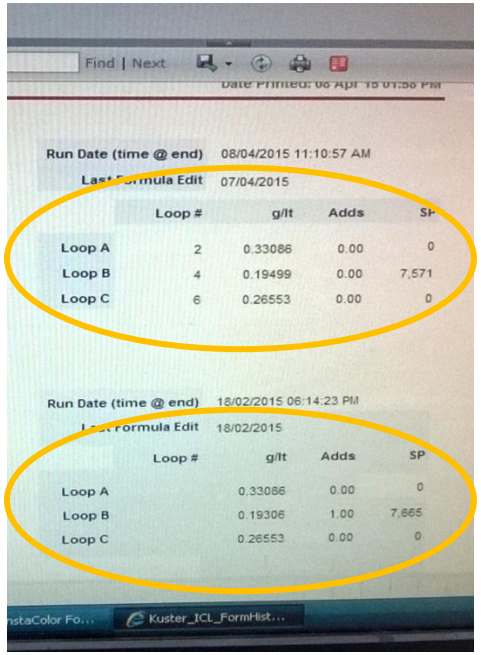


# DMAIC DEFINE

## Elements

Recipe Management



# DMAIC **DEFINE**

## Elements

Carpet Colour Measurement

# DMAIC DEFINE

**Project Name:**

Kuster Colour Variation Reduction

Colour Measurement

**Business Case**

An accurate & reproducible measurement system to objectively determine carpet colour is required to drive improvement in Kuster colour variation.

# DMAIC DEFINE

## TEAM/PROJECT CHARTER

| | |
|---|---|
| **Project Name:** | Kuster Colour Variation Reduction - **Colour Measurement** |
| **Date (Last Revision):** | 11/04/2014 |
| **Prepared By:** | Jason Maher |
| **Approved By:** | Jason Maher, Aaron Dawson, Norm Kotsopoulos, Anthony Legault, Darren Morrison |

| **Business Case:** | **Opportunity Statement (High Level Problem Statement):** |
|---|---|
| The colour variation of the Kuster continuous dyeing operation necess itates the cons umption of 6-8hrs per day of Kuster labour/capacity and resulted in 21,900blm of Kuster dyed greige samples going to waste recyclers over the 12 months ending February 2014. | Variation in colour measurement of the textured carpet pile<br><br>***Defect Definition:***<br>To be determined following measurement and analysis of data |
| **Goal Statement:** | **Project Scope:** |
| *Contribute to the 50% reduction in production line sampling*<br><br>***Expected Savings/Benefits:***<br>Contriubtion of this element is unkown at this time Estimate 20% | ***Process Start Point:***<br>Carpet colour measurement<br><br>***Process End Point:***<br>Development of std work<br><br>***In Scope:***<br>Carpet colour measurement<br><br>***Out of Scope:***<br>Supporting project elements |

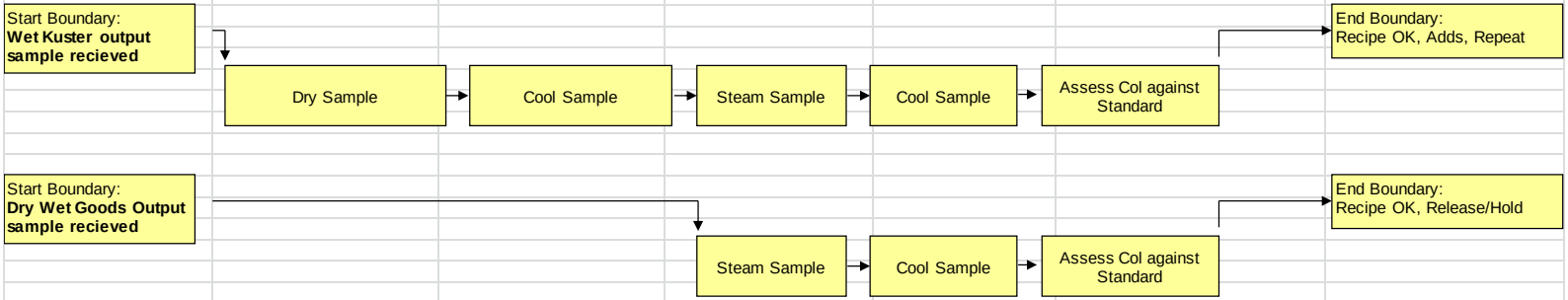
| **Project Plan:** | | | | **Team:** | |
|---|---|---|---|---|---|
| Task/Phase | Start Date | End Date | Actual End | Name: | Commitment (%): |
| Define | 9/04/14 | 16/04/14 | | Jason | 20 |
| Measure | 16/04/14 | 30/04/14 | | | |
| Analyse | 30/04/14 | 7/05/14 | | | |
| Improve | 7/05/14 | 28/05/14 | | | |
| Control | 28/05/14 | 25/06/14 | | | |

# DMAIC DEFINE

## SIPOC DIAGRAM

| | |
|---|---|
| **Process/Project Name:** | Kuster Colour Variation Reduction - **Colour Measurement** |
| **Date:** | **28/04/2014** |
| **Prepared By:** | **Jason Maher** |

| Suppliers | Inputs | | Process | Outputs | | Customers |
|---|---|---|---|---|---|---|
| Provider | Input Description | Input Requirements (optional) | | Output Description | Output Requirements (optional) | Recipient of Output |
| Kuster Output | Wet production sample run | 300mm x 300mm | See High Level Process Steps Below | ColourAssessment | Visual Assessment (Experience)<br>Sample matches Std<br>Sample does not match standard<br>Production within tolerance<br>Production outside tolerance | Int. - Run Production<br>Int. - Adjust recipe, repeat<br>Finishing<br>Hold - Corrective action |
| Wet Goods Output | Dry production run | 300mm x 300mm | | | | |
| Dryer | Sample Dryer | Fan 170°C - Time | | | | |
| Fan | Cooling Fan | On/Off - Time | | | | |
| Steamer | Moisturising Steamer | Water 80-90°C - Time | | | | |
| | | | | | | |

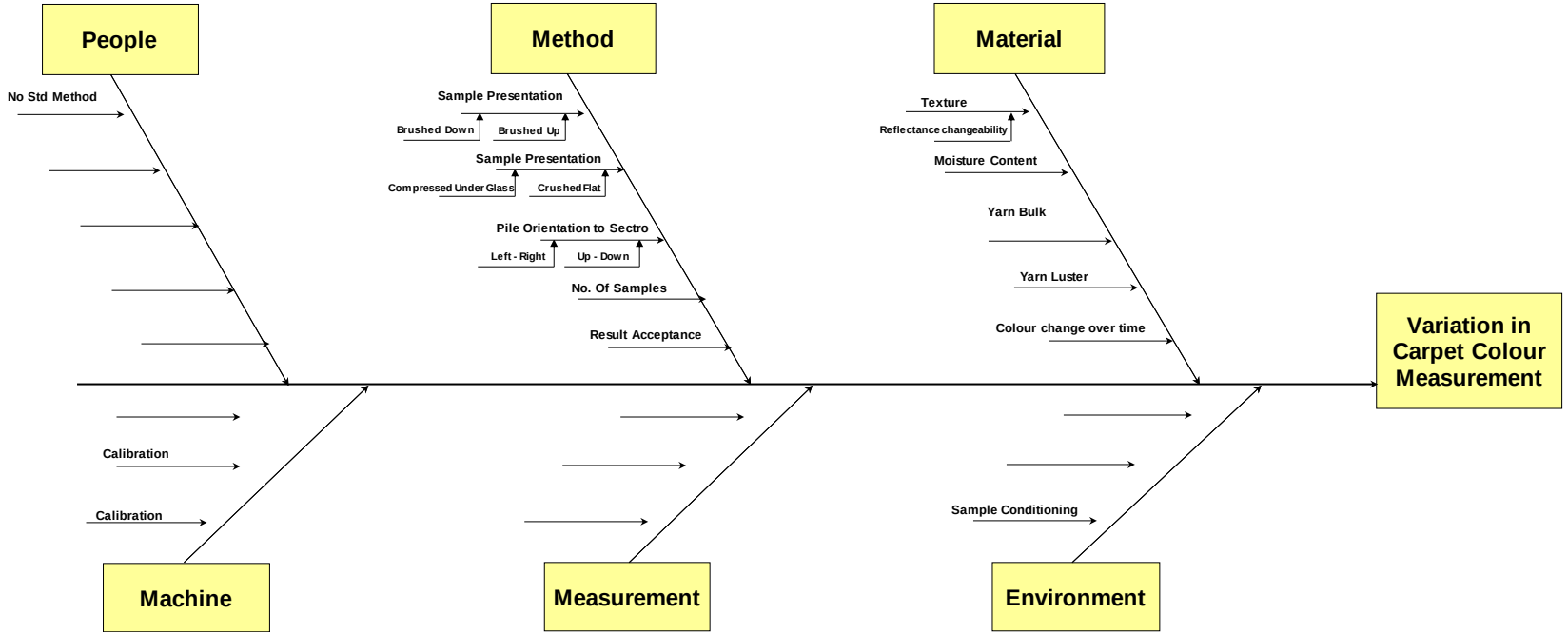


# DMAIC DEFINE

## CAUSE & EFFECT (FISHBONE) DIAGRAM

| | |
|---|---|
| **Process/Project Name:** | Kuster Colour Variation Reduction - Colour Measu |
| **Date:** | 15/04/2014 |
| **Prepared By:** | Jason Maher |

| | |
|---|---|
| **Problem Statement/Effect:** | Variation in Carpet Colour Measurement |



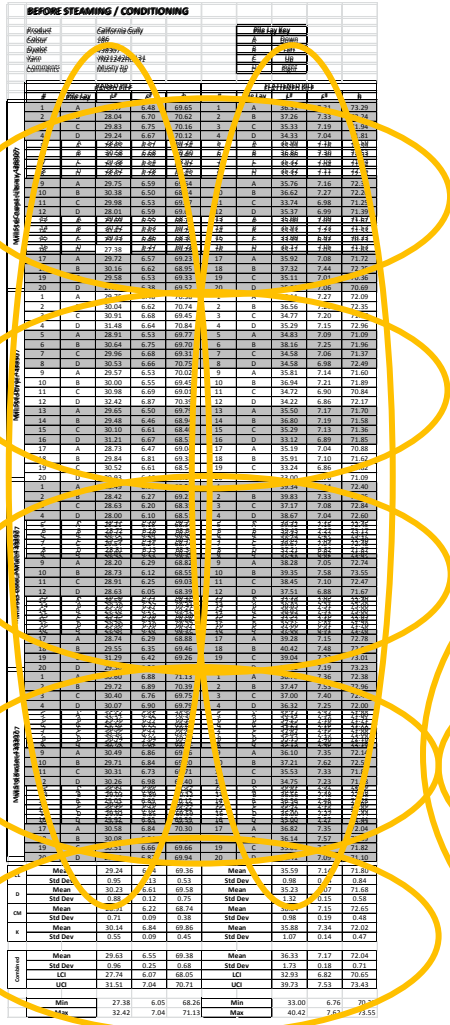
# DMAIC MEASURE

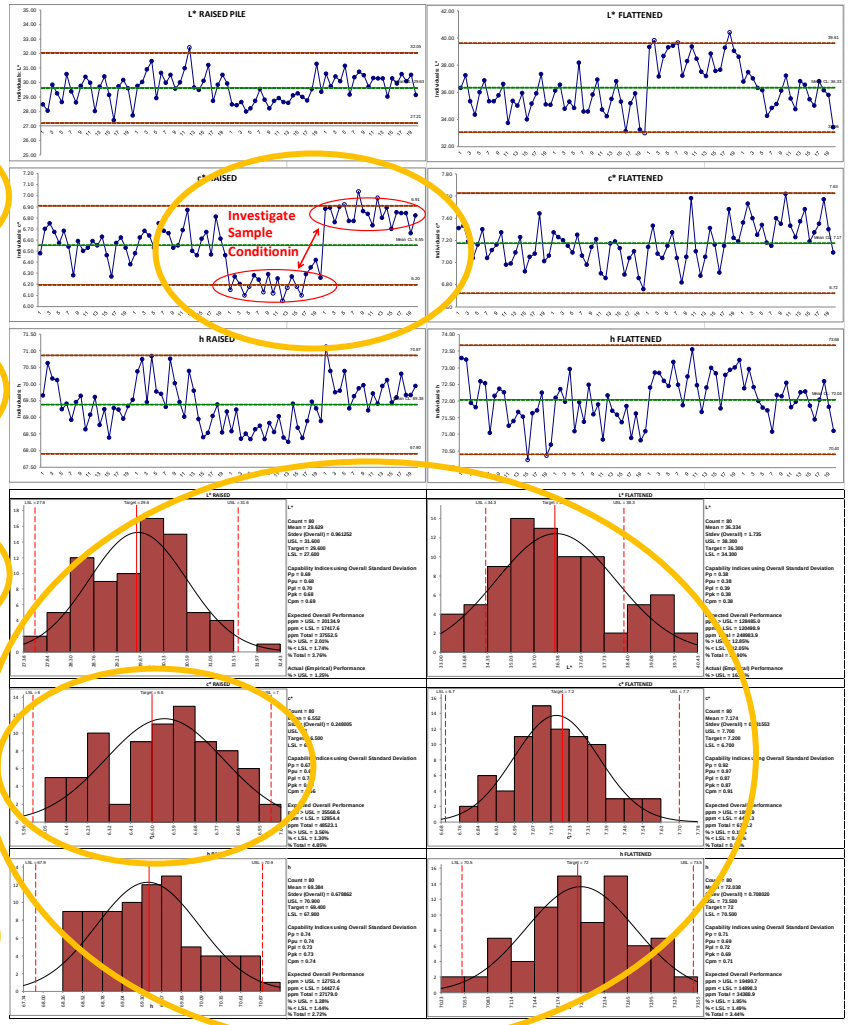
## MEASUREMENT PLAN

| | |
|---|---|
| Project Name: | Kuster Colour Variation Reduction - Colour Measurement |
| Date: | 15/04/2014 |
| Prepared By: | Jason Maher |
| Notes: | |

| Measurement/ Metric | X or Y | Operational Definition | Type of Data Discrete/ Continuous | Data Source and Location | Sample Size | Who Will Collect the Data? | When Will Data be Collected? | How Will Data be Collected? | Is the Meas. System Capable? | Graphical and/or Statistical Tools to be Used |
|---|---|---|---|---|---|---|---|---|---|---|
| Pile Orientation to Spectro | x | Left/Right/Up/Down | Cont. | Colour Spectro | Std Size | Jason | 17-Mar | Meas. Stds/Samples | That is what we are working on | Mean, St Dev, Multi Vari |
| Pile Brushed Up | x | Vertical Pile | Cont. | Colour Spectro | Std Size | Jason | 17-Mar | Meas. Stds/Samples | | Mean, St Dev, Control Charts, Histogram |
| Pile Brushed Down | x | Angled Pile | Cont. | Colour Spectro | Std Size | Jason | 17-Mar | Meas. Stds/Samples | | Mean, St Dev, Control Charts, Histogram |
| Sample Conditioning | x | Repeat of above after conditioning | Cont. | Colour Spectro | Std Size | Jason | 24-Mar | Meas. Stds/Samples | | Mean, St Dev, Control Charts, Histogram |
| Pile Crushed Flat | x | Flattened Pile | Cont. | Colour Spectro | 50mm x 50mm | Jason | 11-Apr | Meas. Stds/Samples | | Control Chart |
| Pile Compressed Under Glass | x | Compressed against glass | Cont. | Colour Spectro | 50mm x 50mm | Jason | 14-Apr | Meas. Stds/Samples | | Mean, St Dev, Control Charts, Histogram |
| Moisture Content | x | Moist / Dry | Cont. | Colour Spectro | 50mm x 50mm | Jason | 14-Apr | Meas. Stds/Samples | | Mean, St Dev |
| L* | y | Lightness Value | Cont. | Colour Spectro | | | | | | |
| c* | y | Chroma | Cont. | Colour Spectro | | | | | | |
| h | y | Hue | Cont. | Colour Spectro | | | | | | |
| a* | y | Red/Green | Cont. | Colour Spectro | | | | | | |
| b* | y | Blue/Yellow | Cont. | Colour Spectro | | | | | | |

# DMAIC MEASURE




Choose Godfrey Hirst first

# DMAIC **ANALYSE**

## Pile Orientation to Colour Spectro

*Test the following hypothesis:*

**$H_0$:** there is no difference in colour measurement for different orientations of the sample *(Null Hypothesis)*


**$H_1$:** at least one orientation gives a different colour measurement. *(Alternative Hypothesis)*

# DMAIC **ANALYSE**

## Pile Orientation to Colour Spectro

*Is the result affected by the selection of an attribute?*

As we are comparing more than two attributes (Pile: Up, Down, Left, Right) ANOVA (ANalysis Of VAriance) is used instead of completing t-tests for all possible pairs.

# DMAIC ANALYSE

## Pile Orientation to Colour Spectro - Raised

Anova: Single Factor

SUMMARY

| *Groups* | *Count* | *Sum* | *Average* | *Variance* |
|---|---|---|---|---|
| Column 1 | 20 | 588.19 | 29.4095 | 0.801826 |
| Column 2 | 20 | 591.8 | 29.59 | 0.549747 |
| Column 3 | 20 | 599.83 | 29.9915 | 0.506982 |
| Column 4 | 20 | 590.46 | 29.523 | 1.780896 |

ANOVA

| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
|---|---|---|---|---|---|---|
| Between Groups | 3.84685 | 3 | 1.282283 | 1.409315 | 0.246602 | 2.724944 |
| Within Groups | 69.14957 | 76 | 0.909863 | | | |
| Total | 72.99642 | 79 | | | | |

# DMAIC ANALYSE

## Pile Orientation to Colour Spectro - Flattened

Anova: Single Factor

SUMMARY

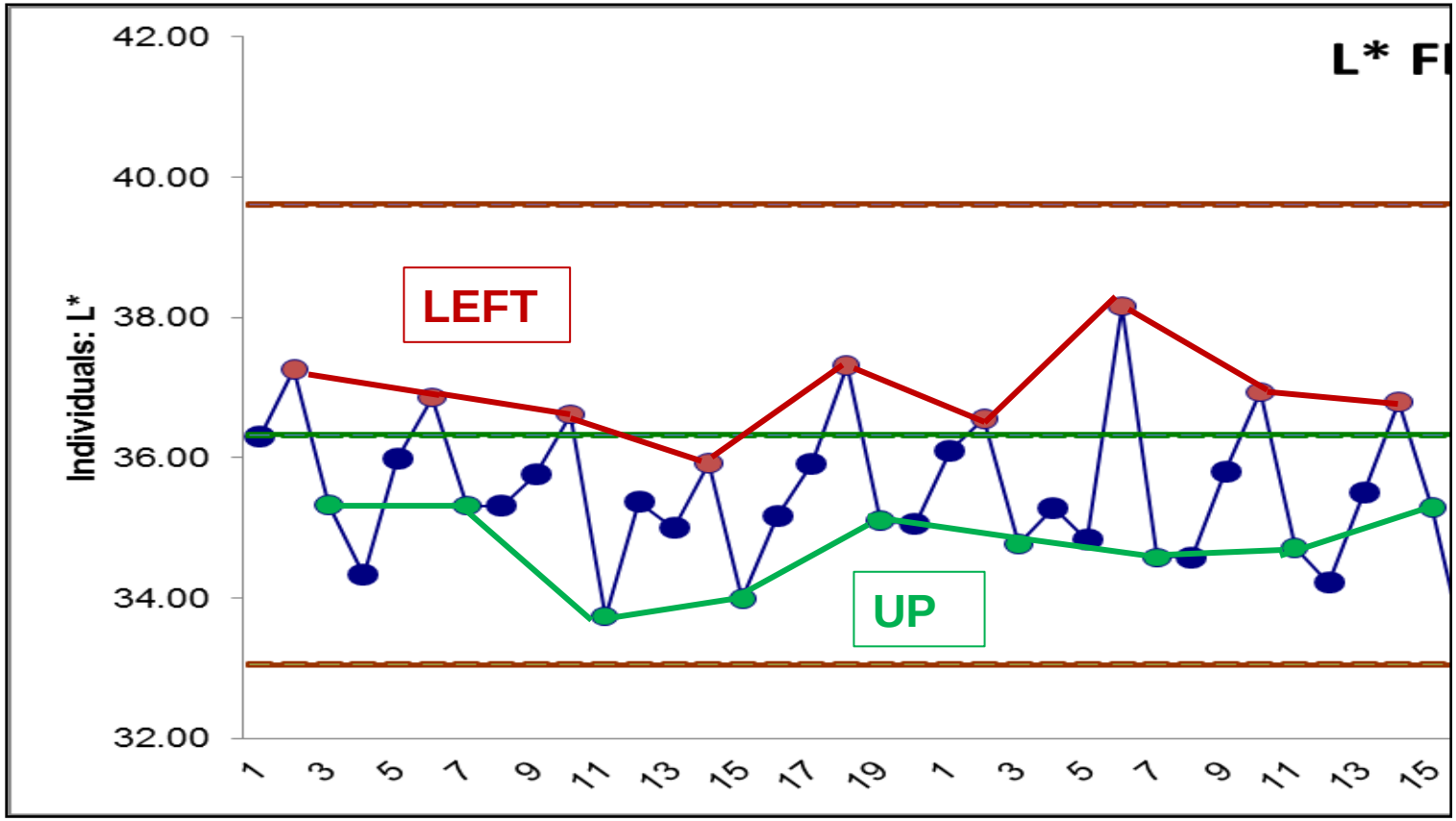
| *Groups* | *Count* | *Sum* | *Average* | *Variance* |
|---|---|---|---|---|
| Column 1 | 20 | 732.48 | 36.624 | 1.958594 |
| Column 2 | 20 | 747.85 | 37.3925 | 2.33742 |
| Column 3 | 20 | 716.63 | 35.8315 | 3.105624 |
| Column 4 | 20 | 709.74 | 35.487 | 2.819138 |

ANOVA

| *Source of Variation* | *SS* | *df* | *MS* | *F* | *P-value* | *F crit* |
|---|---|---|---|---|---|---|
| Between Groups | 43.48875 | 3 | 14.49625 | 5.673248 | 0.001465 | 2.724944 |
| Within Groups | 194.1947 | 76 | 2.555194 | | | |
| Total | 237.6835 | 79 | | | | |

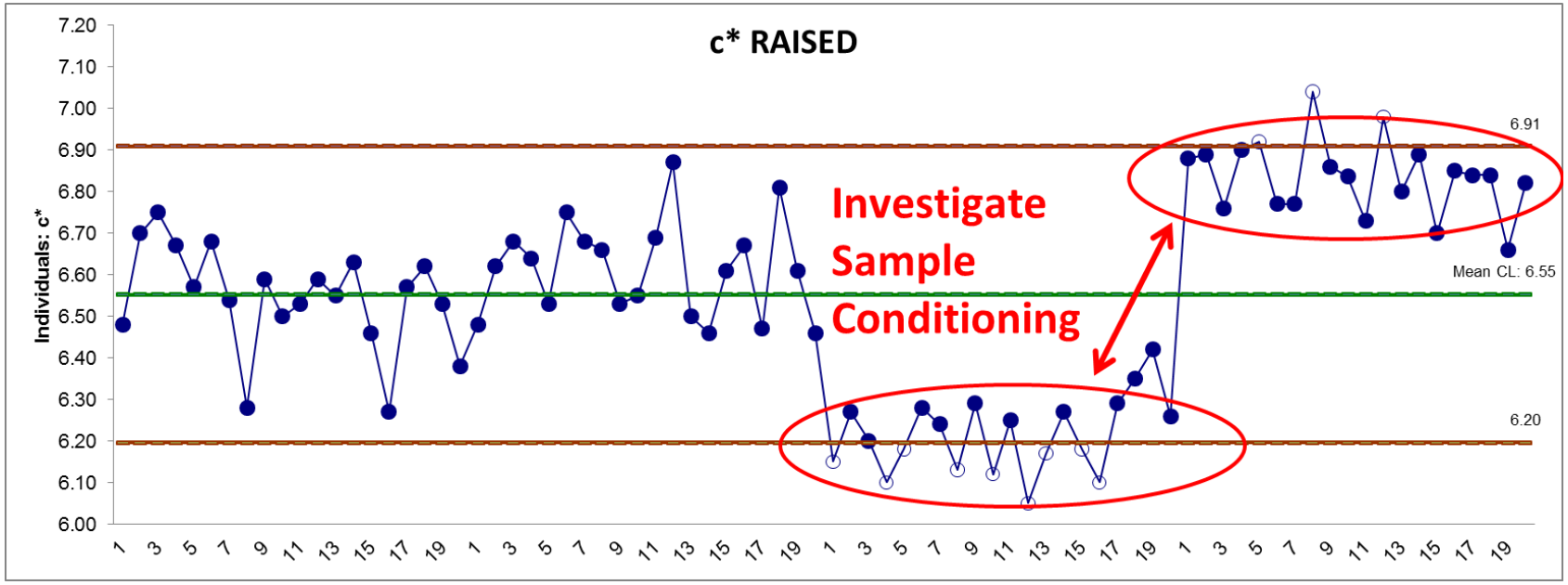
# DMAIC ANALYSE

## Pile Orientation to Colour Spectro - Flattened



# DMAIC ANALYSE

## Conditioning



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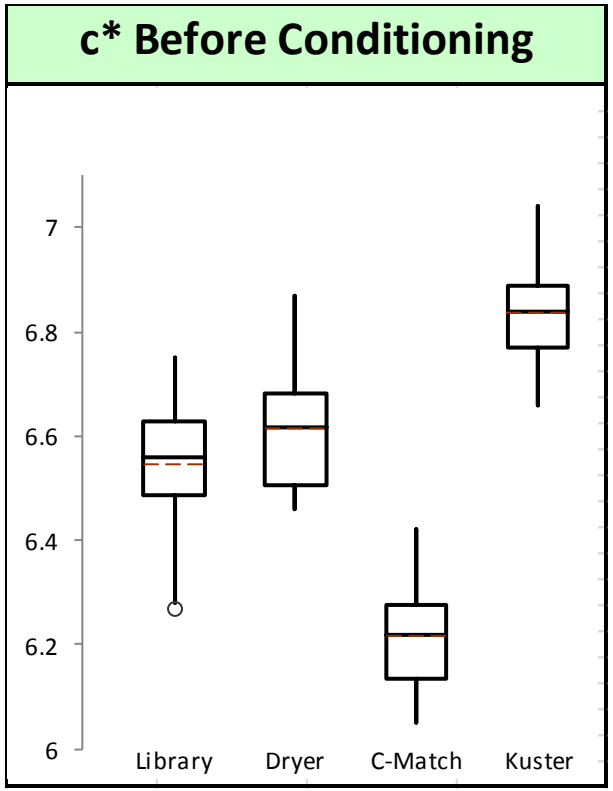
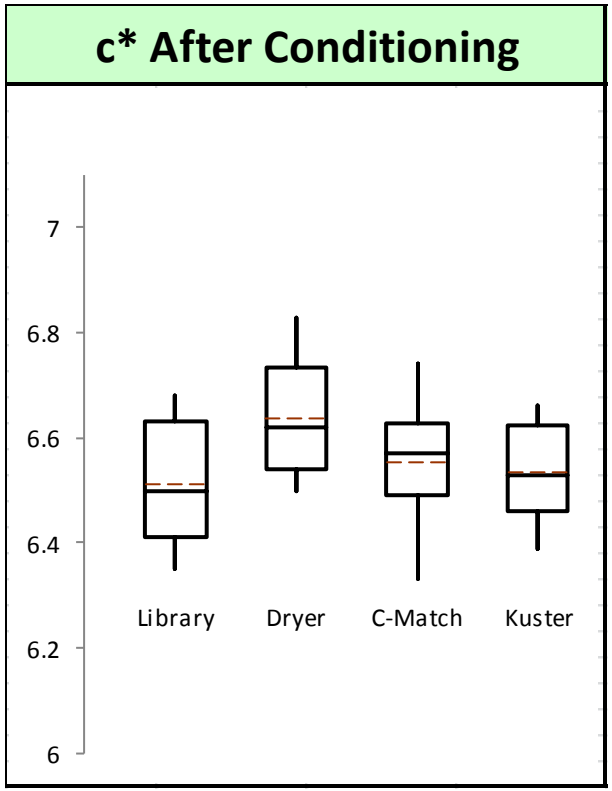
## Conditioning



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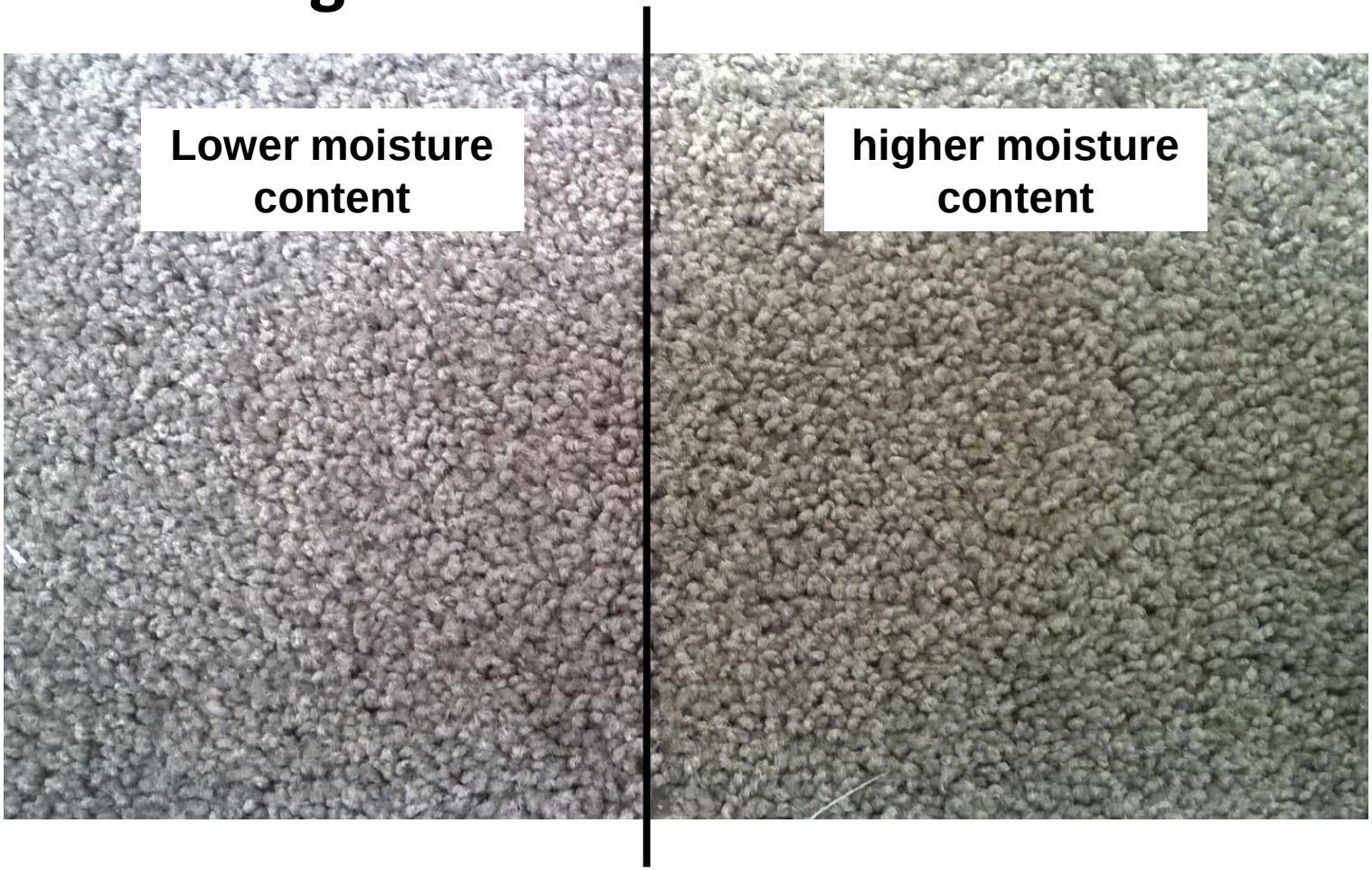
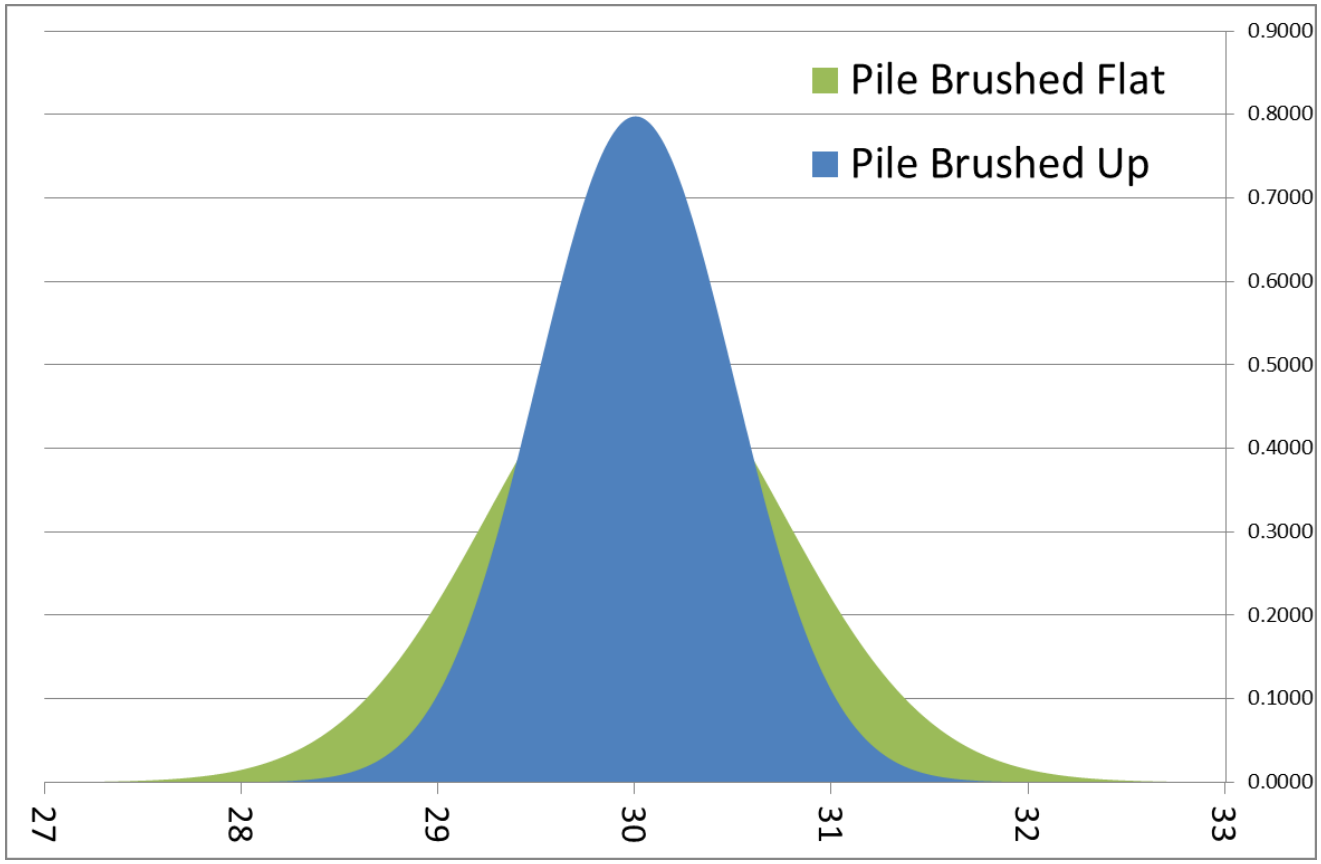
## Conditioning



# DMAIC ANALYSE

## Pile Flattened vs Brushed Up

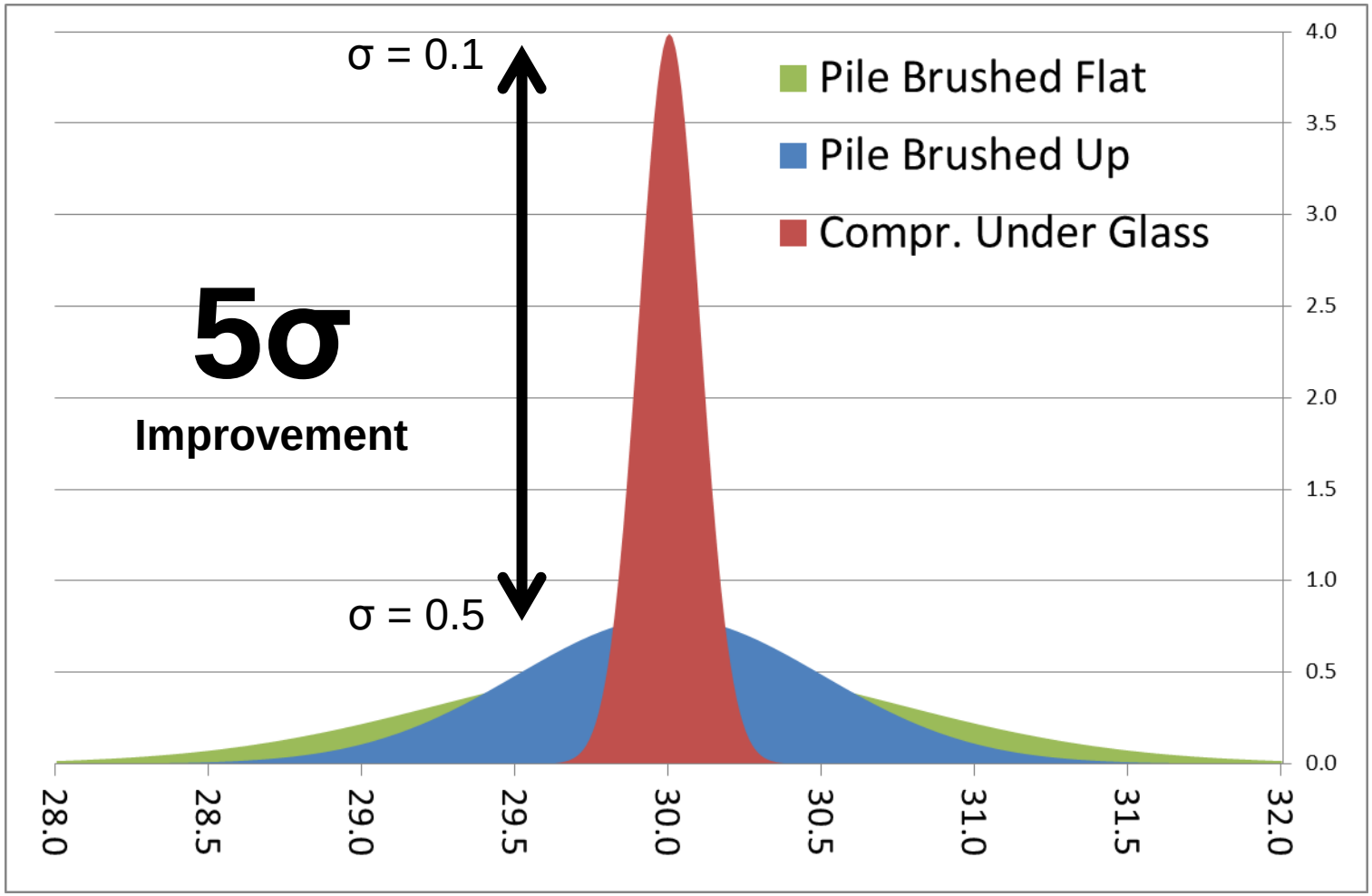


# DMAIC **IMPROVE**

How can we significantly improve the precision?

- Fix pile by compression prior to testing
- Fix pile by compressed under glass aperture

# DMAIC **IMPROVE**



# DMAIC CONTROL

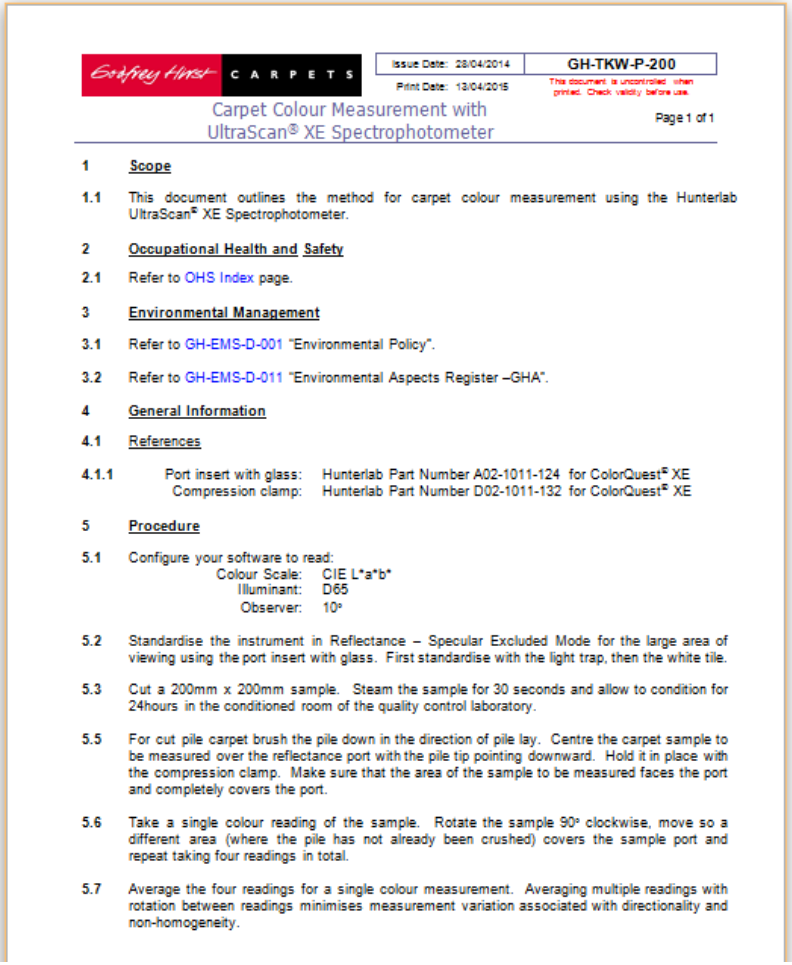
Equipment

- Glass Aperture
- Compression Clamp

# DMAIC CONTROL

Standard work

- Sample Conditioning
- Sample Testing
- System Calibration



Godfrey Hirst CARPETS

Issue Date: 28/04/2014 | GH-TKW-P-200
Print Date: 13/04/2015
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Carpet Colour Measurement with UltraScan® XE Spectrophotometer

Page 1 of 1

**1 Scope**

1.1 This document outlines the method for carpet colour measurement using the Hunterlab UltraScan® XE Spectrophotometer.

**2 Occupational Health and Safety**

2.1 Refer to OHS Index page.

**3 Environmental Management**

3.1 Refer to GH-EMS-D-001 "Environmental Policy".

3.2 Refer to GH-EMS-D-011 "Environmental Aspects Register –GHA".

**4 General Information**

4.1 References

4.1.1 Port insert with glass: Hunterlab Part Number A02-1011-124 for ColorQuest® XE
Compression clamp: Hunterlab Part Number D02-1011-132 for ColorQuest® XE

**5 Procedure**

5.1 Configure your software to read:
Colour Scale: CIE L*a*b*
Illuminant: D65
Observer: 10°

5.2 Standardise the instrument in Reflectance – Specular Excluded Mode for the large area of viewing using the port insert with glass. First standardise with the light trap, then the white tile.

5.3 Cut a 200mm x 200mm sample. Steam the sample for 30 seconds and allow to condition for 24hours in the conditioned room of the quality control laboratory.

5.5 For cut pile carpet brush the pile down in the direction of pile lay. Centre the carpet sample to be measured over the reflectance port with the pile tip pointing downward. Hold it in place with the compression clamp. Make sure that the area of the sample to be measured faces the port and completely covers the port.

5.6 Take a single colour reading of the sample. Rotate the sample 90° clockwise, move so a different area (where the pile has not already been crushed) covers the sample port and repeat taking four readings in total.

5.7 Average the four readings for a single colour measurement. Averaging multiple readings with rotation between readings minimises measurement variation associated with directionality and non-homogeneity.

# DMAIC **DEFINE**

**Design of experiments**

- What variables or combination of variables have the greatest impact on the colour outcome?