Batch to Batch Reproducibility

and how to avoid creases, spots and stains.
Batch-to-Batch Reproducibility

- Only possible to achieve high levels of shade reproduction by using the same raw materials and the same dyeing process
- Check that fabric or yarn to be dyed has same dye affinity as previous batch
- Standard of preparation must be identical
- Maintain same liquor ratio
- Ensure same ‘number of contacts’
- Make sure operators add right chemicals at the same time and temperature
Batch-to-Batch Reproducibility

• Use the same standard program procedures for each batch. May vary with the dyes and chemicals used, and depth, pale/medium/dark, but for reproduction of the same colour the procedure should be identical each time

• Check water supply daily, especially hardness, pH and bicarbonate content

• Oils, waxes and spin finish must be removed to obtain level dyeing and consistent batch-to-batch shade

• Avoid standing times during process. Have dyes and chemicals prepared ready for addition
## Number of ‘contacts’

This is the number of times the fabric comes into contact with the dye liquor during the dyeing process, and will depend on fabric rope speed and the number of jet nozzle passages.

<table>
<thead>
<tr>
<th>Fabric</th>
<th>Rope cycle time (mins)</th>
<th>Speed woven fabric</th>
<th>Speed knit fabric</th>
</tr>
</thead>
<tbody>
<tr>
<td>PES unfixed</td>
<td>1</td>
<td>400</td>
<td>250</td>
</tr>
<tr>
<td>PES heat-set</td>
<td>2</td>
<td>400</td>
<td>200</td>
</tr>
<tr>
<td>PA unfixed</td>
<td>2-3</td>
<td>400</td>
<td>300</td>
</tr>
<tr>
<td>PA heat-set</td>
<td>3</td>
<td>350</td>
<td>300</td>
</tr>
<tr>
<td>CO Reactive</td>
<td>4</td>
<td>350</td>
<td>300</td>
</tr>
</tbody>
</table>

Example - cotton knit - fabric speed maximum 300 m/min
Number of nozzle passages = \(\text{Process time}(480 \text{ mins}) = 120\)
Rope cycle time( 4 mins)
Rope length

Weight per linear metre

- 600 g
- 500 g
- 400 g
- 300 g
- 275 g
- 250 g
- 225 g
- 200 g
- 175 g
- 150 g
- 125 g
- 100 g

Rope length

Weight of the rope 105 kg

weight per linear metre 0.200 kg/m

= 525 m
Cycle time = \textbf{rope length} \ \textbf{fabric speed}

Rope of 900 metres at 225 metres/min - cycle time 4 minutes
Maximum rope length

Calculate the maximum rope length with a fabric of a particular weight per sq. m., having determined the rope speed and cycle time. Keep the same rope length in each jet chamber.

For example - 100% cotton reactive dyeing

- cycle time = 4 minutes
- knit fabric speed = 300 m / minute

Rope length = 4 min X 300 m = 1200 metres

If the rope is shorter, the winch speed should be reduced, so that the same rope circulation time and nozzle contacts are maintained

Rope length = 800 m = 200 m.minute

cycle time = 4 minutes
Creasing

- Abrasion and chafing marks may be caused by:
  - machine speed too high
  - stationary fabric in a running machine, perhaps caused by poor wetting, knots and tangles
  - overloading, leading to mechanical friction
  - rough patches in machine
  
  Such abrasion may exaggerate creasing by damaged fibres dyeing to a different shade

  - often useful to turn tube of knitted fabric inside to outside, particularly single jersey.
Creasing

- Creasing may result from:
  - incorrect loading - twisted rope, poor sewing
  - inadequate preparation, incomplete or too rapid relaxation
  - quality of goods (tight construction, high twist yarns, dense weight per square metre)
  - poor suitability of dyeing machine - folds not moved
  - batch of fabric too heavy
  - incorrect dyeing process - heating/cooling too fast
  - lustre - stationary fabric on hot metal under pressure
Creasing

Fabric should be delivered to dyeing machine already folded and each piece sewn straight, with sewing machine, to next piece. Rope is loaded into dyeing machine without twist.

Only pieces of equal diameter should be sewn together.

Leave small opening to allow ballooning of air to escape.

Load into jet machine.
Creasing, crack marks, rope marks

- Cockling, or dimpling - eliminate by using larger diameter jet nozzle, increasing liquor ratio, reducing fabric speed
- Rope marks caused by poor opening of rope. Avoid by pre-setting or pre-relaxation of fabric before dyeing
- Rope and crack marks also from incorrect process procedures. Higher speed + slower rates of rinse and cooling often solve
- Reduce machine load, run at slightly higher nozzle pressure, or use next largest nozzle size.
- Check that bath draining temperatures are not too high, especially with viscose
- Shock cooling of stationary fabric will cause crack marks
- Crows’ feet or Wrinkling - avoid by presetting or prerelaxation, higher rope speed and increasing liquor ratio help
- Orange peel effect - fabric stopped running during cooling stage - machine is overloaded - not enough liquor - draining bath at too high a temperature and refilling with cold water
Damaged cotton is dyed to a different shade

If we make a scratch on a piece of undyed cotton with a metal coin, and then dye the cotton with a phthalocyanine turquoise and a yellow, the place where we made the scratch will dye more strongly blue than the rest of the fabric.
If we examine the fibres in the scratch mark under the microscope we see that damaged fibres are preferentially dyed blue by the turquoise dye.

Abrasions damages fibres. Damaged fibres are dyed to a different shade.
Lubrifil LAF helps eliminate creasing when dyeing cellulose
Preparation

Batch-to-Batch Reproducibility -

- Fabric or yarn to be dyed must have same dye affinity as previous batch
- Standard of preparation must be identical
- Oils, waxes and spin finish must be removed to obtain level dyeing and consistent batch-to-batch shade
Oils and waxes

Residual oils and waxes in yarn and fabric will make penetration more difficult.

Oils and waxes will tend to form a ‘tide mark’ at the water level on the walls of the dyeing machine, and then wipe off to make a dirty mark on fabric.

If disperse dyes (or other dyes which are more oil-loving) are also present in the bath, they will dye the oil/wax, so any spot or stain will be a coloured spot, very difficult to remove.

Many reactive dyes, especially blues, navies and blacks, are lipophilic, and will dye fabric containing more oil to a different shade, or accentuate a spot.
Detectable wax acids and alcohols in cotton

<table>
<thead>
<tr>
<th>Chemical Formula</th>
<th>Systematic name</th>
<th>Trivial Name</th>
<th>Melting Point deg C</th>
</tr>
</thead>
<tbody>
<tr>
<td>C15H31COOH</td>
<td>hexadecanoic acid</td>
<td>Palmitic acid</td>
<td>64</td>
</tr>
<tr>
<td>C17H35COOH</td>
<td>octadecanoic acid</td>
<td>Stearic acid</td>
<td>69</td>
</tr>
<tr>
<td>C19H39COOH</td>
<td>eicosanoic acid</td>
<td>Arachinic acid</td>
<td>76</td>
</tr>
<tr>
<td>C21H43COOH</td>
<td>docosanoic acid</td>
<td>Behenic acid</td>
<td>81</td>
</tr>
<tr>
<td>C23H47COOH</td>
<td>tetracosanoic acid</td>
<td>Lignoceric acid</td>
<td>81</td>
</tr>
<tr>
<td>C25H51COOH</td>
<td>hexacosanoic acid</td>
<td>Cerotic acid</td>
<td>88</td>
</tr>
<tr>
<td>C27H55COOH</td>
<td>octacosanoic acid</td>
<td>Montanic acid</td>
<td>91 - 93</td>
</tr>
<tr>
<td>C29H59COOH</td>
<td>triacontanoic acid</td>
<td>Mellisic acid</td>
<td>92</td>
</tr>
<tr>
<td>C31H63COOH</td>
<td>dotriacontanoic acid</td>
<td>Locca acid</td>
<td></td>
</tr>
<tr>
<td>C33H67COOH</td>
<td>tetratriacontanoic acid</td>
<td>Ghedda acid</td>
<td></td>
</tr>
<tr>
<td>C17H33COOH</td>
<td>octadecanoic-9-acid</td>
<td>Oleic acid</td>
<td>13</td>
</tr>
<tr>
<td>C19H37COOH</td>
<td>eicosanoic-9-acid</td>
<td>Gadoleic acid</td>
<td></td>
</tr>
<tr>
<td>C24H49OH</td>
<td>tetracosanol</td>
<td>Lignoceryl alcohol</td>
<td>75 - 77</td>
</tr>
<tr>
<td>C26H53O</td>
<td>hexacosanol</td>
<td>Ceryl alcohol</td>
<td>79 - 81</td>
</tr>
<tr>
<td>C28H57O</td>
<td>octacosanol</td>
<td>Montanyl alcohol</td>
<td>83</td>
</tr>
<tr>
<td>C30H61OH</td>
<td>triacontanol</td>
<td>Gossypyl alcohol</td>
<td></td>
</tr>
<tr>
<td>C32H65OH</td>
<td>dotriacontanol</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C34H69OH</td>
<td>tetratriacontanol</td>
<td></td>
<td>92</td>
</tr>
<tr>
<td>C30H60(OH)2</td>
<td>tricontandiol</td>
<td>Coceryl alcohol</td>
<td></td>
</tr>
<tr>
<td>C3H5(OH)3</td>
<td>propantriol</td>
<td>Glycerol</td>
<td>18</td>
</tr>
</tbody>
</table>

This means we need boiling water.
### Composition and removal properties of cotton wax

<table>
<thead>
<tr>
<th>Component</th>
<th>Content ( % )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wax ester</td>
<td>22</td>
</tr>
<tr>
<td>Phytosterols</td>
<td>12 - 14</td>
</tr>
<tr>
<td>Polyterpenes</td>
<td>1 - 4</td>
</tr>
<tr>
<td>Hydrocarbons</td>
<td>7 - 8</td>
</tr>
<tr>
<td>Free wax alcohols</td>
<td>42 - 46</td>
</tr>
<tr>
<td>Saponifiable</td>
<td>36 - 50</td>
</tr>
<tr>
<td>Non-saponifiable</td>
<td>50 - 63</td>
</tr>
<tr>
<td>Inert</td>
<td>0 - 3</td>
</tr>
</tbody>
</table>

This means we need caustic soda.

This means we need detergent / emulsifier.
Soil to be removed in preparation of Knitted Cotton

- Natural Impurities
  - Fats
  - Waxes
  - Hemicellulose
  - Pectins
  - Proteins
  - Mineral matter
  - 10-15%

- Added Impurities
  - Paraffin Wax
  - Spinning oils
  - Knitting oils
  - 0.5 - 2%

Total Impurities 10 - 17%

High soil content - need good detergent to remove and prevent 17 kg of soil from redepositing onto 100 kg fabric
Nearpon LF-JET

Before scour/bleach with Nearpon LF-JET

After scour/bleach with Nearpon LF-JET

Nearpon LF-JET shows an ability to emulsify and remove a very broad range of oils & waxes and to prevent redeposition of soil.
Nearpon LF-JET - comparison with competitors’ low foam detergents

![Graph showing comparison of whiteness and soil removal effectiveness of different samples.]

**Whiteness of Bleached Fabric**
- Nearpon LF-JET
- Sample 1
- Sample 2
- Sample 3
- Sample 4
- Sample 5
- Sample 6
- Sample 7

**% Soil removed from soiled fabric**
- Nearpon LF-JET
- Sample 1
- Sample 2
- Sample 3
- Sample 4
- Sample 5
- Sample 6
- Sample 7
Adding salt to dyebath causes aggregation of the dye. More aggregation = more attraction
Aggregation depends on the cation

\[ \text{NH}_4 < \text{Na} < \text{K} < \text{Mg} < \text{Ni} < \text{Mn} < \text{Zn} < \text{Ca} < \text{Ba} \]

Ammonium salt aggregates less than sodium, calcium and barium salts cause much higher aggregation.

Therefore, wherever concentration of calcium is higher in the fabric, the dye will be more attracted.
# Analysis of samples of cotton fibre of different provenance

<table>
<thead>
<tr>
<th>Provenance</th>
<th>Ca ppm</th>
<th>Mg ppm</th>
<th>Fe ppm</th>
<th>Al ppm</th>
<th>Mn ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sendhwa India</td>
<td>1000</td>
<td>600</td>
<td>125</td>
<td>45</td>
<td>5.9</td>
</tr>
<tr>
<td>Bailhongal India</td>
<td>1030</td>
<td>845</td>
<td>115</td>
<td>64</td>
<td>5.6</td>
</tr>
<tr>
<td>Jetpur India</td>
<td>580</td>
<td>585</td>
<td>84</td>
<td>65</td>
<td>3.9</td>
</tr>
<tr>
<td>Pandurna India</td>
<td>980</td>
<td>790</td>
<td>475</td>
<td>220</td>
<td>9.9</td>
</tr>
<tr>
<td>Izmir Turkey</td>
<td>905</td>
<td>890</td>
<td>22</td>
<td>15</td>
<td>3</td>
</tr>
<tr>
<td>Hatay Turkey</td>
<td>725</td>
<td>640</td>
<td>24</td>
<td>17</td>
<td>3</td>
</tr>
<tr>
<td>Urfa Turkey</td>
<td>6290</td>
<td>1190</td>
<td>63</td>
<td>48</td>
<td>31</td>
</tr>
<tr>
<td>Tarsus Turkey</td>
<td>985</td>
<td>620</td>
<td>29</td>
<td>23</td>
<td>3</td>
</tr>
<tr>
<td>Paranah Brazil</td>
<td>2711</td>
<td>1119</td>
<td>313</td>
<td>not tested</td>
<td>not tested</td>
</tr>
<tr>
<td>Sao Paulo Brazil</td>
<td>944</td>
<td>863</td>
<td>72</td>
<td>not tested</td>
<td>not tested</td>
</tr>
<tr>
<td>Peru</td>
<td>700</td>
<td>440</td>
<td>13</td>
<td>not tested</td>
<td>not tested</td>
</tr>
<tr>
<td>Texas USA</td>
<td>810</td>
<td>365</td>
<td>75</td>
<td>not tested</td>
<td>not tested</td>
</tr>
<tr>
<td>California USA</td>
<td>600</td>
<td>540</td>
<td>40</td>
<td>not tested</td>
<td>not tested</td>
</tr>
<tr>
<td>Russia</td>
<td>1320</td>
<td>567</td>
<td>112</td>
<td>not tested</td>
<td>not tested</td>
</tr>
</tbody>
</table>
Analysis of the metal content of vegetable impurities in cotton

<table>
<thead>
<tr>
<th></th>
<th>Ca</th>
<th>Mg</th>
<th>Fe</th>
<th>Al</th>
<th>Mn</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seeds</td>
<td>25000</td>
<td>5500</td>
<td>600</td>
<td>1100</td>
<td>85</td>
</tr>
<tr>
<td>Stem particles</td>
<td>17500</td>
<td>7000</td>
<td>350</td>
<td>600</td>
<td>90</td>
</tr>
<tr>
<td>Bark particles</td>
<td>6500</td>
<td>550</td>
<td>500</td>
<td>1200</td>
<td>250</td>
</tr>
<tr>
<td>pure cotton fibre</td>
<td>540</td>
<td>490</td>
<td>27</td>
<td>8</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

The more seed we can see in the cotton - the higher the calcium, magnesium and iron content

This means we need sequestering agent
Disadvantages of calcium and magnesium in textile processing

- Insoluble white powder deposits of carbonates, hydroxides, phosphates formed in alkaline scouring/bleaching
- Insoluble silicate deposits in bleaching
- Lime soap stains
- Build-up of deposits on machines
- Peroxide stabilisers blocked by excess calcium - poor stability
- Insoluble yellowish green salts formed with optical brighteners
- Emulsions of oils and greases are broken by Ca and Mg
- **Solubility of dyes impaired**
- **Form spots and stains with dyes**
- **Cause change of shade** and reduced fastness.
- Yellowish deposits on inside and tops of yarn bobbins
- **Unlevel dyeing**
Dyeing cotton with reactive dyes

- Lab to bulk reproducibility - lab procedure should reflect closely the bulk process, including auxiliaries
- Dyeing should follow thorough preparation, in bath free from impurities (especially NaOH and H₂O₂)
- Accurate weighing of dyes and auxiliaries with a checkweigh system, preferably with barcode reader.
- Dissolve dye in sufficient water and sieve before addition to tank, then dilute further, dosing over time.
- Check specific gravity after adding salt
- Check pH at start and after adding alkali
- Have all dyes and chemicals ready and add at appropriate time every time
- Some dyes sensitive to reduction - use Antioxidol SBR
- Sequestering agent needed in dyebath and ‘soaping’
Effect of calcium and magnesium on ISO Cold Water fastness of reactive dye

Contaminant added to dyebath  Contaminant added to rinse bath

EFFECT  COTTON  POLYAMIDE  EFFECT  COTTON  POLYAMIDE

Sequestering of calcium and magnesium is extremely important in preparation before dyeing with reactive dyes, in the dyebath with reactive dyes, and in soaping after dyeing. NEARCHEL TMC is very effective in every case.
NEARCHEL TMC has no demetallizing effect on dyes containing metal and can safely be used in the dyeing process.

NEARCHEL TMC prevents precipitation of hardness salts in the process water, disperses calcium and magnesium salts, pectins, waxes and other insoluble impurities leading to less incrustation of the machine and less deposit on rollers.
Sequestering agents in dyeing

- Various dyestuffs can undergo a shade change in presence of Fe²⁺, Fe³⁺, Cu²⁺, Ni²⁺, Mn²⁺ or Al³⁺, or be influenced in their fastness.
- Polyvalent cations always have a negative influence on the dyeing process, exhaustion curve is steeper, penetration is poorer, danger of dye deposits on fibre is greater.
- Metal ions may come from fibre, contaminated auxiliaries like Glauber's salt, or caustic soda, or from machinery.
- Care needed to select sequestering agent which will not extract metal from metal complex dyes.
- Nearchel TMC is suitable for use in the dyeing process.

**NEARCHEL TMC Sequestering Power for Fe³⁺ ions**

![Graph showing the sequestering power of Nearchel TMC for Fe³⁺ ions vs pH of solution.](image-url)
Ca & Mg contamination

Cotton containing 1500 ppm Ca & Mg into dyeing machine at 10:1 liquor ratio. Water will contain 150 ppm Ca & Mg.

Then theoretically 0.56 g/l NEARCHEL TMC at pH 12 should be used in that water to sequester the calcium and magnesium from the greige fabric (150/270 g/l).

Typical dosages of Nearchel TMC are 0.5 – 1.5 g/l in exhaust preparation processes and 2 – 5 g/l in continuous processes.
The road to reproducibility

Well prepared is half dyed