Batch to Batch Reproducibility

and how to avoid creases, spots and stains.

Nearchimica S.p.A.

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'

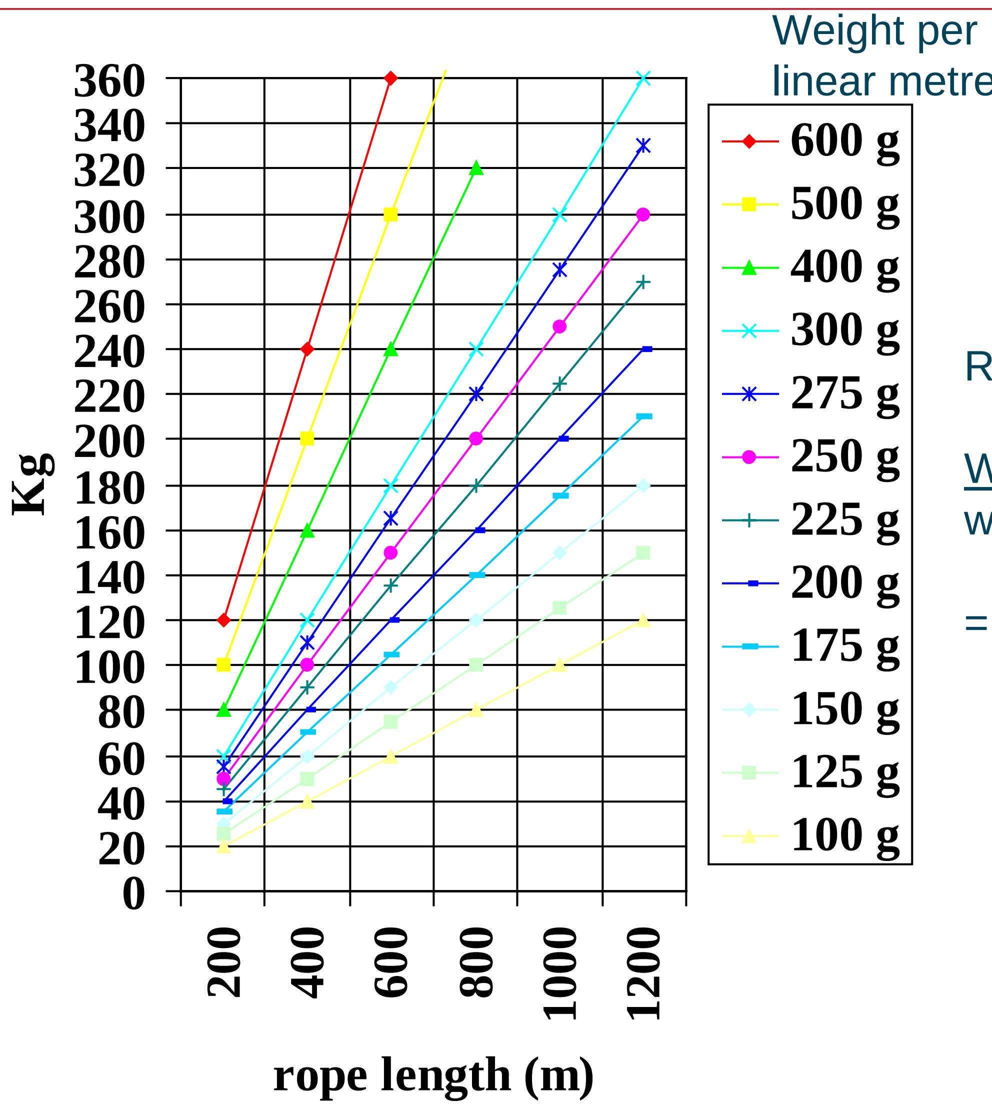
This is the number of times the fabric comes into contact with the dye liquor during the dyeing process, and will depend on fabric rope speed and the number of jet nozzle passages.

Fabric	Rope cycle time (mins)	Speed woven fabric	Speed knit fabric
PES unfixed	1	400	250
PES heat-set	2	400	200
PA unfixed	2-3	400	300
PA heat-set	3	350	300
CO Reactive	4	350	300

Example - cotton knit - fabric speed maximum 300 m/min

$$\text{Number of nozzle passages} = \frac{\text{Process time(480 mins)}}{\text{Rope cycle time(4 mins)}} = 120$$

Rope length

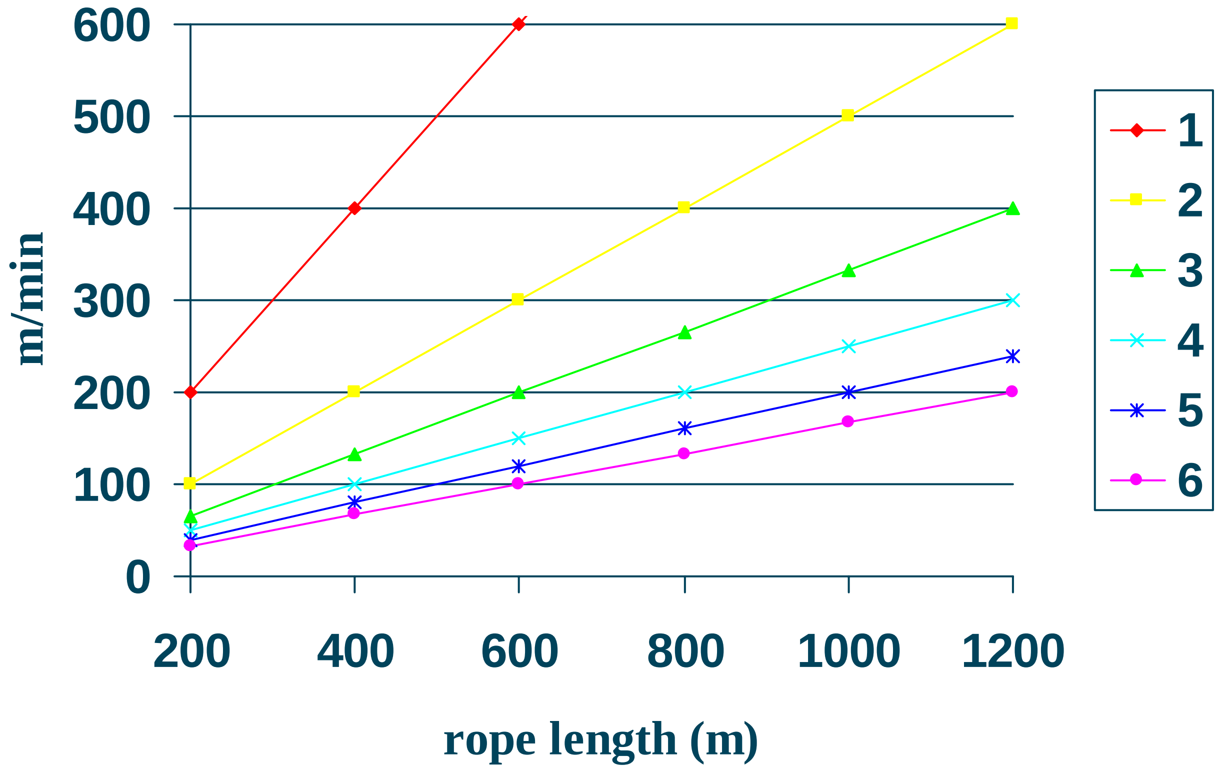


Rope length

Weight of the rope 105 kg
weight per linear metre 0.200 kg/m

= 525 m

Cycle time = rope length / 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

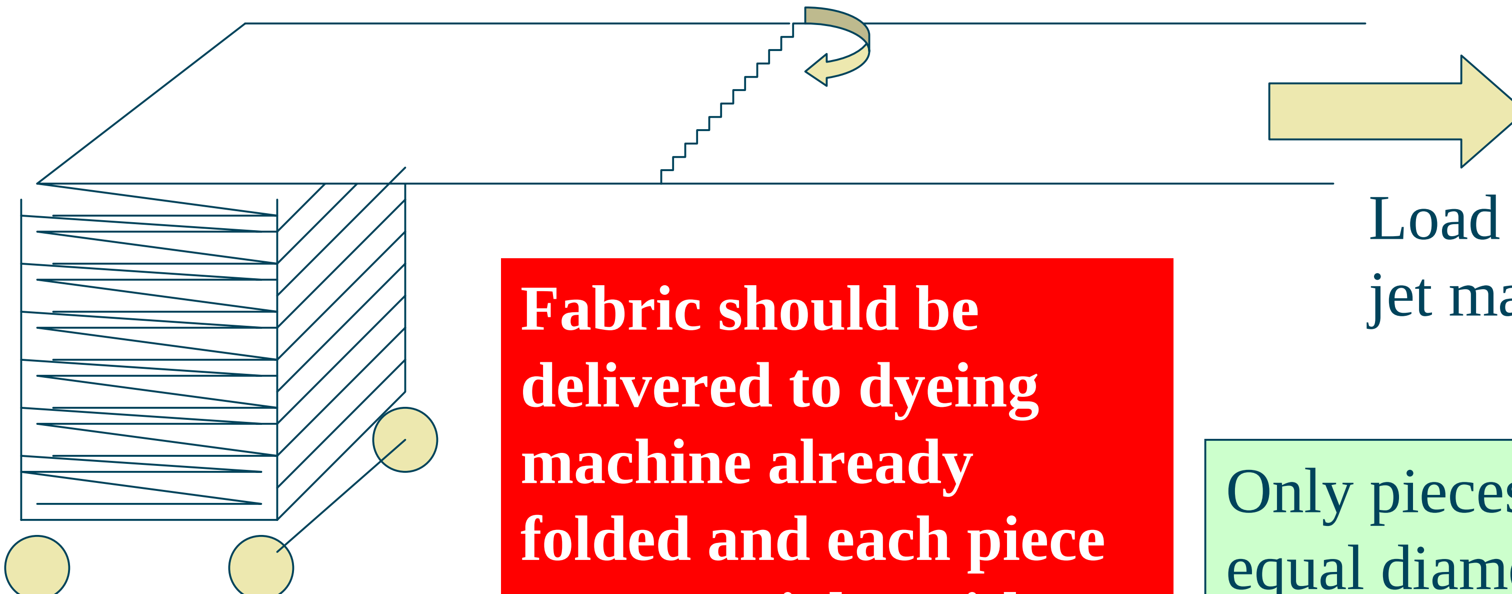
    Such abrasion may exaggerate creasing by damaged fibres dyeing to a different shade
  - often useful to turn tube of knitted fabric inside to outside, particularly single jersey.

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

Leave small opening to allow ballooning of air to escape



Load into jet machine

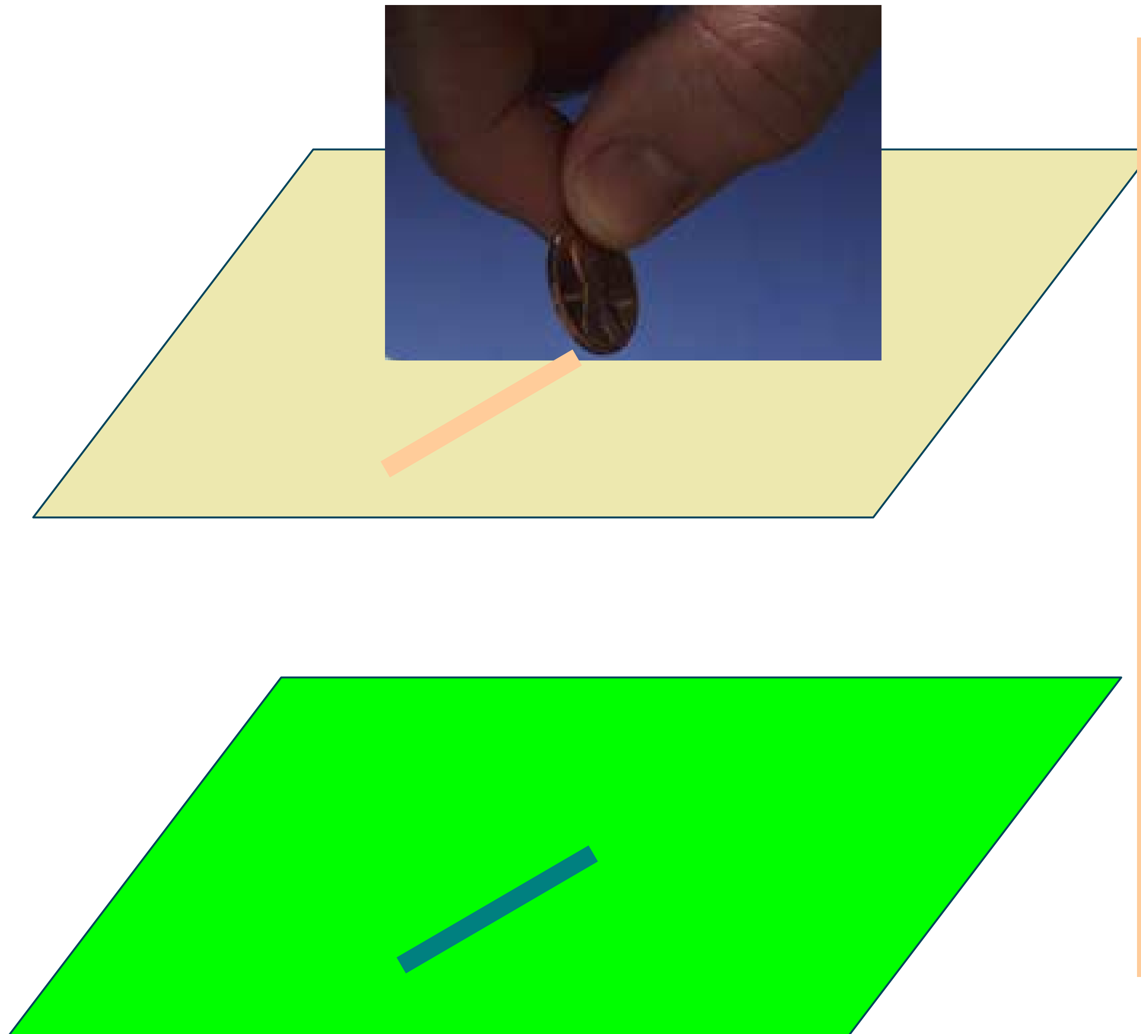
Fabric should be delivered to dyeing machine already folded and each piece sewn straight, with sewing machine, to next piece. Rope is loaded into dyeing machine without twist

Only pieces of equal diameter should be sewn together

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



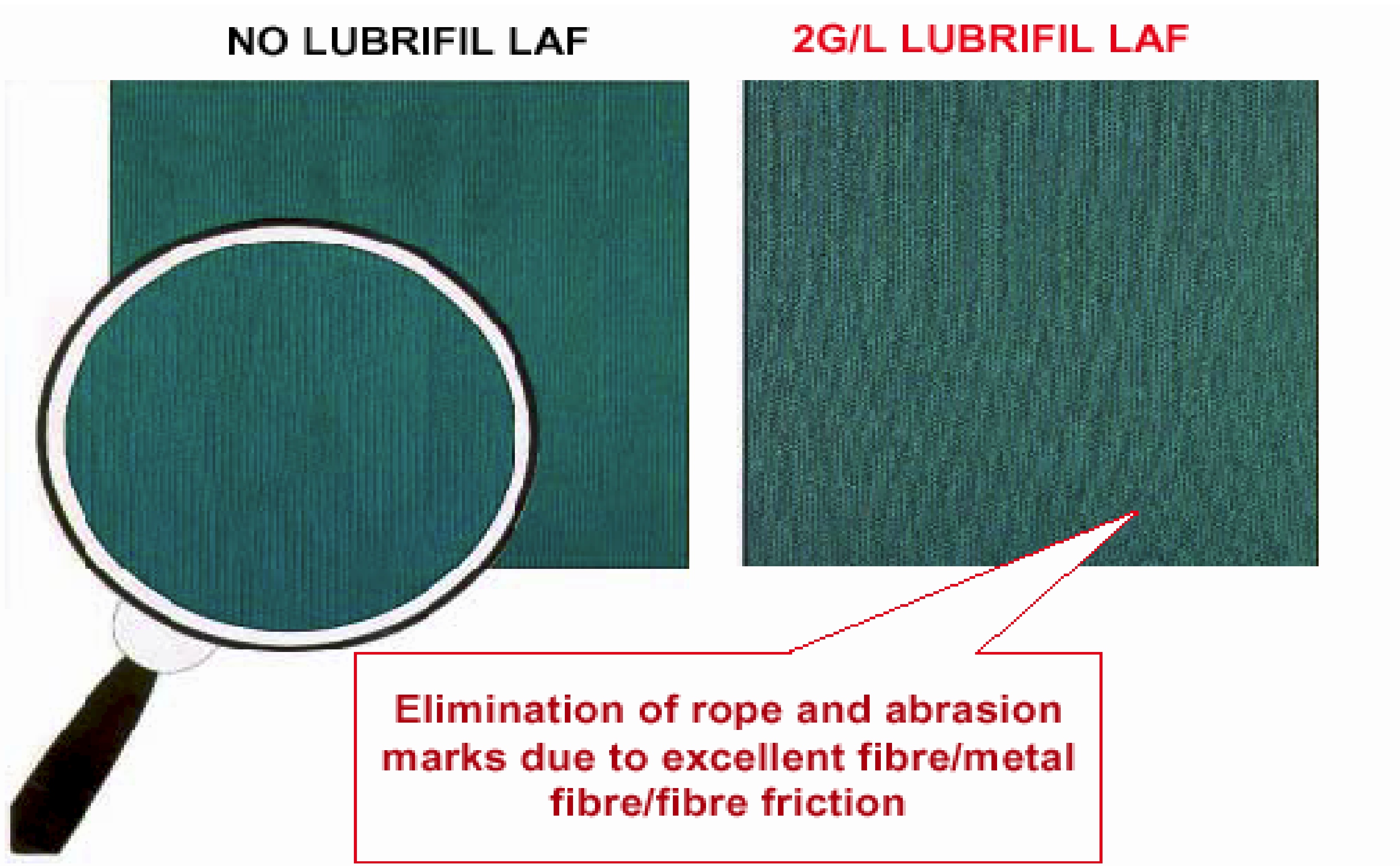
If we make a scratch on a piece of undyed cotton with a metal coin, and then dye the cotton with a phthalocyanine turquoise and a yellow, the place where we made the scratch will dye more strongly blue than the rest of the fabric

Why should reducing fibre-to-metal friction help prevent creases ?

Abrasion damages fibres. Damaged fibres are dyed to a different shade

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.

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.

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Detectable wax acids and alcohols in cotton

Chemical Formula	Systematic name	Trivial Name	Melting Point deg C
$C_{15}H_{31}COOH$	hexadecanoic acid	Palmitic acid	64
$C_{17}H_{35}COOH$	octadecanoic acid	Stearic acid	69
$C_{19}H_{39}COOH$	eicosanoic acid	Arachinic acid	76
$C_{21}H_{43}COOH$	docosanoic acid	Behenic acid	81
$C_{23}H_{47}COOH$	tetracosanoic acid	Lignoceric acid	81
$C_{25}H_{51}COOH$	hexacosanoic acid	Cerotic acid	88
$C_{27}H_{55}COOH$	octacosanoic acid	Montanic acid	91 - 93
$C_{29}H_{59}COOH$	triacontanoic acid	Mellisic acid	92
$C_{31}H_{63}COOH$	dotriacontanoic acid	Locca acid	
$C_{33}H_{67}COOH$	tetratriacontanoic acid	Ghedda acid	
$C_{17}H_{33}COOH$	octadecanoic-9-acid	Oleic acid	13
$C_{19}H_{37}COOH$	eicosanoic-9-acid	Gadoleic acid	
$C_{24}H_{49}OH$	tetracosanol	Lignoceryl alcohol	75 - 77
$C_{26}H_{53}O$	hexacosanol	Ceryl alcohol	79 - 81
$C_{28}H_{57}O$	octacosanol	Montanyl alcohol	83
$C_{30}H_{61}OH$	triacontanol	Gossypyl alcohol	
$C_{32}H_{65}OH$	dotriacontanol		
$C_{34}H_{69}OH$	tetratriacontanol		92
$C_{30}H_{60}(OH)_2$	tricontandiol	Coceryl alcohol	
$C_3H_5(OH)_3$	propantriol	Glycerol	18

This means we need boiling water

Composition and removal properties of cotton wax

Component	Content (%)
Wax ester	22
Phytosterols	12 - 14
Polyterpenes	1 - 4
Hydrocarbons	7 - 8
Free wax alcohols	42 - 46
Saponifiable	36 - 50
Non-saponifiable	50 - 63
Inert	0 - 3

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.

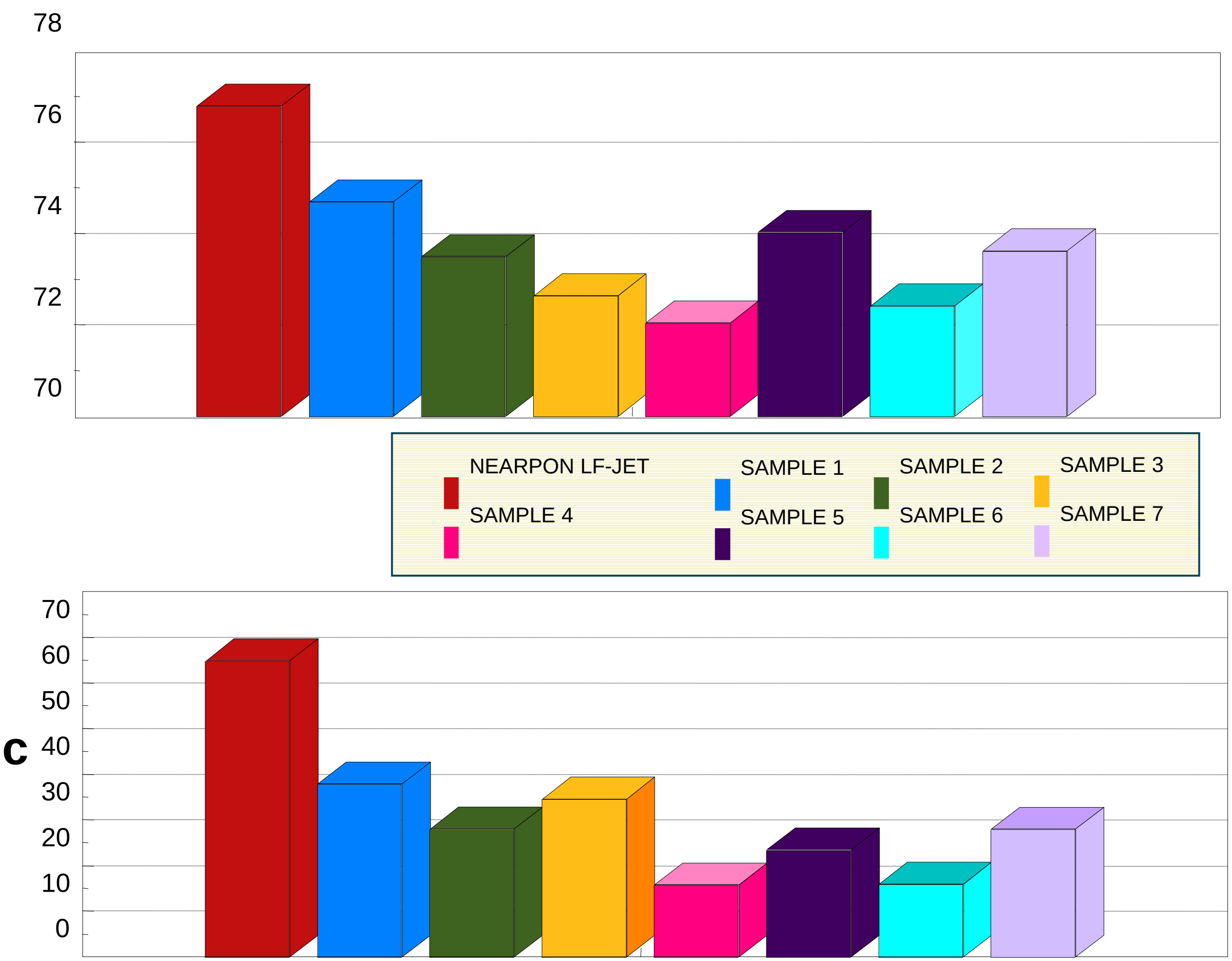
Nearpon LF-JET - comparison with competitors’ low foam detergents

Whiteness of

Bleached fabric

% Soil removed

from soiled fabric



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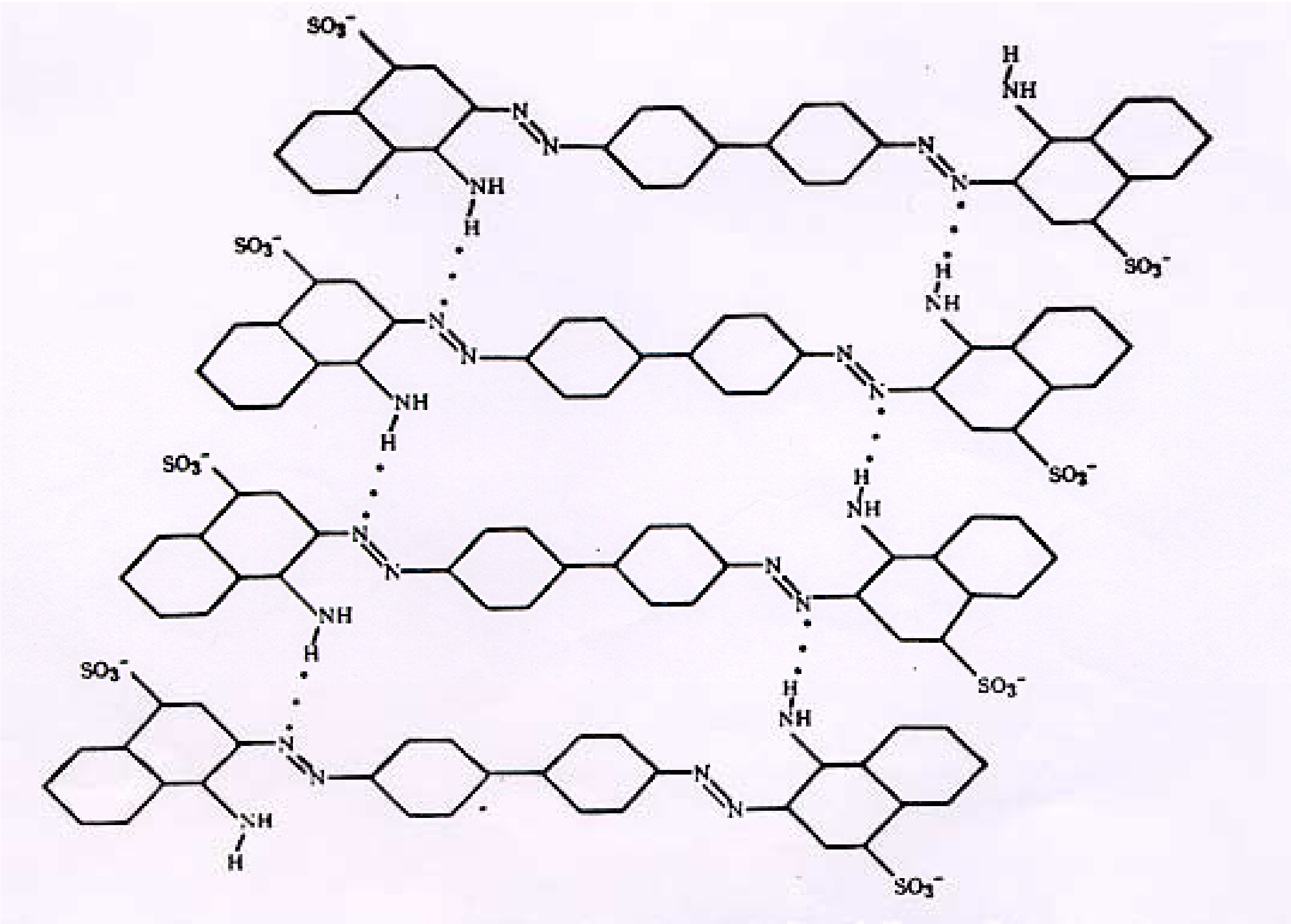
Adding salt to dyebath causes aggregation of the dye. More aggregation = more attraction



Aggregation depends on the cation

NH_4 < Na < K < Mg < Ni < Mn < Zn < Ca < 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

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

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Analysis of the metal content of vegetable impurities in cotton

	Ca	Mg	Fe	Al	Mn
Seeds	25000	5500	600	1100	85
Stem particles	17500	7000	350	600	90
Bark particles	6500	550	500	1200	250
pure cotton fibre	540	490	27	8	<1

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

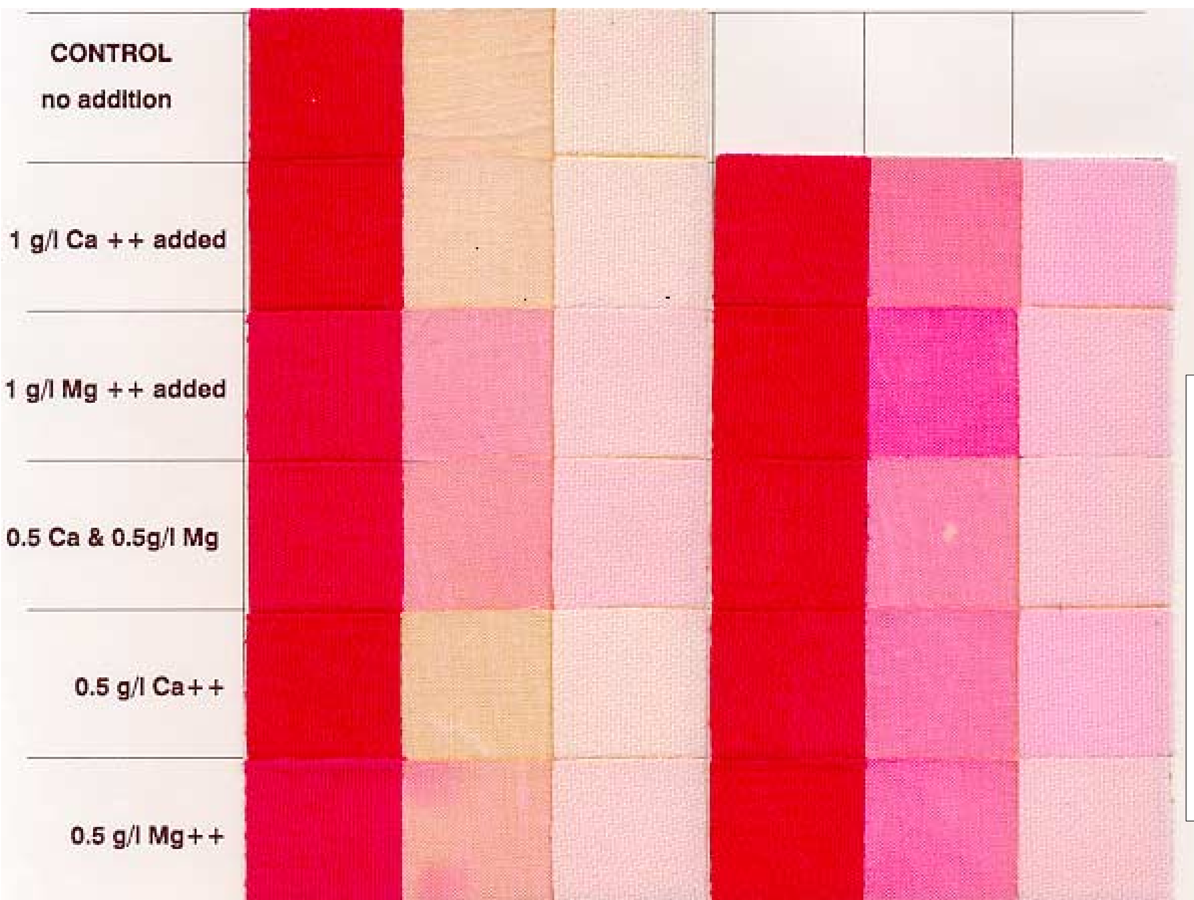
- Insoluble white powder deposits of carbonates, hydroxides, phosphates formed in alkaline scouring/bleaching
- Insoluble silicate deposits in bleaching
- Lime soap stains
- Build-up of deposits on machines
- Peroxide stabilisers blocked by excess calcium - poor stability
- Insoluble yellowish green 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

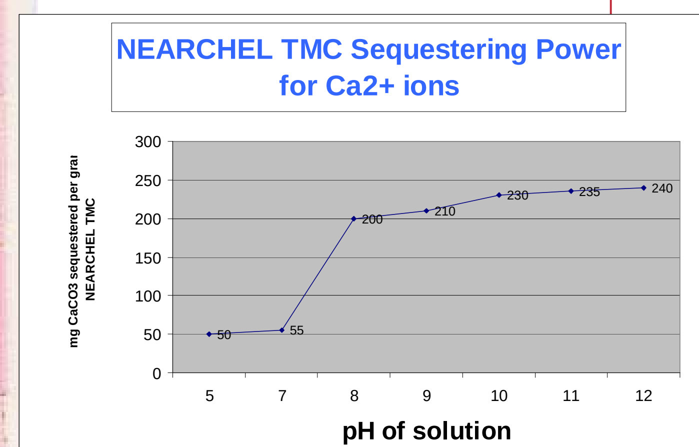
- Lab to bulk reproducibility - lab procedure should reflect closely the bulk process, including auxiliaries
- Dyeing should follow thorough preparation, in bath free from impurities (especially NaOH and H_2O_2)
- Accurate weighing of dyes and auxiliaries with a checkweigh system, preferably with barcode 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.



Disadvantages of alkaline earth impurities (Ca and Mg) in textile processing

- Dust in singeing
- Insoluble white powder deposits of carbonates, hydroxides, phosphates
- Insoluble silicate deposits in bleaching
- Lime soap stains
- Build-up of deposits on machines
- Peroxide stabilisers blocked by excess calcium - Mg ions precipitated – poor peroxide stability
- Insoluble yellowish-green salts formed with FBA's
- Emulsions of oils and greases are split by Ca and Mg
- Solubility of dyes impaired
- Form spots and stains with dyes
- Cause changes in shade and reduced fastness

1 g of **NEARCHEL TMC** sequesters

	mg.Fe^{+++}	mg.$CaCO_3$
pH 9	145	210
pH 10	160	242
pH 11	178	255
pH 12	120	270

Sequestering agents in dyeing synthetics

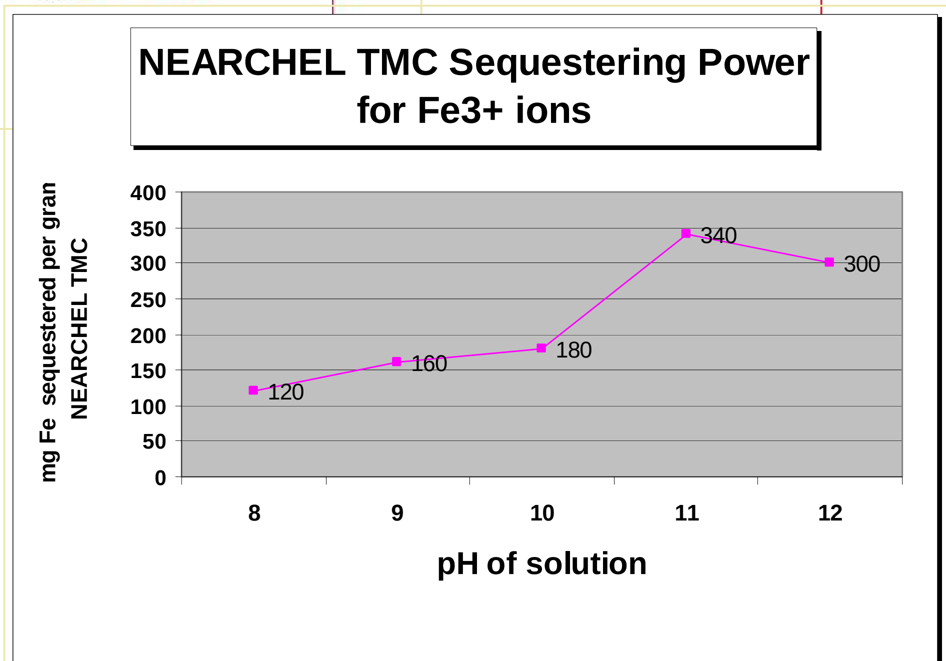
- Typical problem is C.I.Disperse Red 60 becoming blue with presence of hard water (Ca), copper or iron.
- Free copper can reduce blues e.g. C.I. Disperse Blue 73, or cause dehalogenation of navies like C.I.Disperse Blue 79.1
- Nearchel TMC is stable to high temperatures and recommended for dyeing Polyester and PES/cellulose.
- Polyaminophosphonates preferentially remove polyester oligomers, and are used in Nearchel TMC

NEARCHEL TMC has no demetallizing effect on dyes containing metal and can safely be used in the dyeing process.

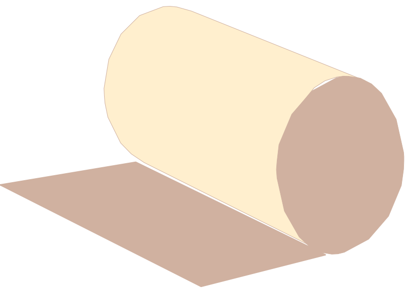
NEARCHEL TMC prevents precipitation of hardness salts in the process water, disperses calcium and magnesium salts, pectins, waxes and other insoluble impurities leading to less incrustation of the machine and less deposit on rollers.

Sequestering agents in dyeing

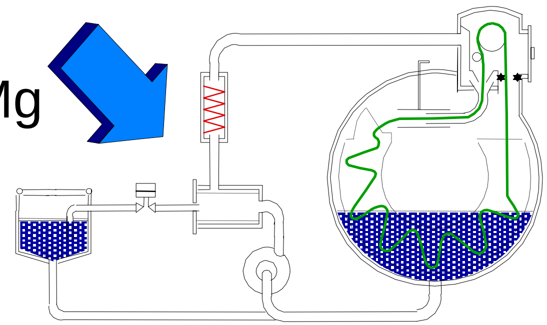
- Various dyestuffs can undergo a shade change in presence of Fe^{2+}, Fe^{3+}, Cu^{2+}, Ni^{2+}, Mn^{2+} or Al^{3+}, or be influenced in their fastness.
- Polyvalent cations always have a negative influence on the dyeing process, exhaustion curve is steeper, penetration is poorer, danger of dye deposits 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



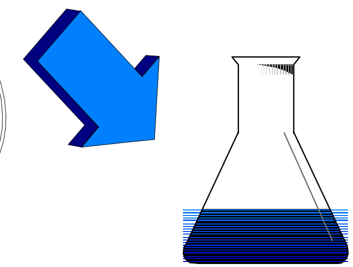
Ca & Mg contamination



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