# Management of dyeing and finishing

## Contemporary wool dyeing and finishing

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## Topics

1. Traditional sequences for producing special types of fabrics.
2. Occupational health and safety in dyeing and finishing.
3. Disposal of effluents from dyeing and finishing.
4. Environmental issues with dyes and auxiliaries.
5. Automation of dyeing and finishing.
6. Revision of the course.

## 1. Traditional sequences for producing special types of fabrics

# Typical finishing sequences for woollen fabrics

**Velour:**

- two-bath scour (high-speed scouring machine).
- carbonise
- bag
- neutralise
- soap mill in combined scour/milling machine
- rinse
- dye
- stenter with 15% overfeed and 4% wider than required finished width
- raise with two passes
- crop twice
- raise with two passes
- crop twice or more as necessary to give required degree of ‘nap’
- steam and roll.

# Typical finishing sequences for woollen fabrics

**Woollen sports coating:**

- two-bath scour (high speed scouring machine)
- carbonise
- wash off
- acid mill
- cool and rinse in cold water
- neutralise in scouring machine
- stenter with 8% overfeed and 2.5% wider than finished width
- light raise
- brush and crop
- steam
- semi-decatise.

# Typical finishing sequences for woollen fabrics

**Plain weave (loose stock dyed):**

- scour (high speed scouring machine)
- carbonise
- light acid mill
- wash off and neutralise in scouring machine
- stenter 5% overfeed 2.5% wider than finished width
- crop once on the back and twice on the face
- continuous decatise.

# Typical finishing sequences for woollen fabrics

## Flannel (loose stock dyed)

- two-bath scour (high speed scouring machine)
- carbonise
- acid mill
- wash off and neutralise in scouring machine
- stenter 5% overfeed 2.5% wider than finished width
- brush and crop
- steam
- continuous decatise.

# Typical finishing sequences for woollen fabrics

**Plain weave (piece-dyed):**

- two-bath scour (high speed scouring machine)
- carbonise
- light acid mill
- piece dye
- stenter 5% overfeed 2.5% wider than finished width
- crop once on the back and twice on the face
- continuous decatise.

# Typical finishing sequences for woollen fabrics

**Melton fabric:**

- scour
- wet raise
- mill at low speed running 2 or 3 draft and reverse fabrics after half time
- soap mill, shrink by 25% in width and 12-15% in length
- wash off
- stenter dry to 4% wider than finished width
- brush
- condition
- crop
- rotary press
- blow.

# Typical finishing sequences for worsted fabrics

**2 / 2 Twill, top-dyed:**

- two-bath scour (high speed scouring machine)
- acid mill in tandem roller machine
- wash off in open-width, 0.25 g/l nonionic surfactant for 20 minutes at 60°C
- rinse in hot water 50-60°C for 1 hour
- stenter 2-3% overfeed 1.5% wider than finished width
- crop once on the back and twice on the face
- pressure decatise.

# Typical finishing sequences for worsted fabrics

**Worsted crepe:**

- crab or relax in open-width scour
- spot clean
- scour (in dolly, winch or overflow dyeing machine)
- dye
- stenter with 2-3% overfeed 1.5% over finished width
- perch
- crop once on the back and twice on the face
- perch
- pressure decatise (low wrapper tension).

# Typical finishing sequences for worsted fabrics

**Panama:**

- greasy blow
- spot clean
- open-width scour
- dye
- stenter with 2-3% overfeed and 1.5% wider than finished width
- perch
- crop once on the back and twice on the face
- perch
- rotary press
- pressure decatise.

# Typical finishing sequences for worsted fabrics

**Fancy suiting (colour woven):**

- open-width scour
- stenter
- crop
- perch
- pressure decatise
- paper press.

# Typical finishing sequences for worsted fabrics

**Super 100s fine worsted plain (colour woven):**

- greasy blow
- scour (dolly with baffle board) to give mild milling treatment
- stenter
- crop
- perch
- semi-decatise.

# 2. Occupational health and safety in dyeing and finishing

# NATIONAL OHS STRATEGY 2002 - 2012

## NATIONAL VISION

Australian workplaces free from death, injury and disease

## NATIONAL TARGETS

Sustain a significant, continual reduction in the incidence of work-related fatalities with a reduction of at least 20% by 30 June 2012 (and with a reduction of 10% being achieved by 30 June 2007).

Reduce the incidence of workplace injury by at least 40% by 30 June 2012 (with a reduction of 20% being achieved by 30 June 2007).

## NATIONAL PRIORITIES

- Reduce high incidence/severity risks
- Improve the capacity of business operators and workers to manage OHS effectively
- Prevent occupational disease more effectively
- Eliminate hazards at the design stage
- Strengthen the capacity of government to influence OHS outcomes

## Areas Requiring National Action

- OHS awareness
- OHS skills
- Practical guidance
- National standards
- Compliance support
- Incentives
- Strategic enforcement
- OHS data
- OHS research

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# OH&S obligations

**Under OH&S legislation, employers are obliged to provide:**

- safe premises
- safe machinery and substances
- safe systems of work
- safety equipment (masks, gloves etc.)
- information, instruction, training and supervision
- a suitable working environment and facilities.

NATIONAL OCCUPATIONAL HEALTH & SAFETY COMMISSION

OCCUPATIONAL HEALTH & SAFETY

# Health and safety management plan elements

**Each workplace must have a health and safety management plan:**

- Management commitment
- Employee consulting and training
- Supervision of visitors, contractors and other persons
- Provision of safe premises/buildings
- Safe work procedures
- Safety rules
- Regular hazard spotting, risk assessments and reporting
- Accurate records of compliance.

# Types of hazards

- Plant and equipment
- Electrical
- Chemical
- Manual handling
- Occupational Overuse Syndrome (RSI)
- Biological
- Psychological
- Noise
- Working environment.

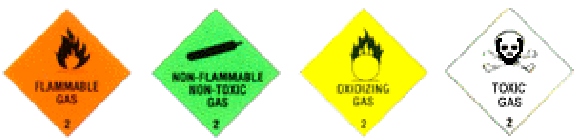
# Hazardous dyes and chemicals

## What can you do?

1. **Existing chemical:**
   - **Check the label – see if there are safety and risk warnings.**
   - **Obtain information - contact the chemical supplier and ask them for a material safety data sheet (MSDS).**
     - A MSDS is a chemical information sheet that must provide information about the health and safety effects of the chemical and safety precautions for its correct use and storage. It should also include first-aid requirements.
2. **New chemicals:**
   - **Ensure that an MSDS is obtained before the purchasing decision is made.**
     - Assess the risk before the chemical is used in the workplace and obtain any equipment required for its use.
   - **When the new chemical arrives ensure that the label is attached and the MSDS is with it.**
   - **All employees who are using the chemical must have access to the MSDS and receive training in its hazards and safe use.**
3. **Information can be obtained from your state or territory health and safety authority if you cannot determine whether a chemical is hazardous.**

# Labels for hazardous goods

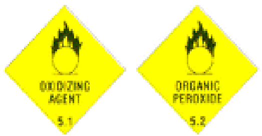
- Class 2: Gases
- Class 2.1 : flammable gases
- Class 2.2 : non-flammable, non-toxic gases
- Class 2.3 : toxic gases



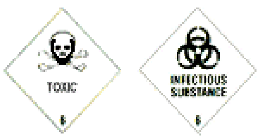

- Class 3: Flammable liquids


- Class 4: Flammable solids
- Class 4.1 : flammable solids
- Class 4.2 : spontaneously combustible
- Class 4.3 : emits flammable gases when wet.


Class 5: Oxidising substances
Class 5.1 : oxidising agents
Class 5.2 : organic peroxides.

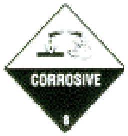



Class 6: Toxic and infectious substance
Class 6.1 : toxic substances
Class 6.2 : infectious substances




Class 7: Radioactive material


Class 8: Corrosive substances




Class 9: Miscellaneous dangerous goods and articles

# Sample MSDS sheet

Chemical: Basolan* DC

Other names: Sodium Dichloroisocyanurate

Formula: C3Cl2N3NaO3

CAS#: 2893-78-9

Database ID: 8257

Last updated: 12/8/2005

Risk phrases:

- RISK LEVEL 4 ALERT
- This chemical will require a risk assessment prior to laboratory use.
- Contact with combustible material may cause fire.
- Harmful if swallowed.
- Contact with acids liberates toxic gas.
- Irritating to eyes and respiratory system.
- Very toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.

# Dyes banned in EU countries

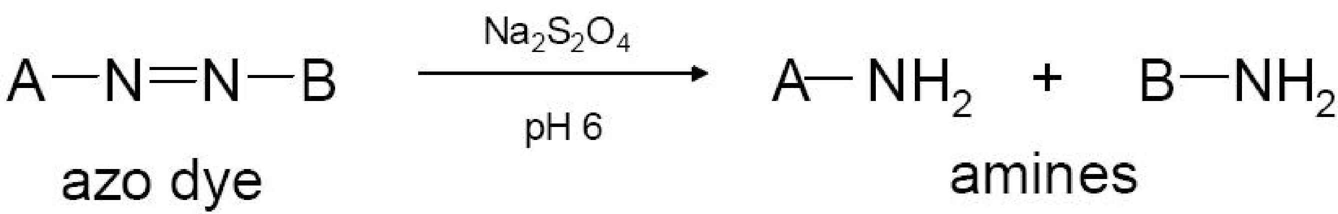
- From September 2003, all EU countries are required to prohibit the manufacture and sale of textile consumer goods which on chemical analysis are found to contain certain aromatic amines originating from a small number of azo dyes.

- The amines are known to be harmful to human health.

- Articles coloured with all other azo dyes will be able to be manufactured and sold without restriction. Only very few azo dyes will be affected. It has been estimated that less than 4 % of known azo dye structures can release the banned amines.

# How banned azo dyes are identified

- Azo dyes were tested to see if they could release banned amines by treating them under reductive conditions using sodium dithionite.
- Azo groups can be cleaved to form two amines.
- The list of banned amines is given on the next slide.



# Banned amines, according to EU directive Com (2000) 785

| No. | Substance | CAS number |
|---|---|---|
| 1 | 4-aminodiphenyl | 92-67-1 |
| 2 | benzidine | 92-87-5 |
| 3 | 4-chloro-o-toluidine | 95-69-2 |
| 4 | 2-naphthylamine | 91-59-8 |
| 5 * | 4-amino-2',3-dimethylazobenzene | 97-56-3 |
| 6 * | 2-amino-4-nitrotoluene | 99-55-8 |
| 7 | 4-chloroaniline | 106-47-8 |
| 8 | 2,4-diaminoanisole | 615-05-4 |
| 9 | 4,4'-diaminodiphenylmethane | 101-77-9 |
| 10 | 3,3'-dichlorobenzidine | 91-94-1 |
| 11 | 3,3'-dimethoxybenzidine | 119-90-4 |
| 12 | 3,3'-dimethylbenzidine | 119-93-7 |
| 13 | 3,3'-dimethyl-4,4'diaminodiphenylmethane | 838-88-0 |
| 14 | 4-cresidine | 120-71-8 |
| 15 | 4,4'-methylene-bis-(2-chloroaniline) | 101-14-4 |
| 16 | 4,4'-oxydianiline | 101-80-4 |
| 17 | 4,4'-thiodianiline | 139-65-1 |
| 18 | 2-aminotoluene | 95-53-4 |
| 19 | 2,4-diaminotoluene | 95-80-7 |
| 20 | 2,4,5-trimethylaniline | 137-17-7 |
| 21 | 2-methoxyaniline | 90-04-0 |
| 22 ** | 4-aminoazobenzene | 60-09-3 |

# Banned acid dyes capable of releasing toxic amines

| | |
|---|---|
| CI Acid Orange 45 | 22195 |
| CI Acid Red 24 | 16140 |
| CI Acid Red 85 | 22245 |
| CI Acid Red 114 | 23635 |
| CI Acid Red 115 | 27200 |
| CI Acid Red 128 | 24125 |
| CI Acid Red 148 | 26665 |
| CI Acid Red 158 | 20530 |
| CI Acid Red 167 | |
| CI Acid Red 265 | 18129 |
| CI Acid Black 29 | |
| CI Acid Black 209 | |

# Vigilance on banned dyes

- All major dye makers took great pains to ensure that any trace of these banned chemicals was demonstrably excluded from their products, leading to a high degree of confidence within the EU market place.
- However, dye houses must ensure that the dyes they are using do conform to the requirements. If dyes are being sourced from non-traditional suppliers it is advisable to have these supplies routinely tested by an accredited laboratory.

## 3. Disposal of effluents from dyeing and finishing

# Typical processing effluents

**Dyeing and finishing effluents provide a varied cocktail for subsequent treatment and will contain some or all of the following materials**:

- oils, fats and waxes inherent or added to fibres during processing
- **vegetable or protein impurities** associated with natural fibres.
- **monomers/oligomers** associated with man-made fibres
- residual **agricultural chemicals** from cotton and linen production.
- **natural pigments, synthetic dyes, salts and metals**
- **processing aids,** e.g. sizes, spinning oils, knitting oils
- **preservatives** such as PCP on imported cloth, including pesticides on raw wool
- **detergents** and surface active agents from washing, bleaching and scouring
- **enzymes** used for desizing but finding applications elsewhere in textiles
- **oxidizing and reducing agents** used as bleaching agents.
- **acids and alkalis** from dyeing operations.

# What can be discharged?

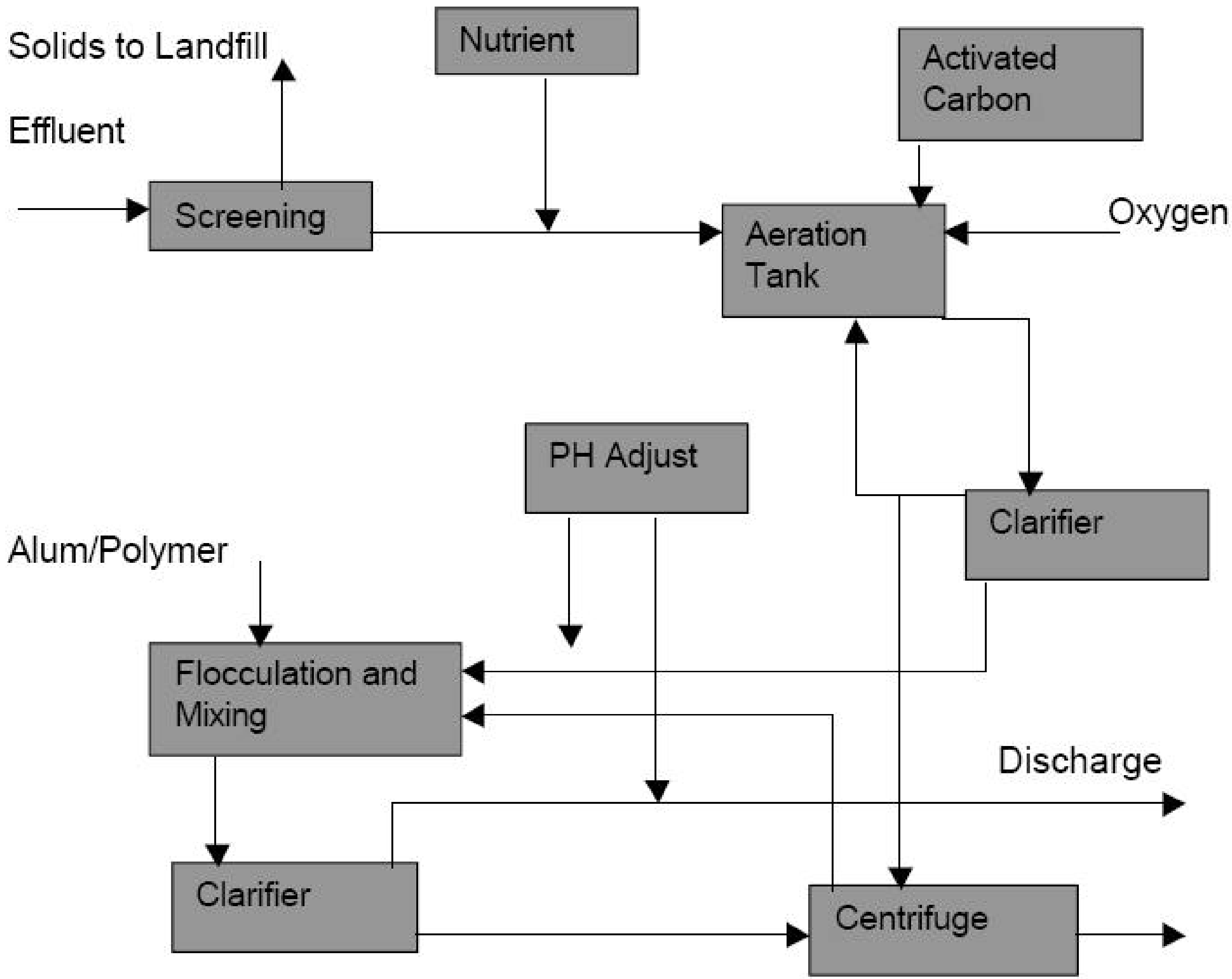
**Regulations vary depending on local authorities.**
**Here are some regulations from the UK.**

| Parameter | Standard/Consent |
|---|---|
| Temperature | Below 42°C at point of discharge |
| pH | Between 6 and 9 at point of discharge |
| BOD | 30mg/l to surface waters |
| | Consented to sewer |
| COD | 50mg/l to surface waters |
| | Consented to sewer |
| Suspended solids | 20mg/l to surface waters |
| | Consented to sewer |
| Colour | Below 1ppm consented |
| Toxic substances | Restricted by legislation |
| Volume and flow | Basis for charging consented |

# Important technologies for effluent treatment

| Physical | Chemical | Biological |
|---|---|---|
| Filtration | Neutralisation | Aerobic digestion |
| Sedimentation | Oxidation | Anearobic digestion |
| Gravity separation | Reduction | Plant absorption |
| Centrifugation | Hydrolysis | Percolating filters |
| Flotation | Electrical | Bioscrubbers |
| Equalisation | Catalytic oxidation | Biofiltration |
| Precipitation | Ozonolysis | |
| Adsorption | Ion exchange | |
| Membranes | | |

# Activated sludge effluent treatment

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## A new method for electrochemical decolourisation of textile effluent.

- This technology can remove over 80 per cent of the colour from dye house effluent, especially effluent contaminated with reactive dyes.
- Electrochemical decolourisation is based on the principle that electrons in an electric current split many textile dyes into smaller, colourless parts which are more readily biodegradable.
- The process was developed by DyStar, the Research Institute for Textile Chemistry and Textile Physics of the University of Innsbruck (TID) in Dornbirn, Austria, and the textile machinery manufacturer Benninger AG, Uzwil, Switzerland.

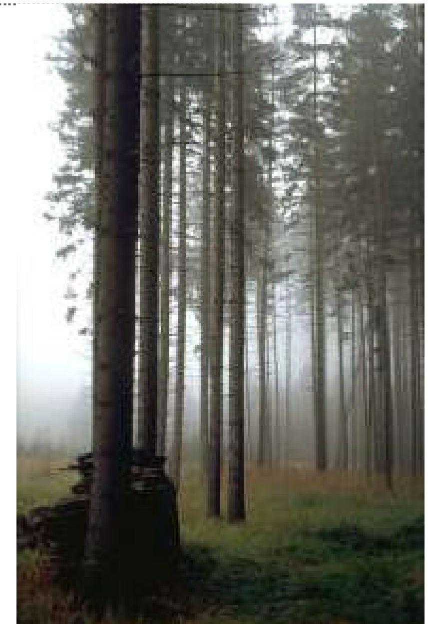
# 4. Environmental issues with dyeing and finishing

# Ecological products

- Recently, particularly in European Union countries, there has been consumer demand for products that are certified free of harmful substances and have minimal impact on the environment during production, use and disposal (cradle to grave).
- This has stimulated the growth of independent testing authorities offering certification based on analytical tests of textile products.
- Many EU countries have set up their own testing authorities.
- Two of the better known EU-wide certifying authorities are Öko-Tex and EU Eco. Of these, Öko-Tex has wider coverage and acceptance at the moment.
- Any textile manufacturer in the EU, or outside the EU but interested in exporting to EU countries, would do well to seek accreditation for their products.

# The Öko-Tex label

- People everywhere are becoming increasingly aware of the relationship between textile production and related environmental issues.
- The media feeds this concern, addressing potentially harmful substances historically present in many textiles and their possible effects on human health.
- This eco-label specific to textiles was founded in 1993 by the Austrian Textile Research Institute.
- Interest has grown to such a level that it is now recognised the most important textile eco-label in the world.



CONFIDENCE IN TEXTILES
Tested for harmful substances
according to Oeko-Tex Standard 100
No 00000000 Institut

# Öko-Tex 100 standard

***Öko-Tex Standard 100*, contains analytical tests for specified potentially harmful substances and gives limiting values based on scientific considerations for the following:**

- **pH**
- **formaldehyde**
- **extractable heavy metals (As, Pb, Cd, Cr, Co, Cu, Ni, Hg)**
- **pesticides**
- **chlorinated phenols**
- **dyestuffs (allergenic, carcinogenic)**
- **chlorinated organic carriers**
- **boicidal finishes**
- **flame retardent finishes**
- **loose dye/colour (poor wet, drycleaning**
- **rubbing fastness etc.)**
- **volatile organics**
- **odours**
- **phthalates (plasticisers)**

# The Öko-Tex label

- A manufacturer whose product meets the requirements set by the standard is licensed to use the registered mark or label ‘Tested for Harmful Substances according to Oeko-Tex Standard 100’.
- There are 12 institutes in Europe, together with associated institutes all over the world, which can test textile products and award the labels.


Oeko-Tex Association

# 5. Automation of dyeing and finishing

# ‘Right first time’ dyeing

- Dyeing has traditionally been more art than science.
- In a manually operated dye house, about 5 to 15 per cent of a typical plant’s production has to be re-dyed or discounted because colours didn’t come out right the first time.
- Incorrectly dyed fabric can cost a textile dyeing plant between $1.5 million to $5 million annually.

# Automation in textile colouration

- For right-first-time production, quick response to orders and just-on-time delivery, full automation is the best solution.
- It is vital that possibilities for human error are minimised at every stage of production.
- Good quality data input and efficient control systems are mandatory. Automate a mess and create an automated mess.

# Automation in textile dyeing

- Automation is now well established in the dyeing industry and robotics are being introduced at an ever-increasing rate.
- Blind dyeing techniques have been practiced now for many years.
- The robotised, 'lights-out' dye house operated with the minimum of staff is becoming more common.
- A 'lights-out' operation is likely to be run by mechanical and electronics engineers and not dyers in the conventional sense.

# Automation in textile dyeing

- Programmable process control of the dyeing machinery (by microprocessors).
- Automatic control of dissolving and dispensing of the dyes, pigments and chemicals in a central colour kitchen.
- Computer-controlled weighing of solid material, with automatic stock control and the printing of recipe and process cards.
- Instrumental colour measurement, computerised colour matching.
- Central computer (network), computerised management system.

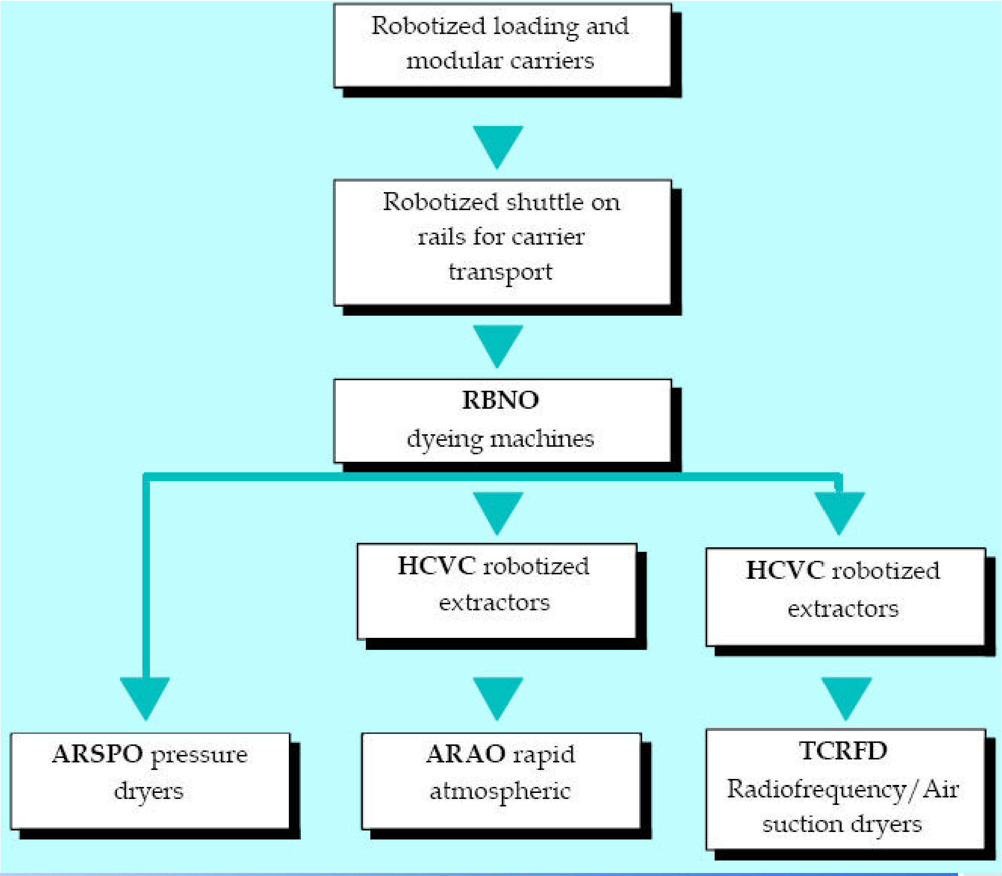
# Loose stock and top

- OBEM SpAs technology focuses on dyeing systems created in modular form that facilitate flexibility and versatility by modifying lot size.
- Flexibility is evident in the design of a four-unit, 250-kilogram (kg)-per-unit machine that can run in a 1,000-kg mode or a 250-kg mode, allowing the textile manufacturer to adapt to business conditions.

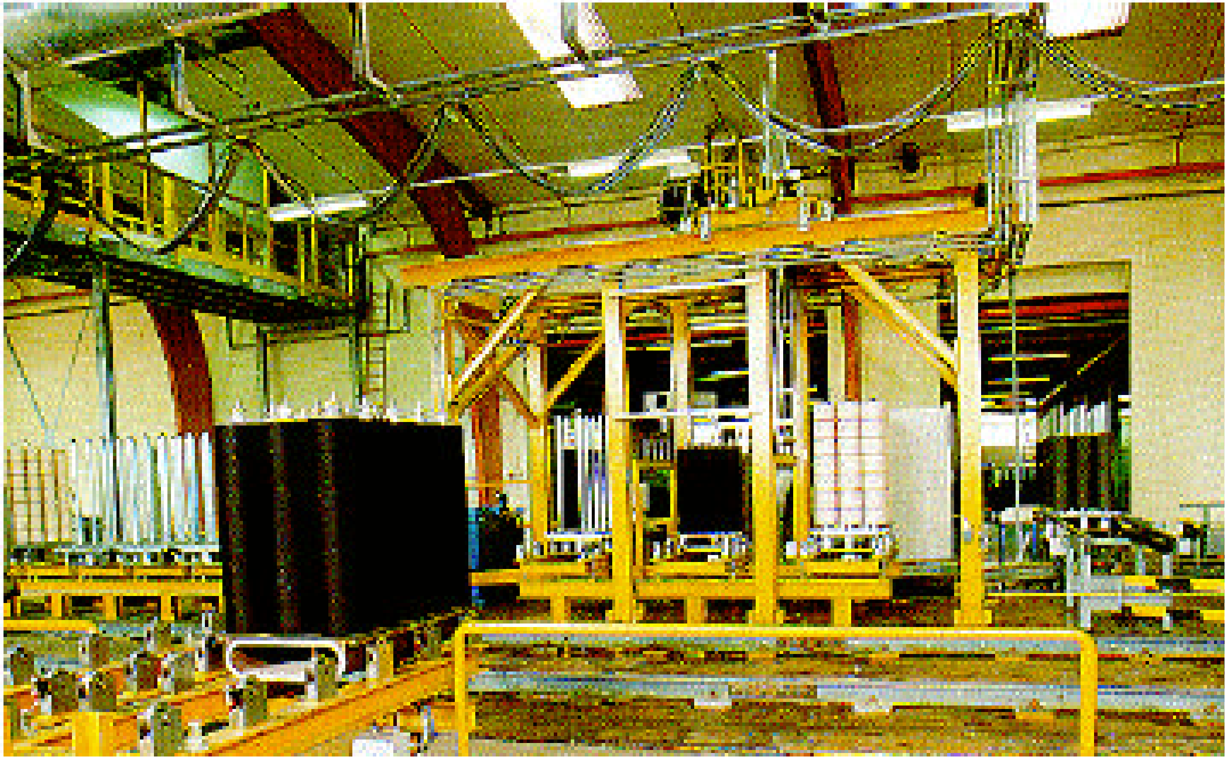
# OBEM automated hank dyeing

- The company's latest technology is the TMB / SV-TR, fully robotised hank-dyeing system.
- The machines use a specially designed spray hank arm, the hanks are processed without tension. The system is particularly suited for fine and soft yarns.

# RBNO robot package dyeing plant



# RBNO robot package dyeing plant

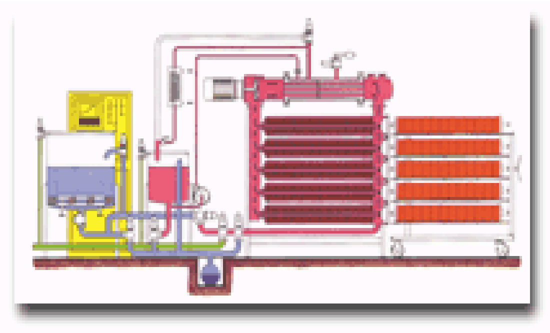


Packages are loaded on dyeing spindles and compressed.

# RBNO robot package dyeing plant

Packages are transported to the dyeing machines.

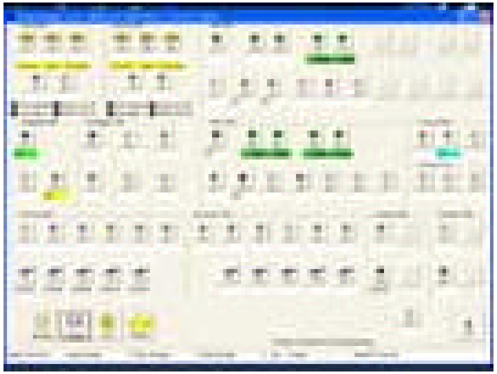
# OBEM robot package dye house

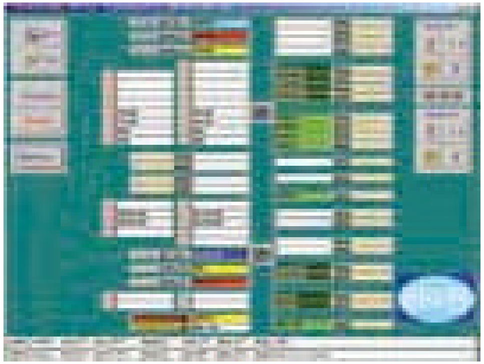


- The robotisation of the dye house is the consequence of continuous research towards the production of more reliable systems.
- Here you can see some robotisation solutions for package dyeing.

# OBEM dyeing machinery robotisation software

- This software controls all  the robotized units in the dyeing plant including shuttles, overhead cranes and loadind and unloading of the automatic dyeing machines.
- The software is called VisualDye Handling and it runs on a PC normally located in the office.
- Through appropriate interfaces the robotised plant is monitored and its operation is recorded in real time, including the actual position of the shuttle and the type of material loaded in every dyeing machine, press, centrifuge, dryer and storage area.
- Direct instructions can be sent to the shuttle, and priorities in operation of the machines can be changed.





# Benefits from dye house automation

- Programmable process control (by microprocessors) results in 10-30% saving in water and energy usage as well as 5-15% saving in dyes and chemicals.
- Computer-controlled weighing of solid material with automatic stock control and the printing of recipe and process cards. 10-15% savings in dyes, pigments and chemicals.
- Lower discharges with less pollution and lower cost of effluent treatment.
- The costs of automation are relatively low, typical return on investment figures are in the range of three months to one year, not including the value of quality and reliability improvements.

# Cost savings with automatic dye dispensing

- Even if full automation is not being considered, a dispensary with its own dedicated staff greatly increases the efficiency and reproducibility of dyeing.
- A separate dispensary is obligatory on health and safety grounds in many countries.
- The installation of a dye house control system and a dispensary allied to it will have a payback of about one to two years. The savings accrued include typically a 50% reduction in labour, a 30% increase in productivity, a 15 to 20% saving in dyes, chemicals, energy.
- Totally automated dispensaries can prepare about 20 dye baths per hour and are thus only justified for a dye house equipped with many machines programmed with short dyeing cycles.
- This level of automation would be difficult to justify for a small dye house with less than 10 machines.

# Cost savings with instrumental colour matching

- Substantial cost savings can be made. For a fabric dyehouse processing 50 tonnes per week :
  1. inventory reduction (to 25% of original)
  2. 30% savings in dye cost per year (15-45%)
  3. reduction in laboratory matchings (from 8 to 2 per shade)
  4. 30% saving for each bulk correction eliminated
  5. dye and substrate savings through quality control improvement.
- Such savings give a short payback period for the cost of the ICM system and the associated laboratory dyeing equipment.

# Tracking of errors in dyeing

- Analysis of errors can provide valuable information for identification of causes of dyeing faults:
  1. if on one type of substrate only - indicates that the substrate or its preparation may be unreliable
  2. on one machine only - indicates a possible machine fault
  3. on one shift only - indicates human error
  4. with a particular technique or with a particular dye - indicates a ‘fragile’ dyeing method or an unsuitable dye.

# Responsibilities of the dye house laboratory

- The responsibilities of the dye house laboratory have been classified as follows [18]
- **Primary task:**
  1. development of shade ranges
  2. aiming for right-first-time (RFT)
  3. just-in-time (JIT) is increasingly necessary.
- **Secondary task:**
  1. monitoring recipe changes as a function of substrate dyeability
  2. elaboration of process parameters as a function of the recipe
  3. universally applicable machine-independent process parameters.
- **Tertiary task:**
  1. untreated and intermediate substrate inspection control
  2. final inspection control.

# 6. Revision of the course