



Pollution Prevention

MOROCCAN TEXTILES INDUSTRY

August 2008



P2 Introduction

WHAT IS P2?

Pollution prevention, commonly referred to as P2, is the reduction or elimination of pollution at its source. P2 occurs when raw materials, water, energy and other valuable resources are conserved and utilized more efficiently, when less harmful materials are substituted for hazardous ones, and when toxic substances are eliminated from production processes. Under the US Pollution Prevention Act, P2 is defined as “source reduction”. The term source reduction conceptualizes the practice of reducing the amount of any hazardous substance, pollutant, or contaminant entering any waste stream or otherwise released into the environment prior to recycling, treatment, or disposal. By taking such a proactive approach to stopping pollution before it starts. We protect human health, strengthen our economic well being, and preserve the environment.

WHAT ARE THE ECONOMIC INCENTIVES FOR P2?

Adopting pollution prevention practices and techniques often benefits industry by lowering a company's operational and environmental compliance costs. By source reducing and preventing the generation of waste,

P2 can reduce or eliminate long-term liabilities and clean-up costs. Furthermore, disposal costs are reduced when the volume of waste is decreased. This can also lead to a reduction in workplace exposures to hazardous materials that can affect workers' health and hence, their productivity. If less waste is produced, there will also be a diminished need for on-site storage space. Finally, businesses shoulder an important responsibility for protecting the environment and natural resources for their own good as well as that of society.



Pollution Prevention Opportunities

WHAT CAN BE DONE?

The Textiles industry has the opportunity to make numerous changes in its daily operations that will conserve limited resources, reduce the amount of harmful chemicals being released into open air and water, and impact the wellbeing of our world in a positive manner. Many strategies aimed at achieving such environmental efficiency have been implemented and proven successful over the last half century. A detailed summary of P2 practices within the textiles industry follows.

DYEBATH REUSE

Excerpted from *“Identification and Reduction of Pollution Sources in Textile Wet Processing”* by Brent Smith

The idea of dyebath renovation and reuse began attracting attention around the middle 1970s when energy costs became a critical factor in overall manufacturing costs. Dyebath renovation and reuse has been shown to be an effective method of cost reduction, energy savings, and pollution source reduction in textile wet processing. Laboratory studies, pilot plant work, and full-scale commercial use have been documented. This report summarizes these documented studies and presents typical examples of comparative procedures.

Dyebath reuse can be and is an attractive alternative to pretreatment systems for dyehouses that discharge to publicly owned treatment works. (POTWs). In many cases, dyehouses operating in cities do not have enough space to construct large pretreatment systems. Dyebath reuse, which has been shown to reduce flow, BOD, and COD loadings by up to 33%, requires a smaller investment in equipment than pretreatment systems. Also, the dyebath reuse concept has a return on investment in the form of dye, chemical, and energy savings which pretreatment does not. Savings that result from dyebath reuse, as well as installation costs and operating expenses, are site-specific.

Dyeing Processes Generalities - Chemicals, Dyes, etc.

Typically, an exhaust dyebath will contain some or all of the chemical components shown below:

Components of a Textile Dye Bath

- Water
- Dyestuff (colorants)
- Buffer system/pH control
- Electrolyte (common salt or Glauber salt)
- Specialty dyeing assistants, such as:
 - Retarder/accelerant;
 - Leveling agent;
 - Lubricant;
 - Defoamer;
 - Surfactant/dispersant;
 - Sequesterant;
 - Other special purpose chemicals.

Typically, only the dye and, to a lesser extent, a few specialty products, are exhausted during conventional dye processes. Most of the chemicals remain in the dyebath and are discarded with it. Reuse saves the cost and pollution associated with discharge of those chemicals in the spent dye liquors, and it also saves the energy required to heat the dyebath up from the fill water temperature to the appropriate starting temperature for the next dyeing.

Savings amounts for energy, chemicals, BOD, COD, pH and hydraulic loading of waste streams vary with amounts and types of specialties that are used. These in turn depend on many factors including the shade being dyed, dye class, color specification (fastness, critical shade match, etc.), equipment, fabric construction and fiber content, and other factors.

Some of these will be reviewed in specific cases for each dye class, but some general comments can be made about dyebath components at this time.

Dyestuff (colorant content) is exhausted to a large extent, usually 90 to 95%, onto the fiber. For some dye classes, this involves an approach to equilibrium governed by thermodynamic and kinetic laws without chemical alteration of dyestuff during the process. Establishment of such equilibrium is governed by factors such as pH, temperature, liquor ratio, concentration of electrolytes, etc. This is true for acid, basic (cationic), direct, and disperse dyes.

In contrast, certain other dye classes undergo chemical reaction during the dyeing process and are therefore conceptually different from the above mechanism. These dyes are typically rendered insoluble, reacted, or entrapped in the fiber in a form that is chemically different from the original form in the dye liquor. Examples are fiber reactive, naphthol (azoic), sulfur, and vat dyes. In such situations, experience with dyebath reuse is not as well documented, although it may be possible to practice dyebath reuse in these cases also.

In any case, dye as it is added to the dyebath is not 100% pure colorant. Commercially, colorants may be cut typically 20% to 80% with various diluents typically which do not exhaust. Because the dye concentrations in the bath are low (typically under 1000 ppm), diluents build up slowly in reused dyebaths over many cycles and are not a severe problem. Diluents vary with dye class, but include surfactants, dispersants, common salt, Glauber salt, soda ash, and other materials that do not

usually exhaust. Buffer systems for pH control include organic acids such as acetic and formic, as well as inorganic salts. Mineral acids are occasionally used. These are usually not depleted except in proportion to the amount that is lost as water is carried off by the substrate (fiber, yarn, fabric).

In some cases, where organic acids are used, substantial COD and BOD reductions can be made by dyebath reuse. Alkali systems are typically materials with little or no BOD contribution, such as caustic, soda, ash, TSP, and TSPP, and these can be saved for dyebath reuses.

Electrolytes, primarily common salt and Glauber salt, are typically not exhausted. Although they do not contribute to BOD and COD loads, they can be present at concentrations of over 10,000 ppm in the dyebath for some shades, and can create problems in waste treatment by inhibiting oxygen transfer in aeration, especially under shock loading conditions. Dyebath reuse can save essentially all of these materials except the proportion that is lost with dye liquor that is carried off in the substrate.

Retarders vary greatly in their exhaustion characteristics. Some act almost exclusively on dye in the solution, while others act primarily on the fiber itself. The latter types are essentially 100% exhausted during the dye process. In many cases, separate retarder is not used; rather dye exhaust rate is controlled by pH, temperature, electrolyte concentration and other process variables.

Accelerants, especially dye carriers for disperse dyes on polyester; vary greatly in their exhaust characteristics. These dye carriers typically are blends of organic solvents and surfactants. Components of such mixtures usually exhaust at different rates and can cause an imbalance in the dyebath after many reuse cycles. Also, the components of the carrier-active blend may vary in volatility, causing losses from open dye machines to the air.

Leveling agents for disperse dyes on polyester generally exhaust less than carriers discussed above, but are otherwise similar for purposes of this presentation. Leveling agents for other classes (acid, basic, and direct) generally work in the dye liquor and are not exhausted.

Surfactants and dispersants do not usually exhaust. In fact, the concentration of surfactants can be expected to increase with reuse cycles due to the accumulation of unexhausted portions of materials such as dye diluents, retarders, accelerants, levelers, lubricants, and fiber finishes. These may eventually cause significant changes in dye exhaust rate, retarding of dyeing, and lower ultimate exhaustion of dyebath if allowed to build up too much. It is impurities like this that limit the number of times a dyebath can be reused. The number of reuse cycles varies for each specific dye/fiber situation; however, in general, most dyebaths can be reused at least 5 to 10 times, and few can be reused more than 20 to 25 times in commercial situations.

Lubricants such as mixtures of surfactants and other materials (like butyl stearate) typically exhaust and must be at least partially replaced for dyebath reuse as part of the renovation procedure. Defoamers, sequesterants, and other specialties are used on an as-needed basis in small amounts, and are not generally lost.



Methods

1. Store the spent dyebath in a tank or in a second identical dyeing machine. One interesting application of dyebath reuse involves moving the dyebath back and forth between two or more machines. For example, package dyeing machine "A" can be preparing yarn while a second identical machine "B" is in dye. When B completes its dye cycle, the bath is pumped to A for renovation and dyeing. In the meantime, the yarn in B is afterscoured, unloaded, and a new batch is loaded and prescoured. By that time, A has finished dyeing, and the bath goes back to B for another reuse cycle.

2. Analyze or estimate the dye and chemical content of spent dye liquor using a spectrophotometer and/or guidelines based on specific production experience. Unexhausted dyestuff is measured by solution coloristic techniques, sometimes using extraction techniques if the bath is turbid. Extraction solvents include 1-octanol for basic and acid dyes and toluene for disperse dyes.

Dyebath Analysis Equipment

Equipment Required	Quantity
25 ml graduated cylinder	2
25 ml sample (separatory) funnels	2
20 cc glass syringe	2
Ring stand and rings	1
Cotton stand and rings	1
Table salt	500 grams
Solvent	4 liters
Sample cells	4

Chemical losses are determined by specific production experience based on losses due to exhaust, volatilization, and dye liquor carry-off with the dyed substrate (usually about 10 to 15%). Chemical losses may be estimated or determined analytically if appropriate equipment is available. Usually the quantities are not as critical as the dye, and an estimate is sufficient.

- 1) Add 20 ml (25 grams) of salt, 25 ml of exhausted dyebath, and 25 ml of solvent such as 1-octanol or toluene in succession into a clean separatory funnel.
- 2) Place stopper in funnel and shake vigorously for 30 seconds. Allow contents to separate for 30 seconds. Shake vigorously again for 30 seconds. (This mixing action results in extraction of dyes from the dyebath water into the solvent.)
- 3) Place funnel on ring stand and allow for distinct separation of salt (bottom layer), water (middle layer), and solvent with dyes (top layer). Solvent layer may appear cloudy due to water in the solvent.
- 4) Remove stopper. Open the stopcock and allow the salt and water layers to drain out to sink. Close stopcock.
- 5) Place two cotton balls in clean, dry syringe. Drain solvent layer from funnel into syringe.
- 6) Allow solvent to pass through cotton balls in syringe to absorb any remaining water, and collect sample in a clean, dry sample cell as it leaves the syringe.

3. Add make-up amounts of dyes and chemicals to renovate the spent bath. Also add water to make up the volume that is carried off by the dyed substrate.

4. Reuse the bath for another dyeing. Because the used dyebath will usually be hot (over 140°F), it must be cooled down to an appropriate temperature for starting the next dyeing. Starting the next dyeing at the highest possible temperature consistent with desired quality factors saves considerable time and energy. This is one, of the main advantages of dyebath reuse. The ultimate "life" of a dyebath varies according to the quality required, contaminant buildup, and other factors.

Dye Classes and Potential for Bath Reuse

There are many different classes of textile dyes, and each class applies to specific fiber types and requires different exhaustion procedures, specialty, chemicals, pH, equipment, etc. Because of these differences, the savings that can be expected vary. Also, results may vary in respect to the fastness, shade reproducibility, and other factors. Batch dye systems have been reported to be adaptable to dyebath reuse. A laboratory study of reuse of disperse dyes on 100% polyester spun yarn (package dye) showed that nine reuse cycles could be expected, with savings of about 80% on water and chemicals, and about 40% on energy.

Systems for Dyebath Reuse

Product	Fiber	Dye class(es)	Machine
Knit fabric	Polyester	Disperse	Jet
	Cotton	Reactive or direct	Beck
	Poly/cotton	Disperse/reactive or direct	Beck
Yarn package	Polyester	Disperse	Package
	Poly/cotton	Disperse/reactive or direct	Package
Socks	Nylon/spandex	Acid	Paddle
Pantyhose	Nylon/spandex	Disperse/acid	Rotary drum
Carpet	Nylon	Disperse/acid	Beck
	Polyester	Disperse	Beck
Woven fabric	Aramid	Basic	Jet
Skein	Acrylic	Basic	Skein

Limitations

To gain the maximum benefit from dyebath reuse, users must keep certain considerations in mind. The easiest systems to manage for dyebath reuse are dye classes that undergo minimum chemical changes during the dyeing processes.

These are:

1. Acid dyes for nylon and wool
2. Basic dyes for acrylic and certain copolymers
3. Direct dyes for cotton
4. Disperse dyes for synthetic polymers

A higher degree of difficulty can be expected from other classes. The easiest situation to manage is the reuse of a dyebath to repeat the same shade with the same dyes and equipment on the same fiber. It is also possible to reuse a dyebath to produce a darker or lighter shade with the same dyestuff selection on the same fiber. More difficult situations would involve addition of new colorants to renovate a dyebath. This would lead to potential problems with shade matching and metamerism.

The number of cycles that a dyebath can be reused is limited by buildup of impurities. These impurities can come from several sources. One source is fabric impurities from incomplete preparation, which include natural impurities in cotton and wool, knitting oils, winding waxes and emulsions, fiber finishes, size materials-and the like. Impurities can also accumulate from dye diluents, salt buildup from addition of acids and bases for pH control, steam impurities for direct steam heated baths, and emulsifier systems from exhausted specialties.

STEAM LOSS REDUCTION

Many impurities are surfactants, and these can cause stripping and/or retarding of dye exhaust if allowed to buildup excessively. Other problems such as spotting and excessive foaming can occur if too many reuse cycles are attempted. The usual range of reuse cycles is 5 to 25, and each process and/or shade must be optimized by actual production experience.

Specialty dye assistants and other materials that are essential to the dyeing process may be lost by several mechanisms. These include losses due to vaporization from open dyeing machines, exhaust onto the fabric, chemical reaction, and dye liquor carry-off by the substrate. These losses may vary from 10% upward and may vary between components of a blended chemical specialty. To assure best results, dyeing assistants must be carefully screened for reuse performance.

One major reason for using bath (exhaust) dyeing is the ability to produce small lots, short runs, and fast turnaround times. Because dyebath reuse requires special scheduling considerations, it may limit somewhat the flexibility of bath dyeing operations.

In summary, batch dyebath reuse may not be for every situation; however, the economic savings are large, if properly applied.



Steam is used for heating dyebaths, washing solutions, heating rinse water, ironing fabrics, drying fabrics, process heating and fabric heat setting.

Since most of the produced steam is directly used, it is not obvious that adequate provisions can be made to collect and return condensate to the boilers.

Most factories express interest in reducing overall energy consumption. There are some basic operation and maintenance (O&M) procedures that a factory should observe to improve overall energy efficiency.

One list of these measures has been published and it is available at the following website:

http://www.mass.gov/envir/ota/resources/pdf/energy_efficiency_final.pdf

Boiler Systems:

Boiler should be tuned at least once a year and the air fuel mixture adjusted periodically to keep the combustion efficiency high above 80%. Boilers should be maintained to remove scale. Scale build-up of about 3.2 mm can cause a 3% loss in boiler efficiency.

One facility has a boiler designed to raise steam at 12 bars but was producing steam at 8 bars. Generally, it is recommended to operate the boiler at the design pressure and then to reduce the pressure through a valve because the steam exiting the valve will be slightly superheated, resulting in less water in the steam lines and heat exchangers.

Every factory should investigate the reclamation of the heat of combustion or exhaust gases to preheat boiler feed water or combustion air feed. If the temperature of exhaust gases is more than 120°C, the viability of using a waste heat exchanger in the form of economizer or plate and frame heat exchanger should be explored.

Steam Traps:

Steam Leaks are a very common contributing factor to energy waste and lack of efficiency. Steam pipes and fittings with no insulation are often to blame for such a high volume of unnecessary steam loss. A program to repair leaks and install insulation on steam pipes, condensate return pipes and their fittings should be vigorously pursued.

Steam traps are automatic valves that discharge condensate from a steam line without discharging steam. They are important because without them, steam pipes and heat exchangers would quickly fill with condensate that would prevent the flow steam and transfer of heat. The factories should have a program to check and replace failed steam traps regularly.

The factories should review steam distribution and use system throughout to increase the volume of condensate reclaimed and returned to the boiler. High condensate return will reduce energy, water and water treatment costs.

If most of the produced steam is consumed directly and the condensate return is minimal, makeup feed water will be high. Therefore, blowdown rate should be minimal: more than 15 cycles per blowdown.

Compressed air system (CAS): Every factory should have a regular program to fix leaks of the compressed air system.

Factories should discourage inappropriate use of compressed air. It is a waste of energy to use compressed air to blow-dry every item of equipment or to remove dust and dirt. The on set point and the off set point pressures should be carefully and adequately regulated to reduce the cycling of compressors. The on set-point pressure should be fairly close to the specified operating pressure of equipment using the compressed air.

Motors:

The factory should have a current list of motors. Variable speed drives should be available for motors that operate with varying loads. The factory should use premium efficiency motors for change-out of old motors

CHEMICAL REDUCTION

Most textile mills have wastewater issues related to meeting typical limits for biological and chemical oxygen demand, metals, total nitrogen, pH, oil and grease, etc. Occasionally, textile wet processing mills will be presented with compliance issues related to effluent toxicity either in the form of acute or chronic toxicity. Unlike most other wastewater parameters, toxicity can result from any number of and combination of constituents that can be extremely difficult to identify. The following list contains options to pursue in order to reduce effluent toxicity related issues for textile operators.

- 1. Chemical Substitution or Reformation** - work with supplier to find alternatives or modify chemistry of existing product. Effective, but can result in other problems due to new chemistry.
- 2. Dyehouse Formula Modifications** - small reductions in required adds of toxic products can reduce effluent loading. Many companies have effectively reduced scouring chemicals, dyeing auxiliaries, and finishing chemicals by as much as 25% without affecting product quality. This often leads to improved effluent while reducing operating costs.
- 3. Equipment Modifications** - investment in more efficient technologies that would reduce chemical usage or losses. While this requires a capitol expense, there is a payback in reduced operating costs while treatment technologies typically have no payback at all.
- 4. Operational Modifications** - reuse of bleach baths or finish baths to reduce losses to the effluent and increased attention to control parameters such as time and temperature during dyeing and reduce dye auxiliary requirements.



TEN EASY P2 TIPS

In addition to the Work Plan template, the following Environmentally Friendly, Money Saving Tips can assist in your efforts to practice P2.

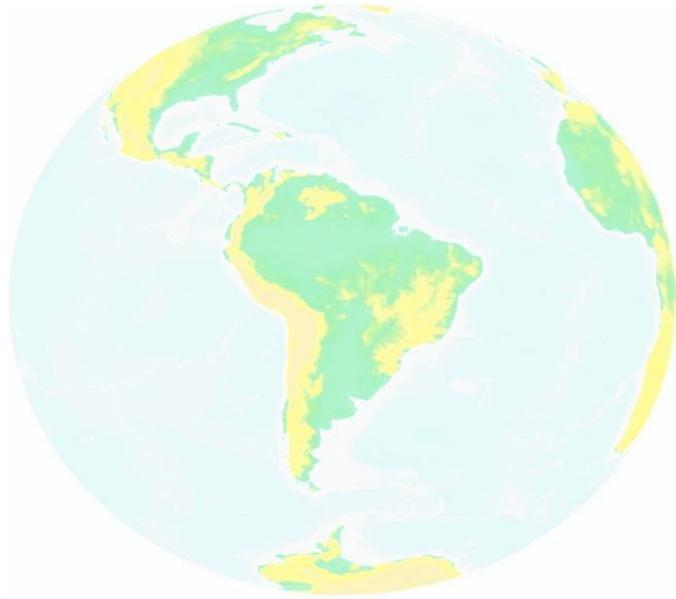
Action	Environmental Benefit	Cost Savings*
Reduce the pressure or eliminate use of compressed air. Most applications do not require pressurized air.	Reduced emissions of CO ₂ , due to reduction in fossil fuel burning to produce electricity. (~1 ton/1,000 kWh reduction).	\$50/1,000 kWh reduced
Turn off or put in “sleep” mode machines when not in use.	Reduced emissions of CO ₂ , due to reduction in fossil fuel burning to produce electricity. (~1 ton/1,000 kWh reduction).	\$50/1,000 kWh reduced
Switch to energy saving bulbs with reflectors and turn off lights during the day, if adequate natural light available.	Reduced emissions of CO ₂ , due to reduction in fossil fuel burning to produce electricity. (~100 lbs/50 watt reduction).	\$50/1,000 kWh reduced
Install programmable thermostats: set temperatures for non-work hours.	Reduced emissions of CO ₂ , due to reduction in fossil fuel burning to produce electricity. (~50 lbs/degree reduction).	\$50/1,000 kWh reduced

Install timers for hot plates and coffee makers: turns off when not needed.	Reduced emissions of CO ₂ , due to reduction in fossil fuel burning to produce electricity. (~1 ton/1,000 kWh reduction).	\$50/1,000 kWh reduced
Install motion detectors for lights in seldom used areas (storage, conference and break rooms).	Reduced emissions of CO ₂ , due to reduction in fossil fuel burning to produce electricity. (~1 ton/1,000 kWh reduction).	\$50/1,000 kWh reduced
Insulate water heaters and reduce set temperature.	Reduced emissions of CO ₂ , due to reduction in fossil fuel burning to produce heat.	\$100/heater/1,000 gal
Minimize space heating in unoccupied areas and buildings (storage, etc).	Reduced emissions of CO ₂ , due to reduction in fossil fuel burning to produce heat.	\$50/1,000 sq. ft./year
Install cardboard baler in order to recycle cardboard without taking up valuable storage space	Reduced land filling of cardboard that could be recycled. (~3 metric tons CO ₂ /ton of waste recycled instead of land filled).	Saves on landfill fees plus is a source of revenue. Examples indicate less than 2-year payback.
Install low-flow toilets and showers	Reduced use of potable water for sanitary purposes.	\$150/toilet/year

* Based on U.S. estimates for coal and water.

For specific energy reduction estimates go to:

<http://www.epa.gov/stateply/resources/guidance.html>



**National Pollution
Prevention Roundtable**
11 DuPont Circle, NW
Suite 201
Washington, DC 20036 USA
(202) 299-9701
www.p2.org
staff@p2.org

**Centre Marocain
de Production Propre**
23, Boulevard Med Abdouh
Palmiers
20 100, Casablanca, Maroc
(212) 5 22 99 70 53
www.cmpp.ma
cmpp@cmpp.ma