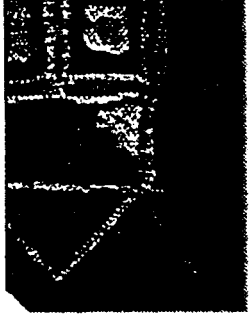


ATI's

Dyeing and Printing Guide

Dyeing and printing are textile processes almost as ancient as humanity itself – yet as modern as the new techniques that have been spawned in our space-age society.

This reference guide contains basic information helpful to the beginner, as well as to the veteran technologist in the industry.

Topics covered include:

-Dyeing processes.

-Printing systems.

-Glossary of dyeing terms.

-Dyes and their properties.

-Fastness tests.

-Dyeing methods and machinery used.

-Examples of dyeing methods for some selected fabrics and products in the trade.

This reference guide was compiled for America's Textiles International by Dr. C. Brent Smith, associate professor of Textile Engineering, Chemistry and Science at the College of Textiles, North Carolina State University, Raleigh, N.C.

The Process of Dyeing

Dyeing is accomplished by either continuous or exhaust methods. Continuous dyers apply controlled amounts of dye solution to textile materials, rapidly treat with heat or steam to cause penetration, then fix the dyestuff, and finally wash off unfixed dye. Exhaust dyers, on the other hand, bring textile materials into contact with dye solutions in discrete batches. Because of affinity of dyes for fiber, the dyestuff leaves the dye solution and enters the fiber over a period of minutes to hours. This action is accelerated and optimized by the use of chemicals and controlled temperatures. Once in the fiber, the dye is fixed in place. Then the textile material is washed.

Three fundamental exhaust dyeing behaviors or "isotherms" observed: Nernst, Langmuir, and Freundlich.

Physical Mechanisms, Dyeing Behavior, and Isotherms

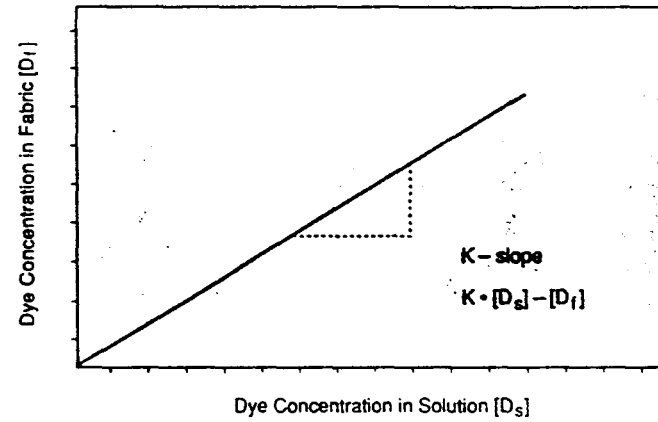
Dyeing Mechanism	Dyestuff/Fiber Example	Observed Isotherm
Simple Distribution	Disperse/Synthetic	Nernst
Specific Affinity	Acid/Wool Acid/Nylon Basic/Acrylic	Langmuir
	Direct/Cellulose	Freundlich
Entrapment	Vat/Cellulose Sulfur/Cellulose Naphtol/Cellulose Fiber Reactive/Cellulose	None*
Binding	Pigment/All	None

*Exhaust dyers apply certain types of dyes in a two-step procedure, in which the exhaust phase (described by an isotherm) is followed by a reactive phase not described by any isotherm.

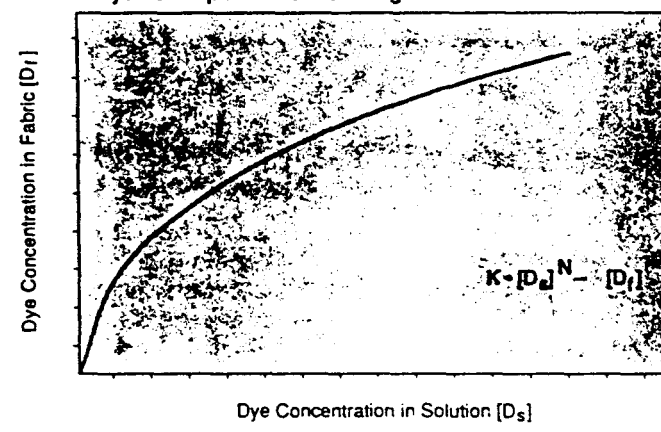
Each isotherm expresses a relationship between equilibrium concentrations of dye in the fiber (D_f), dye in the dye liquor (D_s) as well as the number of dyesites in the fiber (S_f), and constants (N,K) which are characteristic of the system. These represent specific equilibrium conditions and are influenced by many factors. In practice, the equilibrium, which is represented by the isotherm, is never fully attained. Thus, another critical factor for the exhaust dyer is the kinetics or rate of dyeing. This rate must be carefully tailored to the isotherm specifics of the equipment, dye, and substrate. There are 4 basic dyeing mechanisms which are used both in exhaust and continuous dyeing.

1. Simple distribution of dye between the substrate and dye liquor (non-ionic) [Nernst].
2. Specific affinity of dye for fiber by hydrogen bonding, Van der Waals forces, or ionic inter action which may occur at specific sites, by electrical effects, or formation of bonds. [Langmuir or Freundlich].
3. Mechanical entrapment of dye within fiber, especially by rendering the dye insoluble by chemical reaction (in which the fiber may, or may not participate).
4. Binders which hold pigments in place on the fiber surface.

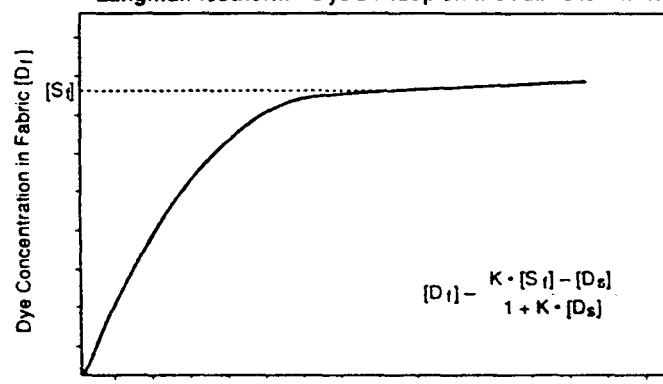
Nernst Isotherm—
Dye Buildup in Fabric is Proportional to Solution



Freundlich Isotherm—
Dye Buildup Diminishes at High Concentration



Langmuir Isotherm—Dye Buildup on the Fabric is Limited



For printing, the fundamentals of dyestuffs, fabrics, fastness properties, and many other factors are similar to dyeing. However, the aim of printing is the localized application of color. This requires careful cloth preparation to provide for optimum absorbance of the print paste, but without spreading. Also, the print paste must be carefully formulated not only to insure proper flow properties during application, but also to remain in place from the time it is printed onto the fabric until dried.

The two general types of printing are "pigment printing" and "wet printing," the former being done with pigments, and the latter with dyes. By far the most common for general purposes is pigment printing. Wet printing is typically used for special purposes or higher quality work. Although it is possible to do wet printing with almost any dye class, dyes must be selected which will wash off cleanly without staining the ground or white areas of the printed cloth. In all types of printing, multicolor patterns are produced by sequentially overprinting multiple patterns on top of each other. Typically, 6 to 8 colors can be combined on commercial printing machines. There are several methods of printing.

1. **Flatbed Screen Printing**

Flatbed screen printing employs pattern screens mounted in flat frames. This method accounts for approximately one-tenth of all printing. In this method, print paste is placed on top of the screen and is pushed through by a moving squeegee. Fabric is indexed to the next print position between printing operations, and both the fabric and screen are stationary during the actual printing process.

The size of the printed pattern is limited by the dimensions of the screen, and this can be fairly large. Pattern resolution is good (i.e., on the order of 40 x 40 to 80 x 80 per square centimeter). Screen making, changeovers of patterns and/or colors, screen cleaning, and other startup tasks are somewhat easier with flatbed screens than other methods, thus this method is frequently chosen for short runs or piecework. Although flat screens can produce fairly large patterns by simply using large screens, it is not commercially practical to produce unlimited continuous patterns. Small flat screens can be used manually, without any printing machine, thus they are frequently the method of choice for laboratory and design strike-off use, and handprinting work.

Because of the features of the method, typical flatbed screen printed products include items such as tablecloths, towels, T-shirts, and scarves which require discrete noncontinuous patterns. Also designer items, limited prints, prototype patterns, and also specialty patterns with very large numbers of colors (over 10) would be good candidates for flat screen printing. Finally, laboratory or sample prints are frequently flat screen printed.

2. **Rotary Screen Printing**

Rotary screen printing uses some of the same basic ideas as flat screen printing, but the screen is in a cylindrical form, which is rolled along as the fabric passes beneath it. A continuous, endless pattern results, but the pattern must repeat at an interval equal to the circumference of the cylinder, which is typically 75 to 150 centimeters. Print paste is pumped inside the cylinder, and is pushed through by a squeegee.

Rotary screen printing accounts for approximately one-third of worldwide printing, and approximately two-thirds of printing in the USA. Printing speeds are higher for rotary screens than for flat screens because of the continuous nature of the process. The fabric, as well as the screen, are both in continuous, synchronized motion. This method is increasing in its share of the printing market, especially as older roller printing machines are replaced with newer rotary screen printing equipment. Modern screen making methods for rotary screen printing, employing digital computer pattern scanners, laser screen making techniques, etc. can produce beautifully precise screen patterns.

The screens are much easier to make than rollers for roller printing (discussed below).

Because of the configuration of the screens, they are somewhat harder to clean than flat screens. Also, the squeegee configurations required and systems to deliver print paste inside of the screen are more complex and, thus, the entire system is more difficult to operate than flat screens. This method is for general purpose, and almost any product can be produced, subject to the repeat limitations cited above. Typical products include apparel, sleepwear, sheeting and shirting, curtains, and upholstery.

3. **Roller Printing**

Roller printing uses copper rollers with engraved patterns which pick up print paste and transport it to the fabric. Extremely high resolution and quality can be obtained this way. Print paste is brushed on the rollers, then excess paste is removed by a "doctor blade," leaving the engraving of the roller filled with printing paste. This is then transferred to the fabric.

This method accounts for about one-half of printing worldwide, but less than one-fourth of printing in the

USA. Due to the difficulties and expenses of the method compared to rotary screen printing, this method is decreasing. One of the major factors in roller printing is the cost and difficulty of making the copper printing rollers. Thus, short runs are not economically feasible: Long production runs, or patterns which will be run year-after-year, are more appropriate. An advantage of roller printing is the long-term durability of rollers compared to screens. Also, the circumference of the rollers is typically much smaller than rotary screens, thus limiting repeat length of patterns which can be produced.

Roller printed products include high quality, high resolution products, and high fashion products. Examples are fine women's wear apparel fabrics, men's neckties, and printing of small patterns requiring high resolution.

4. **Transfer Printing**

Transfer printing uses printed paper which is placed in contact with the fabric and heated under high pressure. Dye sublimes and transfers as a vapor to the fabric. This accounts for less than one-tenth of all printing. This technique can only be used for printing synthetic fabrics, primarily polyester and nylon with disperse dyes. No other dye class is commercially used. Cotton and cotton blends cannot be commercially printed in this way. The advantage is that quality control can be done on the paper prior to printing the fabric, so that off quality misprinted fabric is minimized. Also, there is essentially no cleanup, expense or time required for changeover of colors or patterns. Transfer printing is ideal for short runs, one of a kind items, piecework, and frequent color or pattern changes. Another feature of the method is that the paper must be compatible with the fabric width and, thus, prior planning must assure that the proper paper is on hand. However, paper can be printed much more rapidly than fabric, so the wet printing step is facillitated.

5. **Discharge Printing**

Discharge printing is performed on patterns requiring a solid ground, usually dark shades, and extremely tight registration of peg objects to the background. White, as well as colored pegs, are printed. The dyed ground has to be colored with dyestuffs that are fugitive to a reducing agent, usually a sodium hydrosulfite. Ground shades can be dyed with either Direct colors or selected Naphthol combinations. Vats are more comonly used as print colors. In some cases,pigments will carry enough hydrosulfite to achieve the discharge.

6. **Carpets Printing**

Carpets are frequently printed with low resolution jet printing techniques, using streams of dye sprayed from nozzles. These are turned on or off to produce desired patterns either with valves or air jets (to deflect the spray into a waste collection gutter).

Carpets are also printed on rotary screen printing machines. This type printing is best suited to geometric, floral and border patterns. The random patterns so popular a few years back are not suited for rotary screen execution.

7. **Experimental or Special Applications Printing**

There are also other printing methods which are either experimental or used in specialty applications. These included dry-on-dry techniques (xerographic or powders) and high resolution ink jet printing. The latter has many advantages, such as:

non-contact, thus extremely delicate materials, three dimensional materials, etc., can be printed electronic pattern, thus, there are no screens or rollers to make or clean, also the entire pattern can be transmitted as electronic data from one location to another compatible with CAD systems, thus, patterns can be modified to different sizes, rotated, duplicated without making new media fast and versatile resolution approaching photographic quality.

Glossary: Explanations of Dyer's Terms

Appearance: The appearance of an object depends on its color as well as other factors, including luster, opacity, transparency, sheen, luminescence, and directionality.

Batch Dyeing: Dyeing processes in which a given amount of textile material, usually 100 to 1000 kg, is loaded into a dyeing machine and brought to equilibrium (or near to equilibrium) with a solution containing dye.

Chroma: The brilliance or brightness of a color. The lowest chroma is gray. Some other descriptions of chroma are "grayish," "dull", "bright", "vivid", and "brilliant."

Clear: To remove an undesirable stain from a fiber, especially in a blend.

Color: An observer's response to light, which depends on the light source, observer, object, surroundings, and intangibles. Color is properly described by specifying the Value, Chroma, and Hue (e.g. "medium brilliant red"). Color is not the property of an object (or a fabric).

Color Standard: Any sample or numerical data which specifies color. See also "Shade Guide" and "Metamerism."

Continuous Dyeing: Processes in which textile materials are fed continuously into a dye "range" at speeds of roughly 50 to 250 meters per minute. This usually requires 10,000 meters or more per color for economic feasibility, but with this constraint, continuous dyeing is generally more economical that batch dyeing. Continuous dyeing processes usually consist of dye application, dye fixation with chemicals or heat, and washing.

Cross Dye: Dyeing different fibers in a blend to different hues.

Discharge: To remove color from a dyed fabric, especially by the local application of a stripping or discharge agent. This is usually a printing technique which requires selection of dyes which will discharge to a pure white.

Dye: Any colorant, including dyes which have natural affinity for the textile material, but also pigments which may be held in place with binders.

Exhaust: Dye migration from a dyebath into a fiber or other textile material.

Fastness: The ability of dyed goods to withstand use conditions, i.e., washing - washfastness; exposure to light - lightfastness; rubbing - crockfastness.

Filling Bands: Widthwise color bars in woven fabric which result from inconsistent dye uptake due to variation in the filling yarns.

Fugitive Tint: A colorant which has little or no affinity or fastness on a textile material, and which can easily be removed by washing. Fugitive tints are used for yarn identification in spinning.

Hue: Color family. The color family names are "red," "orange," "yellow," "green," "turquoise" (or "aqua"), "blue," and "purple" (or "violet").

Metamerism: Either of two specific conditions which may be observed in fabric sample pairs. The first type of metamerism is that two samples appear to match under one light source, and mismatch under another when viewed by the same observer. The second manifestation of metamerism occurs when two observers (each with "normal" color vision) view the same sample at the same time under the same light source (and other conditions): One sees a match; the other sees a mismatch. This happens when different fabric styles and/or dye recipes are compared. See "Shade Guide."

Reserve: To dye one fiber in a blend and keep the other white. The white fiber in a dyed blend is said to be "reserved."

Shade Guide: A sample of the same textile material which is being dyed or printed, and which serves as a specific color standard for that style or condition of material. Shade guides are made from the same dye recipe, fabric, yarn, etc. and increase greatly the reliability of both visual and instrumental color judgments by minimizing metameric and appearance problems. See also "Metamerism."

Stain: A contamination of a fiber, usually meaning the undesirable fugitive coloring of another fiber in a blend. These stains must be cleared to insure good light - and washfastness.

Strip: To remove color from a dyed fabric. This is usually a repair procedure and generally degrades the cloth, especially if cotton.

Tint: See Fugitive Tint

Tone-on-Tone: Different fibers in a blend are dyed to different values of the same hue.

Union Dyeing: Different fibers in a blend are dyed the same color.

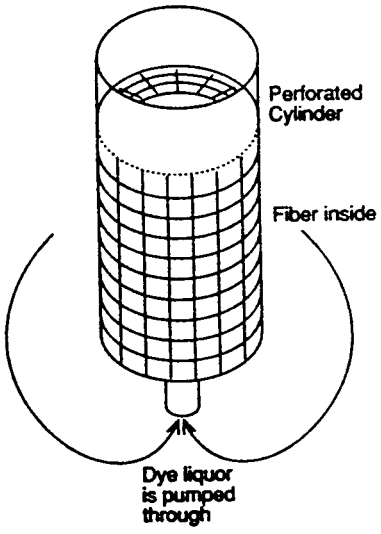
Value: The depth of a color. The lowest value is black, the highest is white. Other descriptors of value are "light," "medium," and "dark."

Dye Class	Fibers Dyed	Dye Mechanism	Application Methods*	Light	Wash	Crock	Bleach	Dyeing Method
Acid	Nylon Wool	Strong (ionic affinity)	Exhaust of Continuous	Good	Vary	Good	Fair	Exhaust from acidic bath
Basic (Cationic)	Acrylic Basic deyeable Polyester Basic dyeable Nylon	Strong (ionic) affinity	Exhaust [continuous]	Vary	Exc.	Exc.	Poor	Exhaust from acidic bath
Disperse	Acetate Polyester Acrylic Nylon (all) Other synthetics	Simple Solubility	Exhaust or Continuous	Good	Good	Good	Good	Exhaust from neutral to acidic bath
Fiber Reactive	Celluiosic Wool	Chemical reaction with the fiber	Exhaust or Continuous	Good	Exc.	Exc.	Poor	Exhaust, then react in alkaline dyebath
Mordant	Natural Fibers (Primarily cotton and wool)	Dye affinity for mordant (preapplied)	[Exhaust or Continuous]	Vary	Fair	Fair	Vary	Apply mordant, then colorant. Conditions vary
Naphthol (Azoic)	Celluiosic	Entrapment, by reaction of dye	Continuous [Exhaust]	Exc.	Exc.	Exc.	Exc.	Pad coupler, then color salt
Pigment	All Fiber	Binders	Continuous	Exc.	Fair	Fair	Exc.	Pad colorant with binder
Sulfur	Celluiosic	Entrapment	Continuous or Exhaust	Exc.	Exc.	Good	Poor	Pad, steam, then oxidize
Vat	Celluiosic	Entrapment	Continuous or Exhaust *Most common listed first. [ ] indicates possible, but rare or unusual method of application.	Exc.	Exc.	Good	Exc.	Pad, reduce then oxidize

Standard Test Methods: Dyeing and Dyed Fabric

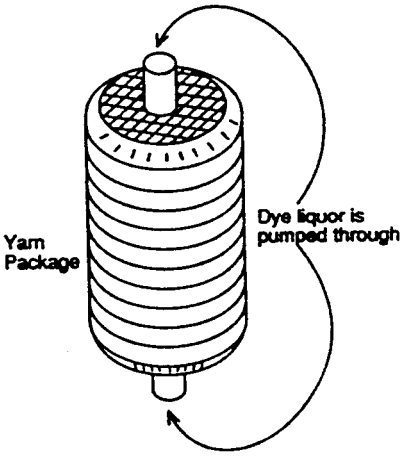
Test	Method Numbers	Test	Method Numbers
Acid and Alkali Fastness	AATCC #6	Dye Migration (Processing)	AATCC #140
Acid Dye Transfer (Migration)	AATCC #159	Gasfading	AATCC #23
Ageing of Sulfur Dyed Cloth	AATCC #26	Hot Pressing Colorfastness	AATCC #133
Basic Dye Compatibility	AATCC #141	Home and Commercial Washing	ASTM #61
Basic (Cationic) Dye Transfer	AATCC #156	Instrumental Color Measurement	ASTM #E308 and AATCC #153
Chelates in Dyeing	AATCC #161		
Chlorine Bleach Fastness	AATCC #3	Light Fastness	AATCC #16
Crocking (Rubbing) Fastness	AATCC #8 and 116	Nitrogen Oxide Fading	AATCC #164
Disperse Dye Thermosol Test	AATCC #139	Ozone Fastness	AATCC #109 and 129
Disperse Dye Transfer	AATCC #155	Peroxide Bleach Fastness	AATCC #101
Disperse Dyebath Stability	AATCC #146	Prespiration Fastness	AATCC #15
Drycleaning Fastness	AATCC #132	Sea Water Fastness	AATCC #106
Dry Heat Color Transfer	AATCC #117		

Machine	Type of Substrate	Width	Typical Configuration Capacity/Limitations/Advantages
Stock	Fiber	500kg	Fiber is dyed inside of perforated tubes. Same machine can be used for package and beam dyeing. Large quantities of dyed fiber can be blended for color consistency.



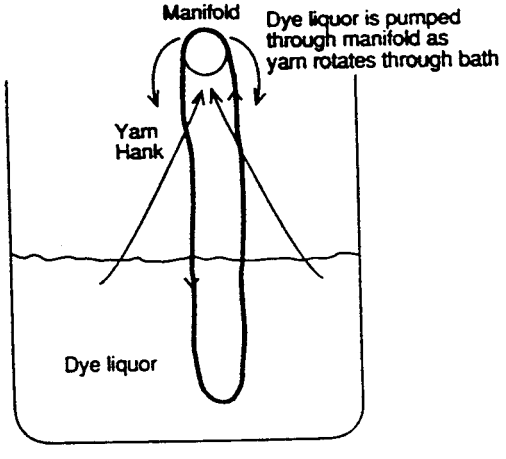
Stock Dyeing

Machine	Type of Substrate	Width	Typical Configuration Capacity/Limitations/Advantages
Package	Yarn	550 kg	Yarn is stationary, bath is pumped through. Same machine can be used for beam or stock dyeing.



Package Dyeing

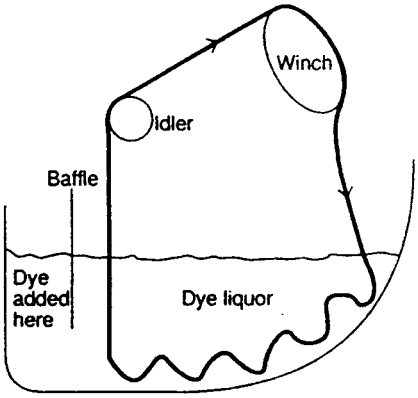
Machine	Type of Substrate	Width	Typical Configuration Capacity/Limitations/Advantages
Skein	Yarn	100kg	Yarn is dyed in hanks. Used for bulky acrylic and wool yarns.



Skein Dyeing (end view)

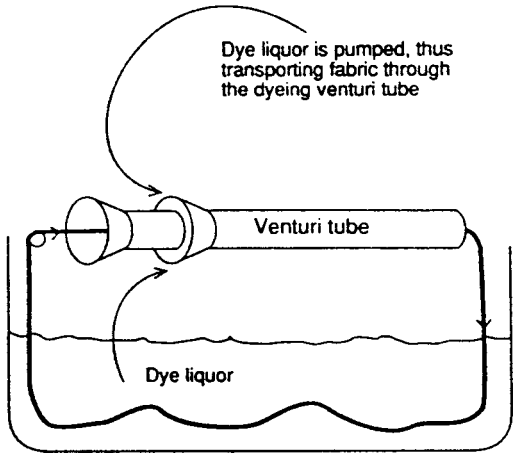
Machine	Type of Substrate	Width	Typical Configuration Capacity/Limitations/Advantages
Dope	Polymer melt prior to yarn formation.	Continuous	Pigments are added polymer before extrusion into fiber.

Machine	Type of Substrate	Width	Typical Configuration Capacity/Limitations/Advantages
Beck	Fabric	Rope	900 kg Very versitile - can be used almost universally. Good for repair work. Causes substantial mechanical working of goods. Can cause creases and cracks in delicate, lightweight goods (eg. nylon, and acetate).



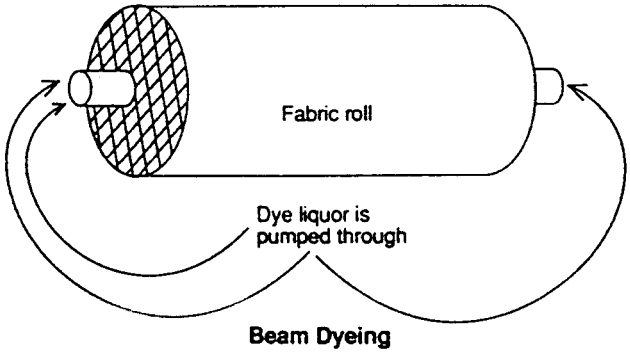
Beck Dyeing (end view)

Machine	Type of Substrate	Width	Typical Configuration Capacity/Limitations/Advantages
Jet	Fabric	Rope	500 kg Capable of high pressure and temperatures. Fabric is handled gently. Fabric and bath both are in motion.



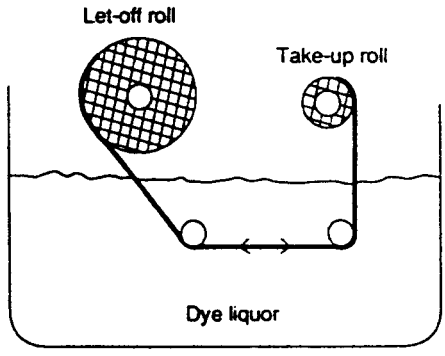
Jet Dyeing

Machine	Type of Substrate	Width	Typical Configuration Capacity/Limitations/Advantages
Beam	Fabric	up to 5 meters	1000 kg Fabric is handled flat, thus reducing creases and cracks in delicate goods. Optimum for lightweight wide, and delicate goods. Fabric is stationary, bath is pumped through. Same machine can be used for stock or package dyeing.



Beam Dyeing

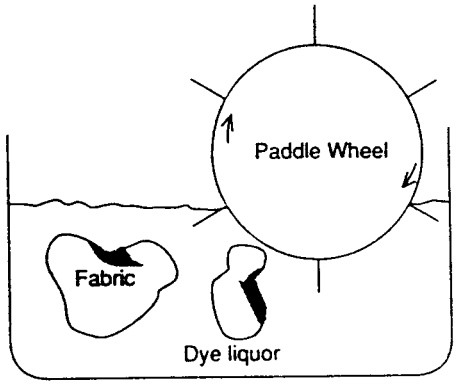
Machine	Type of Substrate	Width	Typical Configuration Capacity/Limitations/Advantages
Jig	Fabric	2 meters	250 kg Fabric is handled flat reducing creases and cracks. Does not run disperse dyes very well. Too much tension for weft knits



Jig Dyeing (end view)

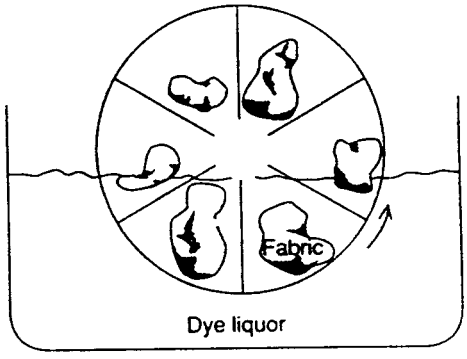
Dyeing Machinery

Machine	Type of Substrate	Width	Typical Configuration Capacity/Limitations/Advantages	
Paddle	Fabric or Products		100 kg	For products such as hoisery, rugs, etc.



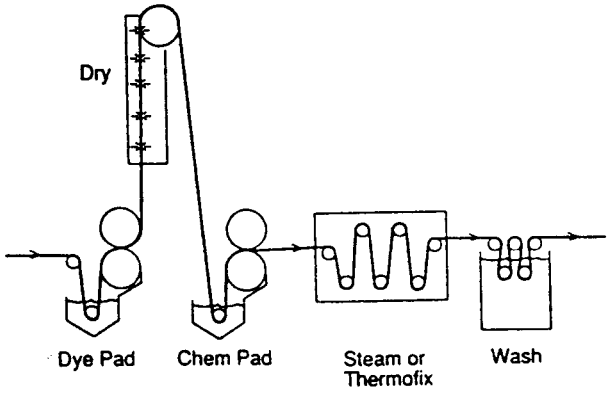
Paddle Dyeing

Machine	Type of Substrate	Width	Typical Configuration Capacity/Limitations/Advantages	
Garmment (Rotary)	Products (garments)		500 kg	Garments are dyed cutting and sewing



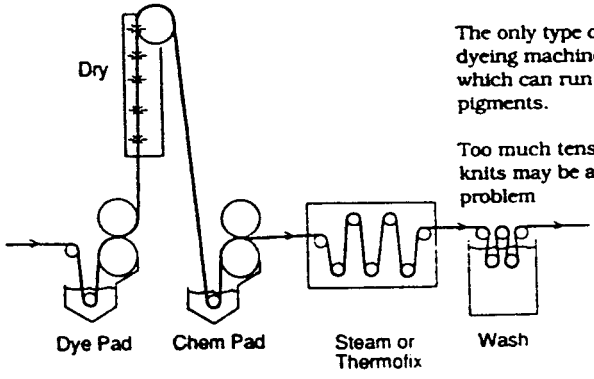
Rotary Garment Dyeing

Machine	Type of Substrate	Width	Typical Configuration Capacity/Limitations/Advantages	
Chain (Tow)	Yarn		Continuous	Used tp dye yarns continuously.



Continuous Yarn Dye

Machine	Type of Substrate	Width	Typical Configuration Capacity/Limitations/Advantages	
Continuous	Fabric	up to 3 meters	Continuous	Best economic for long runs. Poor economics for short runs. Several types of fixing methods include steam, chemical reactions, thermofix, and cold batch methods. Not effective for general purpose repair work. The only type of dyeing machine which can run pigments. Too much tension for knits may be a problem



Continuous Dyeing

Fabric and End Uses	Dye Class	Machine and/or Method
Jersey or interlock 28 cut 40 stitches per inch 100% cotton 28/1 combed cotton 4 oz per sq yard 136 grams per sq meter Men's, women's, and children's lightweight outwear, primarily shirting weight	Direct Covers dead cotton. Generally low cost.	Deck Jet Package (yarn) Garment
	Fiber Reactive Higher cost. Brighter shades. Used in yarn dyes.	Beck Jet Package Garment All Printing
	Vat Good for yarn dyes. Low cost, for green and blue especially	Package Jet Beck Garment
	Sulfur Low cost. Dark and dull shades.	Package Jet Beck Garment
	Pigment	Printing Only
Blend knit (jersey, interlock) 28 cut 40 stitches per inch 50/50 polyester/cotton 28/1 combed yarns 4 oz per sq yard 136 grams per sq meter Men's, women's and children's lightweight outerwear, primarily top weight	Direct (only) Pastel shades only. Polyester not dyed. Lowest cost.	Beck Jet Garment Package [Beam]
	Disperse/Direct Generally low cost.	Jet Beck Garment Package [Beam]
	Disperse/Reactive Higher cost. Brighter shades.	Beck Jet Garment Package [Beam]
	Disperse/Vat Low cost, especially for green and blue.	Package Jet Garment [Beam] [Beck]
	Disperse/Sulfur Low cost, especially for dull and dark colors.	Package Jet [Garment] [Beam] [Beck]
	Pigment	Printing
Terry knit and velour 100% cotton 20/1 combed yarns 8 oz per sq yard 272 grams per sq meter Men's and women's outerwear.	Direct Generally low cost. Covers dead cotton.	Beck Jet Package Garment
	Fiber Reactive Brighter shades. Used in yarn dyes. Higher cost.	Beck Jet Package Garment
	Vat Good for yarn dyes. Low cost, for green and blue especially.	Package Garment Jet [Beck]
	Sulfur Dark and dull shades. Low cost.	Package Jet Beck Garment
Bulky knit 10 cut jersey knit 15 stitches per inch 100% Acrylic yarns 16 oz per sq yard 545 grams per sp meter Men's and Women's sweaters	Basic (cationic)	Skein Stock Package Garment [Beck] [Jet]
	Disperse Pale shades only.	Package Stock Garment [Skein] [Beck] [Jet]
Shirting (blend) 76x72 woven 50/50 polyester/cotton 50/1 to 60/1 combed 68 grams per sq meter Men's, women's, and childrens bottom weight suiting, dresses, etc.	Direct (only) Pale shades only. Polyester is not dyed. Very lowest cost.	Beck Jet Jig Garment Beam [Package]
	Disperse/Direct	Beck Beam Jet Garment
	Disperse/Reactive Good fastness. Bright shades. Higher cost.	Continuous Package Beam Jet Beck Garment Jig [Printing]
	Disperse/Vat Low cost, for green and blue especially.	Continuous Package Beam Jet Beck Jig Garment
	Disperse/Sulfur Dark and dull shades. Low cost.	Continuous Package Beam Jet Beck Garment
	Pigment	Printing [Continuous]

Methods shown between brackets ([ ]) are possible, but not used much.

Fabric and End Uses	Dye Class	Machine and/or Method
Bottomweight (blend) 100x60 woven 50/50 polyester cotton 18/1 to 30/1 combed 5.0 oz per sq yard 170 grams per sq meter Men's, women's, and children's bottom weight suiting, dresses, ect.	Direct (only) Pale shades only. Polyester is not dyed. Very lowest cost.	Jet Beck Jig Garment [Package] [Beam]
	Disperse/Direct	Jet Beck Garment Package [Beam]
	Disperse/Reactive Good fastness. Brighter shades. Generally higher cost.	Continuous Package Jet Beck Garment Beck Printing
	Disperse/Vat Low cost, for green and blue especially.	Continuous Package Jig Beam [Garment] [Beck] [Jet]
	Disperse/Sulfur Dark and dull shades. Low cost.	Continuous Package Jig Beam [Garment] [Beck] [Jet]
	Pigment	Printing
Polyester woven 96x108 woven 100% filament polyester 5.0 oz per sq yard 170 grams per sq meter Men's and Women's Outerwear	Disperse	Jet Beck Package Continuous [Beam] Transfer Printing
	Pigment	Printing
Career Apparel 60x60 woven 50/50 polyester/rayon 3.0 oz per sq yard 100 grams per sq meter Men's and women's working uniforms, generally industrial or institutional uses.	Direct (only) Pale shades only. Polyester is not dyed. very lowest cost.	Jet Beck Jig [Beam] [Garment]
	Disperse/Direct	Jet Beck [Beam] [Garment]
	Disperse/Reactive Good fastness. Brighter shades. Generally higher cost.	Continuous Beck Jet [Garment] [Beam]
(Career Apparel Continued)	Disperse/Vat Low cost, for green and especially.	Continuous Beam [Garment] [Beck] [Jet]
	Disperse/Sulfur Dark and dull shades. Low cost.	Continuous Beam [Garment] [Beck] [Jet]
	Pigment	Continuous
Denim 100% cotton 6/1 to 10/1 yarns 9 oz per sq yard 310 grams per sq meter Warp only is yarn dyed Men's and women's outerwear, Jeans.	Vat Usually indigo.	Continuous Chain Slasher
	Sulfur Gray shades.	Continuous Chain Slasher
	Naphthol Red only.	Continuous Chain
Corduroy 45x100 woven 100% cotton 13/1 to 16/1 combed 8.1 oz per sq yard 275 grams per sq meter Men's, women's, and children's outerwear, primarily bottom weight for dresses, jackets, etc.	Direct Generally low cost. Covers dead cotton.	Beck Jig Garment [Jet] [Package] [Continuous]
	Fiber Reactive Brighter shades. Generally higher cost.	Continuous Beck Garment Jig [Jet] Printing
	Vat Low cost, for green and blue especially.	Continuous Garment [Beck] [Jig] [Jet]
	Sulfur Dark and dull shades. Low cost.	Continuous Garment [Beck] [Jig] [Jet]
	Pigment	Printing

Fabric and End Uses	Dye Class	Machine and/or Method
Cotton Sheeting 100% cotton 60x60 woven 20/1 to 40/1 yarn 2 to 4 oz per sq yard 78 to 136 grams per sq meter Domestic - sheets, pillowcases	Direct Generally low cost. Covers dead cotton.	Jig Beck [Continuous] [Jet] [Package]
	Fiber reactive Higher cost. Brighter shades.	Continuous Jet Beck Package Jig Printing
	Vat Low cost, for green and blue especially.	Continuous Package [Jig] [Beck] [Jet]
	Sulfur Dark and dull shades. Low cost.	Continuous [Package] [Jig] [Beck] [Jet]
	Naphthol (Azoic) Low cost.	Continuous Package [Jig] [Beck] [Jet]
	Pigment	Printing
Cotton Duck 88x32 plain weave 100% cotton 6/1 to 11/1 10 ounces per sq yard 340 grams per sq meter Industrial uses, tents, awnings, etc.	Direct	Continuous Jig Beck
	Pigment	Continuous
	Vat	Jig Continuous Beck
	Sulfur	Jig Continuous Beck
	Fiber Reactive	Continuous Jig Beck
Wool 50x50 100% wool 8.5 ounces per sq yard 290 grams per sq meter Men's, women's, and children's outerwear suiting and bottom weight.	Acid	Stock Wood tops Package Skein Beck Jet Jig - Tension less Printing Vigoreux printing (wood top)

Fabric and End Uses	Dye Class	Machine and/or Method
(wool continued)	Fiber Reactive (selected proper PH)	Stock Package Beck Jet [Jig - tensionless] Skein Printing
	Pigment	Printing
Wool blends 56x80 woven 80/20 Polyester/Wool 6.3 ounces per sq. yard 215 grams per sq. meter Men's, Women's and children's outerwear. Suiting and bottom weight	Disperse/Acid	Beck Jet Package [continuous] Note: Continuous dyeing of wool fabrics is not the best way to do it but it can be done if aesthetic properties are not paramount
	Disperse/Reactive	Beck Jet Package [Continuous]
	Acid (only) Heather shades only.	Stock Beck Jet Package
	Fiber Reactive (only) Heather shades only.	Stock Beck Jet Package
	Pigment	Printing
Nylon Hosiery 100% Nylon yarns very lightweight Women's hosiery	Acid	Garment Package
	Disperse	Garment Package
Automotive Weight varies widely 100% Nylon Auto interiors, upholstery	Disperse	Beck Jet Continuous
Automotive Polyester Weight varies widely 100% Polyester	Disperse	Beck Jet Continuous