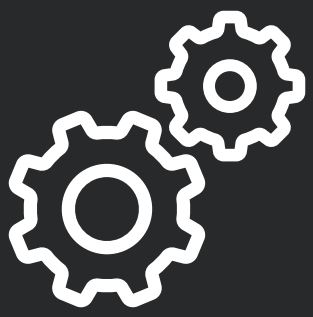

Materials Processing & Manufacturing

MATERIALS PROCESSING & MANUFACTURING

Overview

We often think of sustainable fabrics as those that are made out of more sustainable materials. But the many steps that happen between raw material cultivation and a finished fabric or garment component can have significant impact on people and the environment. This part of the process is called materials processing.

For most fashion materials, fiber is processed and spun into a yarn, which then gets woven into cloth. After a material is woven or made, additional processing involves multiple stages. Many of these processes includinge water and liquid solutions, referred to as “wet processing”. Each step could take place at different facilities, or may be part of one vertical facility.

Manufacturing usually refers to the assembly of finished materials and components to create a final product, but can also include wet processing. The same tools and resources can be used to measure environmental impact in materials processing and manufacturing facilities.

In this section you will learn about what goes into materials processing, as well as tools to help you implement more sustainable practices.It is important to note that a significant factor in materials processing and manufacturing has to do with the facility itself. To implement sustainability at the building level please see Sustainable Buildings & Offices of this guide.

NRDC CLEAN BY DESIGN

"Eco-fiber section can make a big difference in lowering the environmental footprint of a garment or collection. However, fibers must be woven/ knitted, dyed, and finished before they become fabric. All of these processes have negative environmental impact, and the size of the total production impacts is determined by the efficiency of the factories that dye and finish fabrics, as well as the fiber type. For example, although organic cotton is a natural fiber, the impacts of dyeing it are higher than the impacts of dyeing polyester."

WORKSHEET

Implementing sustainability at production facilities

1. Get to know your suppliers!

Most importantly, get to know your suppliers! This includes farms, slaughterhouses, mills, dye houses, tanneries, chemical suppliers, mines, etc. Every place touched by your product. Visit the facilities, see the process in person, and establish a personal relationship.

2. Create a code of conduct & RSL to share with suppliers

Develop environmental and social guidelines to share with suppliers and stakeholders. This should include:

Create a Code of Conduct

A code of conduct is a document outlining your company's position on labor and environmental values and policies you hope to be implemented in all facilities you work with. This document can be shared with your suppliers, partners, and all stakeholders (including on your website).

There are many templates and examples of Codes of Conduct that exist. Two great examples include the LVMH Supplier Code of Conduct and Kering Sustainability Principles.

Create a Restricted Substances List (RSL)

An RSL is a list of harmful or illegal chemical substances often found in the apparel supply chain that are either prohibited or limited.

There are multiple tools and existing RSLs that can help you to develop your own and enforce it, including those from ZDHC, GOTS, and bluesign®.

3. Assess your suppliers

Has Your Supplier Already Completed an Assessment?

First, you should ask the facility if they have already done environmental or social assessments. If they are already measuring and providing information to other companies, perhaps there is no need to ask them to do it again.

Choose the Best Approach

There are multiple ways to assess a supplier:

- You can start with something as simple as a basic, one-page questionnaire. Even just a few answers can give you great insight into a facility's values and practices.
- The supplier can use a self-assessment tool. The Higg tools are a great place to start measuring sustainability performance. (Apparel, footwear, and home textiles manufacturers have the unique option of using the Higg Index without joining the Sustainable Apparel Coalition. For a fee of $85 per year, any manufacturing facility can access and use the Higg Index Facilities environmental and social modules online.)
- You can pay a third party to do an official assessment.

*Please note that in order to measure environmental impact, the right equipment is needed. This includes meters and tools to track water, steam, and electricity consumption at the process and equipment level. If the facility doesn't have these, work with your suppliers to install them.

WORKSHEET

Implementing sustainability at production facilities cont'd

If You Can Ask Nothing Else of a Manufacturer, Ask These Questions:

According to the Sustainable Apparel Coalition, these are the critical questions to determine if your manufacturer does basic sustainability management (beyond artisan production).

Has your facility been in compliance with all legal requirements/permits within the last 12 months?

- Behind this Q: Whether or not the manufacturer has a formal process for complying with local and national environmental laws
- How to use this info: If the facility isn't complying with local laws it is unlikely to be a solid sustainability actor

Does this site track and measure, at least annually, energy use from all sources, including energy used on-site (direct) and purchased energy (indirect)? Do you set and review at least annually improvement targets for reducing energy use (including fuel use for on-site transportation if applicable)?

- Behind this Q: While energy isn't the greatest area of risk, managing it well will yield financial returns for the manufacturer. Sophisticated and well managed facilities manage their energy well and this is a good indicator of overall sustainability performance.
- How to use this info: If you are looking to see whether or not your manufacturer is sophisticated about sustainability, energy management indicates they are moving in the right direction but shouldn't be used on its own.

For Wet Processes: Is all wastewater that is produced at your site being treated with primary and secondary treatment? Do you monitor the quantity and quality of wastewater produced at your site?

- Behind this Q: If the facility has wet processes and isn't managing and monitoring its wastewater it's not a responsible actor. Also it can be an indication of sound chemical management
- How to use this info: You can't make sustainable products if your wet processes aren't treating their wastewater. Period.

4. Help Your Suppliers Create a Sustainability Roadmap, and Work With Them Over Time

Provide Your Supplier With Support

Based on the results of the assessment, look at areas where improvement can be made. Support the facility to create a Sustainability Strategy with specific timeline and measurable goals.

Good Work Should be Rewarded

The best way to reward suppliers is with increased business and long-term commitments. If possible, provide other incentives (financial or community benefits).

TOOLS & RESOURCES

Tools

Tools to measure chemical and toxicity:

Higg Facility Tools (Higg FEM) from the Sustainable Apparel Coalition

This tool includes green-chemistry considerations, and recognizes many existing green-chemistry certifications. The Higg FEM measures:

- Environmental management systems
- Energy use and greenhouse gas emissions
- Water use
- Wastewater
- Emissions to air (if applicable)
- Waste management
- Chemical use and management

CHEM-IQ

Developed by VF Corp with NRDC, Chem-IQ tests samples for the presence of 400 chemicals; if the samples are above set levels, VF Corp works with suppliers to optimize the chemistry.

GreenScreen for Safer Chemicals

Focuses on hazard profiling (only) of chemicals, and on developing alternatives to the most objectionable.

The Sustainability Consortium

The Sustainability Consortium focuses on optimizing chemistry to reduce water pollution, as well as on reducing water and energy consumption.

MaterialWise

With this free tool you can screen the substances in your product against authoritative lists that identify known human health and environmental hazards. You can also reference restricted substance lists to check for compliance with certification and preferred purchasing programs.

TOOLS & RESOURCES

Tools

Restricted substances lists:

The Zero Discharge of Hazardous Chemicals (ZDHC) Manufacturing Restricted Substances List (MRSL)

The ZDHC Program is a collaboration of brands, value chain affiliates, and associate contributors committed to advancing towards zero discharge of hazardous chemicals in the textile, leather, and footwear value chain, thereby reducing harm to the environment and human well-being.

Bluesign® Restricted Substances List

The bluesign® system eliminates harmful substances right from the beginning of the manufacturing process and sets and controls standards for an environmentally friendly and safe production. They certify products, all of which adhere to their RSL, though this is just one aspect of the certification.

Global Organic Textile Standard (GOTS)

The GOTS Standard lists all substances prohibited in Organic certification. It lists them by stage, which is helpful to understand where to watch out for toxic substances in your supply chain. It also lists what is allowed, so it can help serve as a guide for better alternatives.

American Apparel & Footwear Association (AAFA) RSL

The AAFA RSL focuses on what substances are illegal, which doesn't necessarily cover all substances which are toxic. It's intended to provide apparel and footwear companies with information related to regulations and laws that restrict or ban certain chemicals and substances in finished home textile, apparel, and footwear products around the world.

TOOLS & RESOURCES

Standards & Certifications

Standards and certifications for materials processing:

bluesign®

The bluesign® system reduces the environmental impact concerning the entire textile supply chain, helping to eliminate harmful substances from the very beginning. With its holistic approach the Input Stream Management provides an efficient solution for chemical suppliers, textile and accessories manufacturer as well as fashion brands. The bluesign® system is based on five principles:

1. Resource productivity
2. Consumer safety
3. Water emission
4. Air emission
5. Occupational health & safety

Cradle to Cradle Certified™ (C2C)

The C2C Certified Products Program aligns with the goals of all the programs above, specifically in promoting safe chemistry; however, it goes deeper into the supply chain, and integrates “design for next use” into the chemistry itself.

Global Organic Textile Standard (GOTS)

GOTS is recognized as a leading standard for textiles made from organic fibers. It covers textile processing, manufacturing, packaging, labeling, exportation, importation and distribution. The GOTS quality assurance system is based on on-site inspection and certification of the textile processing and trade chain. In particular operators from post-harvest handling up to garment making as well as traders up to the import stage have to undergo an on-site annual inspection cycle and must hold a valid certification as prerequisite in order for final products to be labelled as GOTS certified.

Oeko-Tex® Standard 100

A worldwide consistent, independent testing and certification system for raw, semi-finished, and finished textile products at all processing levels, as well as accessory materials used. The tests for harmful substances cover:

- Legally banned and controlled substances
- Chemicals known to be harmful to the health (but not yet legally controlled)
- Parameters for health protection
- Taken in their entirety, the requirements go far beyond existing national legislation.

EXAMPLE

Greenpeace Detox Fashion Campaign

Since July 2011, the Detox campaign has mobilized hundreds of thousands of people around the world to challenge major clothing brands to eliminate all releases of hazardous chemicals from their supply chains and products. Read more about it here. Greenpeace asks of clothing companies to adopt a credible, individual and public commitment to phase out the use and release of all toxic chemicals from their global supply chain and products, by 1 January, 2020.

In order to be credible, the commitment needs to be based on three fundamental principles:

1. Zero discharge of all hazardous chemicals
This means really eliminating all releases: whether via waste water pipe discharges, other production emissions (e.g. air and solid wastes) or later life "losses" from the final product -- recognizing that there are no environmentally safe levels for hazardous substances.

2. Prevention and Precaution
This means taking preventative action towards the elimination of hazardous chemicals in the face of scientific uncertainty. This should be focused on elimination at source through substitution with sustainable alternatives or even product redesign.

3. Right to know
This means that brands and their supply chains need to be fully transparent and that they need to publicly disclose information about the hazardous chemicals used and discharged when making their products.

Major Fashion brands need to "walk the talk"

Adopting clear and ambitious deadlines by when they will have eliminated all releases of the different types of hazardous substances, with priority chemical groups for elimination including alkylphenols and perfluorinated chemicals. A comprehensive `blacklist´ of hazardous chemicals for elimination and setting deadlines in the near future that are based on the precautionary principle should be established.

Brands need to require their suppliers to disclose the quantities of hazardous chemicals released, in a fully transparent and accessible way. This needs to begin with facilities in the Global South, in countries such as China.

Publicly demonstrating to others how they are making the transition to non-hazardous chemical use so that their process and steps can be followed.

What is materials processing?

In the words of Annie Gullingsrud, from the book *Fashion Fibers: Designing for Sustainability*, *"These days, garments are almost always dyed or printed, bleached, or washed in order to give them a more desirable, aged, or unique look. Processing is also the most often ignored when it comes to considering the environmental impacts of fashion design... which is understandable given that sometimes these processes and finishes account for an overall low percentage by weight of the final garment. What might be surprising is that processing methods can produce some pretty significant negative ecological impacts to the planet and the communities surrounding the factories that process our clothes."* (The book lays out a fantastic overview of materials processing stages and their impacts, along with the recommended techniques and alternatives to mitigate or circumvent these potential impacts - we highly recommend it.)

MATERIALS PROCESSING

Fiber & yarn processing

Processing at this level includes preparation of the fiber, spinning or making it into yarn, and preparing the yarn for fabrication (making it into fabric).

"A yarn is a continuous strand of textile fibers, filaments, or materials in a form suitable for knitting, weaving, or otherwise intertwining to form a textile fabric." (ASTM definition) Generally, less processing is required for synthetic fibers. An exception to this can be when they are blended with natural fibers. Natural fibers require a lot more steps, including growing, harvesting, cleaning, packaging, and shipping.

Fibers and yarns can be processed in many different ways to create different kinds of yarn, but generally they are cleaned, aligned, bended, and twisted. Multiple dry and wet processes can include opening, carding, drawing, and combing, among others.

Once spun, yarn is wound onto bobbins to be transferred to a mill. We won't go into all the different types of yarn production here. As you can imagine, it is quite complex and technical and varies greatly depending on fiber type, intended use, and style. That said, you should try to find out exactly how your yarn is made as it is not only a question of sustainability, but a question of quality (like pilling, for example).

To learn in depth about textiles, what they're made of, all the different fiber processes, the types and techniques of yarn production, and much more, we recommend Sara Kadolph's textbook Textiles. A timeless resource for any professional in the industry, the Twelfth Edition has been updated to discuss sustainability, technological advances, and new career opportunities in the textile industry.

At this phase, you should generally think about:

Water: This part of the process can use a lot of water.

Energy: This phase of the process can be very energy intensive depending on the type of machinery used.

Chemicals: Natural or synthetic lubricants and oils can be added during the spinning process to reduce friction.

Air: In addition to carbon impact and air pollution, at the first stage yarn processing produces a huge amount of airborne contaminants like dust and fiber bits. Good dust control systems should be in place in facilities.

Waste: A large amount of waste is produced during opening, carding, and combing, including short fibers, dirt, and other debris. This waste can be utilized in a number of ways, for example dirt and plant debris can be used as compost, and short fibers can be recycled into alternative yarns or products.

People: In addition to the good labor practices that should be applied at every stage of production, specific health and safety issues arise during yarn processing. For example, machine rotors can work at such high speeds that the sound of them can cause hearing loss. Workers should wear gear that protects their ears and ensures they don't inhale airborne contaminants.

MATERIALS PROCESSING

Weaving, knitting & other fabrication methods

Threads undergo a lot of tension and abrasion during weaving and knitting. In order to prevent the threads from breaking under this pressure, some or all of the yarn is given a protective coating before it is threaded into the loom or machine. This process is called sizing. Sizing can contain natural starches, synthetic resins (polyvinyl and polyacrylamide), metal-to-fiber lubricant, preservative, defoamer, and more. After weaving, it is removed in a desizing process. Sizing often uses large amounts of energy, chemicals, and water. Knitting and weaving oils can contain harmful heavy metals. Sizing agents allowed in the GOTS global organic standard include starch, starch derivatives, other natural substances and CMC (carboxymethylcellulose). Below is a list of other fabrication methods used:

Fabrics From Solutions

- **Films:** Include materials like latex, chloroprene, and vinyl. Most are made from vinyl or polyurethane solutions.
- **Foams:** Include things like molded bras or shoulder pads, or laminated to other fabrics to provide thickness and warmth. Most are made from polyurethane, but they can also be made from soy-based foam or rubber.

Fabrics From Fibers

- **Nonwoven or Fiberweb (not made from yarn):** Include things like felt, tapa cloth. Fibers (any can be used, both natural and synthetic) are laid out, bonded together, and then strengthened to become fabric (using needling, chemical compounds, adhesives, or heat).
- **Fiberfill:** Not a fabric, includes batting, wadding, and fiberfill used in snowsuits and quilted materials, for example. Often made out of polyester, but can be made out of other materials like waste fiber (wadding), new fibers (batting), or down.

Fabrics From Yarns

- **Braids:** Includes things like shoelaces, sennit, and horsehair. Often used for trims, coverings, or technical applications.
- **Lace:** Complex hand or machine made.
- **Embroidery:** In addition to being used for surface decoration, can be used to create textiles using aramid, carbon, PBO, glass, resin and more.

Composite Fabrics

- **Coated Fabrics:** A textile fabric with a polymer film (often PVC, neoprene, and polyurethane). The film can be adhered to the fabric multiple ways, for example adhesive or heat.
- **Poromeric (Microporous) Fabrics:** Thin, micropourus films that allow water vapor but not liquid to pass through. Made from polytetraflouroethylene (Gore-Tex), polyester, or polyurethane.
- **Suedelike Fabrics:** Includes things like Ultrasuede and Ultraleather. “Microdenier fibers and polyurethane solution are mixed together, cast on a drum, then napped on both sides.”
- **Flocked Fabrics:** Short, straight natural or synthetic fibers are applied to the surface of an already-finished base material, usually with synthetic adhesives like acrylic, nylon, or polyester.

Tufted-Pile Fabrics

- Yarns are stitched on top of an existing base fabric. Laminates
- Adhesive or foam are used to bind two layers of fabric together. Often called interfacing or fusible.

Stitch Bonded Fabrics

- **Knit-through fabrics:** Fibers or yarns are knitted around laid yarns, kind of like basket making.
- **Quilted fabrics:** Two layers of fabric with batting or fiberfill in between, all stitched together.

MATERIALS PROCESSING

Pretreatment

After a fabric is woven and before it receives treatments it is often referred to as "greige" or "raw". It has a fiber's natural color, smell, and other impurities; both natural and those added during its cultivation/ manufacture including pesticides, insecticides, lubricants, oil, dust, size, etc.

A number of treatments are used to both remove these impurities and prepare the fabric for dyeing or printing. These treatments can be toxic and use high amounts of both energy and water.

- **Singeing:** Fiber ends sticking up on the surface of the fabric are burned off, usually passing through gas flame bars. This reduces pilling, dullness and roughness.Desizing: Depending on the agent used, sizing can be removed using physical, biological, or chemical processes. Often, desizing uses large amounts of energy and water and contributes to wastewater pollution. (Alternative: bio desizing with ultrasonic energy).
- **Desizing:** Depending on the agent used, sizing can be removed using physical, biological, or chemical processes. Often, desizing uses large amounts of energy and water and contributes to wastewater pollution. (Alternative: bio desizing with ultrasonic energy).
- **Scouring:** A purifying treatment (that may or may not use chemicals) to remove all waxes, pectins, oil, minerals, soils, starch, etc. Usually, scouring uses high amounts of water and energy, using chemical-intensive alkaline solutions and detergents. (Bio-scouring, enzyme scouring, or ultrasonic scouring are more sustainable options.)
- **Bio-polishing:** Removing surface fuzz with an enzyme treatment. An alternative to singeing. While it often enhances the appearance of a fabric, it also makes it a little weaker.
- **Bleaching:** Removes uneven natural color. Different bleaches are used on different fiber types. Peroxide bleaches are common for natural fibers. (Peracetic bleaching is a more sustainable option (lower energy, water, and fiber damage).Mercerization: A process used on many natural fibers to increase strength softness, and the affinity for dyes/finishes. Yarns or fabrics are treated with an alkali (caustic soda/ sodium hydroxide/ lye).
- **Optical Brighteners (OBAs):** Usually used in addition to (not instead of) bleaching, OBAs soak into a fiber and mask yellow by absorbing ultraviolet light (invisible to most people) and re- emitting it as fluorescent light (visible to the human eye). These may be added in the spinning process as well.
- **Mercerization:** A process used on many natural fibers to increase strength softness, and the affinity for dyes/ finishes. Yarns or fabrics are treated with an alkali (caustic soda/ sodium hydroxide/ lye).
- **Ammoniating Finishes:** Liquid ammonia treatments that provide an alternative to mercerization for some fibers.
- **Mordanting:** Substances used to bind or set dye to fabric are referred to as a mordant. Mordants can be used before dyeing, in the dyebath itself, or after dyeing.

TOOLS & RESOURCES

Tools for dyeing & printing

Tools to help measure impact at the dying and printing phase:

The Sustainable Apparel Coalition
Higg Facility Tools

NRDC
Dyehouse Selection Guide

Sustainable dye processes:

DyeCoo
Dutch company DyeCoo's technology uses a 100 percent water-free and chemical-free textile processing solution. It provides geographical freedom from water sources and offering textile manufacturers a head start on legislation that restricts the use of hazardous process chemicals. It uses machines for dying polyester in high pressure CO2 without one drop of water.

Colourtex
Colourtex offers the is the first range of commercial dyes suitable for CO2 dyeing, called Coranger. These are used in DyeCoo's process.

Color Zen
Color Zen makes dyeing far more efficient and environmentally friendly.

AirDye
AirDye offers water-free dyeing and printing on textiles

IndiDye
By utilizing ultrasonic technology, IndiDye® reaches high levels of color fastness for natural dyes without the use of chemicals, at the same time reducing water consumption significantly. They utilize a new patented dyeing technology that combines natural beautiful colors and ancient dyes with an innovative new ultrasonic fiber dyeing process. The dyeing is implemented at fiber level before the IndiYarns™ are spun. Dye-tanks are filled with batches of fiber together with liquid natural dyestuff, and exposed to ultrasonic pressure waves that push the color pigments into the core of the fiber. They were identified by H&M and Fashion Positive as an Emerging Material Innovator.

TOOLS & RESOURCES

Tools for dyeing & printing

Sustainable dye processes

Faber Futures
Faber Futures is a creative R&D studio that conceptualizes prototypes and evaluates the next generation of materials that are emerging through the convergence of biology, technology and design. They've developed pigment producing bacteria that are grown directly on the fabric, significantly reducing water usage. They were identified by H&M and Fashion Positive as an Emerging Material Innovator.

Natural & artisanal dye resources:

Sasha Duerr / **Permacouture**

Rebecca Burgess / **Fibershed**

Jane Palmer / **Noon**

Audrey Louise Reynolds/ **ALR Dying**

India Flint

Liz Spencer / **The Dogwood Dyer**

Arun & Sonal Baid / **Aura Herbal**

MATERIALS

Finishing

Examples of finishing include:

*Just like other processing stages, finishing processes can use large amounts of toxic chemicals, energy and water.

- Drying
- Shrinking
- Stone washing
- Sandblasting
- Enzyme Washes
- Water Jet Fading
- Water repellent
- Stain Release
- Coatings & Films
- Flame/fire retardant
- Anti-Microbial (odor control)
- Permanent Press
- Other “performance” finishes
- Resins (formaldehyde helps shrinkage, chlorine based, etc.)
- Softeners

Dimpora

Dimpora’s hydrophobic porous system keeps the rain out and lets the sweat evaporate. Dimpora stands for the combination of dimension and pore. Both are key to their vision of a seamless breathable membrane formed directly on any 3D surface. They aim to take a step forward in an established industry, relying on 2D large scale processes, towards the individual point of sales assembly of your personal outdoor equipment.

Tandem Repeat

A self-healing and biodegradable fabric coating that reduces microfiber shedding and increases the fiber’s lifetime.

MARC JACOBS

"We expect our vendors to respect and adhere to the same business philosophy in the operation of their businesses. California law requires companies to disclose their efforts to address the concerns regarding slavery and human trafficking raised by the California Transparency in Supply Chain Act of 2010 (the "Act"). MJI has a Vendor Code of Conduct which is based on principles of ethical business practices and recognizing the dignity of others, and specifically prohibits the use of involuntary or forced labor, human trafficking, child labor, and harassment and abuse. MJI shares and expects its direct product suppliers (including their designated manufacturing facilities and third parties involved with the manufacturing process) and license partners to adhere to and to implement MJI's Vendor Code of Conduct (including Supplemental Guidelines) as well as MJI's Employee Code of Conduct. MJI's ongoing internal risk assessment of its supply chain is aimed at understanding the potential challenges in a global supply chain. We rely on and analyze information gathered from external resources, updates from expert organizations, and companies dedicated to social compliance issues. MJI engages external third party compliance auditing firms to perform announced, semi-announced and unannounced assessments of a selection of MJI's direct product vendors each year to evaluate compliance with MJI's Vendor Code of Conduct and Supplemental Guidelines."