PaCT Decision Support Guidance

More Sustainable Wet Processing of Lightweight Knits / Jersey and Denim

Version 2.5 – April 2016
Foreword

Before you lies the second version of the Decision Support Guidance (DSG), developed within the framework of the Bangladesh PaCT: Partnership for Cleaner Textile (PaCT). PaCT is a four-year programme which has the objective to bring about systemic, positive environmental change for the Bangladesh textile wet processing sector, its workers, and surrounding communities, and to contribute to the sector’s long-term competitiveness. PaCT is implemented by International Finance Corporation (IFC) in partnership with Solidaridad. Figure 1 gives an overview of all partners involved.

In order to achieve the above mentioned objective, PaCT partners with factories, brands and retailers. In addition, other key stakeholder groups and experts are engaged in implementation and through creating platforms for a community and national level dialogue on sustainable water use in the textile sector.

This guidance manual is part of the work with brands and retailers. It aims to provide guidance on the environmental impact of different options available for textile wet processing to achieve a certain product – enabling staff of brands to consider environmental aspects next to other parameters such as look, feel and price.

For the development of the DSG, PaCT implementing partners Solidaridad and Water Footprint Network joined hands with MADE-BY®, a not-for-profit organization with the mission to make sustainable fashion common practice. A range of different experts and stakeholders have contributed to this manual through input or review, including independent or sector experts and individuals and teams within the eight PaCT partner brands. In addition to these stakeholders, the authors would like to particularly recognize the following organisations for their contribution:

- Archroma
- Colour Connections Textile Consultancy
- DuPont
- Hunstman Corporation
- Jeanologia
- Levi Strauss & Co.
- Novozymes
- GoBlu International Ltd.

This manual focuses on options for circular knit fabric processing and denim finishing; the two key product categories in the Bangladesh textile sector when it comes to wet processing impact.

On behalf of the development team we request that you send feedback and suggestions for improvement of this manual to PaCT via info@solidaridad.nl.
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1. Introduction into the Bangladesh apparel sector and PaCT

The apparel sector is vital for the Bangladesh economy, accounting for almost 80% of the export business and providing jobs for 4 million people, of whom 85% are women. The apparel sector has a great growth potential, which could further boost the Bangladesh economy and create even more jobs. In order to tap this potential, however, a number of challenges to growth will need to be overcome. Next to aspects such as infrastructure, sustainability challenges are among these. Areas for improvement with regards to working conditions are well known. Less well known is the environmental impact of the industry in the country, in particular that of textile wet processing. This term refers to textile dyeing and finishing as well as garment washing; processes which are very water and energy intensive. Most of these run for several hours and take place in large hot water baths. A wide range of process chemicals and auxiliaries are used to create the look and feel we’d like our products to have.

It is estimated that in Bangladesh approximately 719 wet processing facilities consume around 750 billion litres of groundwater annually. While in Bangladesh there are factories which are top of class, there are also indications of water consumption levels of 300 litres per kg of fabric – a figure which is approximately 3 times higher than the global average. High water consumption also comes with relatively high energy consumption, heating more water than strictly required in the dyeing process. This contributes to a set of water-related challenges which are described in more detail in the Appendix. Bangladesh is also facing severe energy shortages. The country produces only about ¾ of its energy needs, requiring many fabric and garment manufacturers to generate their own. These energy shortages are, according to a survey from the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), a key challenge for the future growth of the Bangladeshi economy.

As mentioned, it is not possible to create one picture of the sector in Bangladesh; on the one hand there are front runners that produce in a manner on par with or even better than global averages. At the same time, the cleaner production pilot projects implemented by IFC and Solidaridad have shown a great potential for improvement in the Bangladesh textile wet processing industry. The Bangladesh PaCT: Partnership for Cleaner Textile takes these learnings to the next level. Among other activities, the programme will work with a significant proportion of the sector – dyeing and finishing units – to support in the identification and implementation of improvements. PaCT partners with brands and retailers to demonstrate how they can increase the demand for better practices in their supply chains and how decisions made with regards to product development and sourcing, can have a preferable impact on the environment. This Guidance Document aims to support brands and retailers to more effectively reduce the environmental impact of wet processing in their supply chains through considering the environmental implications of design or sourcing decisions – with a focus on the two key product categories in Bangladesh which contribute to the water challenges in the country: circular knit fabric dyeing and finishing and denim finishing.

More information about the Bangladesh PaCT: Partnership for Cleaner Textile can be found at the programme website: www.textilepact.net.

Chapter 2 describes further the goals and scope of this Decision Support Guidance (DSG).
2. Goals and Scope of DSG

Water is crucial for the economy. Virtually every economic sector, from agriculture, electric power, manufacturing, beverage and apparel to tourism, relies on fresh water to sustain its continuity. Water is becoming scarcer globally with every indication that it will become even more so in the future. Decreasing availability, declining quality, and growing demand for water are creating significant challenges to communities, economies and the environment. Bangladesh is no exception; in fact, the water challenges in the country are becoming more and more apparent. Brands and retailers can influence the impact of their supply chain by motivating them to implement cleaner production measures, but also through taking environmental aspects into account in product development and sourcing decisions.

The Decision Support Guidance (DSG) aims to provide guidance on how a brand can positively influence environmental aspects of textile wet processing through:

1. supply chain management and sourcing decisions and
2. incorporating environmental considerations in product design and development.

PaCT acknowledges that collaboration with suppliers in the identification and implementation of improvement options is key to addressing sustainability concerns, including but not limited to waste water concerns. PaCT therefore today works with more than 140 wet processing facilities, the majority of which are nominated by the 8 PaCT partner brands. If all stakeholders play a role towards ensuring that dyehouses measure and properly manage their water, energy and chemical usage and treat their effluent, the Bangladesh sector and community will benefit tremendously. Today, brands are particularly powerful players who can ensure that proper environmental management becomes a precondition to doing business sooner rather than later.

The advice within this manual is to spark dialogue on sustainability, promoting more sustainable processing techniques that have been developed over the past years. Sharing this knowledge with supply chain partners, and together support one another in achieving continuous improvement of wet processing.

The DSG is focusing on the key product categories for which textile wet processing takes place in Bangladesh in large volumes: dyeing and finishing of circular knit fabric, and denim finishing.

DSG provides information on sustainability concerns, water, energy, and chemical intensiveness, as well as occupational health and safety (OHS) and effluent considerations for a selection of common wet processing techniques. It furthermore includes specific advice on decisions or actions those in the

- design/ product development,
- sourcing/buying, and
- QA/fabric management roles

can make to influence sustainability. The advice is tailored to each role’s sphere of influence.

The advice contained within the DSG is based on first-hand experience (in PaCT), publically available information and expert opinions. The starting points and outline of the DSG has been developed in consultation with PaCT partners. The DSG itself has been reviewed by subject matter experts and after that by PaCT partners to evaluate usability. A number of assumptions and generalisations are contained within this document. Section 5 on ‘Limitations’ outlines the relevant challenges, variables and limitations.
3. Framework and how to use the DSG

As a tool to guide decision-making, the DSG has been designed to address the needs of various people on the brand/retailer side who are able to influence the ultimate sustainability of the product. This chapter outlines details on the structure of the tool and suggestions on how to use it.

3.1 Structure: Where decisions can be made

Decisions that can have an impact on the sustainability of the end product are made, both intentionally and unintentionally, throughout garment and textile production. This includes all steps from concept, to design, product development, sourcing, and quality assurance (QA), as well as all the steps in between. Decisions are likely to be made first by designers and product developers, then buying/sourcing/merchandising employees, and finally quality assurance and fabric management teams. This tool takes into account the decisions likely to be made by people in those roles, both in brand headquarters and in local sourcing offices in Bangladesh.

People working in the above mentioned roles are likely to see that there is overlap in their spheres of influence. Therefore, the advice tailored to each role has been set within a particular context to ensure that guidance is relevant to brands with varying structures and divisions of labour.

i. Design/PD: Things to consider

Guidance for designers and product developers has been set within the context of “things to consider”. Sometimes, those involved in the earlier stages of the product creation cycle inadvertently limit options, or negatively influence sustainability. By understanding that there are concrete implications associated with their decisions, they can leave as many options as possible open for the next stage of development. Much of the guidance for designers and product developers is intended to educate and coach them on how best to set the scene for those making concrete demands through product specification documents.

ii. Buying/Sourcing/Merchandising: Options and implications

Guidance for those within Buying/Sourcing/Merchandising roles has been set within the context of “Options and implications”. In this phase of the product creation cycle, individuals can make specific demands or set requirements for their suppliers by listing desirable or undesirable processes and techniques on their product specifications. One goal of the DSG is to empower those in Buying/Sourcing/Merchandising roles to specify more sustainable processing options, as they specify quality requirements or design elements. By understanding the more and less sustainable options available, and understanding any cost or quality implications of these decisions, people in this stage can concretely and positively influence the sustainability of the end product.

iii. QA/Fabric Manager: Supporting implementation

Whereas the guidance up to this stage has emphasised product specifications, the guidance for those in QA/Fabric Management roles has been placed in the context of “Supporting implementation,” and comes from a supply chain management perspective.
3.2 How to use this tool:

Given that brands have their own unique ways of approaching the broad issue of sustainability, this tool has been designed to be used in a number of ways, depending on each brand’s particular goals and priorities.

i. **Product Approach**
   Some brands will find that the product approach—making a particular product or style as sustainable as possible—is the best approach for them. This tool outlines all the ways that sustainable wet processing could be applied to, for example, a jersey product, such as t-shirts.

ii. **Process Approach**
   Some brands may prefer a process approach—focusing on optimising a particular process, such as fabric dyeing—for a range of products. This tool highlights more sustainable options for a range of processes, from bleaching, to garment fabric dyeing, to printing, and to garment finishing.

iii. **Topic Approach**
   Many brands set targets or key performance indicators (KPIs) around the reduction of water, energy, or chemical use. These brands may prefer a topic approach. This approach is made possible through the use of icons highlighting the degree to which a particular process is water, energy, or chemical intensive.

**Icon Key**

Icons and a traffic light colouring system are used to illustrate whether the particular technique described is particularly low in terms of water/energy/chemical use (green), moderate in terms of water/energy/chemical use (yellow), or particularly intensive in terms of water/energy/chemical use (red).

- **Water Use**
- **Energy Use**
- **Chemical Use** (Hazardous and/or toxic)

For example, the first set of icons below indicates that the process described is high impact in terms of water, energy, and chemicals.

By contrast, the second set of icons indicates the process described is low impact in terms of water and energy, and moderate impact in terms of chemicals.

These icons can be used to compare different processes that are in the same category. For example, comparing different dyeing techniques to one another. In order to clearly show the cases in which comparisons are valid and useful, overviews have been included for separate process categories. It is not possible to compare different categories with
each other. For example, a dyeing process that is moderate (yellow) in resource use does not require the same inputs as a garment finishing process that is moderate in resource use; some categories of processes, such as dyeing, generally require more resources than other categories of processes, such as denim garment finishing.

As explained in the upcoming section on limitations of this tool (section 5), it is not possible to provide strict quantitative values. This is due to the lack of standardisation of processes within the industry, lack of accurate data, and the varied types of machines, recipes, desired effects as well as the variation which is caused by process optimisation differences and of course the desired look. Rather, these icons allow for general comparisons and indicate where resource savings or excesses related to water, energy, and chemicals are likely to be found.

Additionally, the authors acknowledge that the full story of a process cannot be told in just water, energy, and chemicals. Therefore, an overview section has been developed that includes broader recommendations based on a more holistic perspective. See section V below.

Visual Summaries
To allow for a quick overview and to support in easily finding the most relevant sections in the Guidance, one-page summaries were developed for both jersey and denim (figure 2). These use a different set of icons to give a more holistic recommendation that goes beyond the water, energy, and chemical icons, and incorporates additional considerations such as:

- Are there serious OHS implications?
- Are there serious environmental considerations?
- Are there reasonable alternatives readily available?

The icons are defined as follows:


✓ Recommended  ! Know the risks and the alternatives  Ø Not recommended

Greenpeace Detox Campaign
Where possible, footnotes have been added to highlight chemicals that are listed on the Greenpeace Detox Campaign Priority 11 list, as this is particularly relevant for brands. These chemicals are persistent, bioaccumulative, and/or reprotoxic, and have been prioritized by the Greenpeace Detox campaign for elimination. This list includes:

- Phthalates
- Brominated and Chlorinated flame retardants
- Azo Dyes
- Organotin Compounds (e.g. TBT)
- Chlorobenzenes
- Chlorinated Solvents
- Chlorophenols
- Short-Chained Chlorinated Paraffins (SCCPs)
- Heavy Metals (cadmium, lead, mercury, chromium VI)
- APEOs/NPEs
- Perfluorinated Chemicals (PFCs)
4. Textile Technology Business Centre (TTBC)

As part of PaCT, the Textile Technology Business Centre was established (TTBC). TTBC is the technical information platform of PaCT, which acts as a repository of all relevant knowledge and experience that PaCT develops in the course of its work with a significant proportion of wet processing facilities. The TTBC supports the textile sector in adopting best practices and technologies that improve business and environmental sustainability.

TTBC collects, analyses, translates, and shares guidance on practical implementation of
- Cleaner Production (CP)
- Occupational Health and Safety (OHS)
- Water Sanitation and Hygiene (WASH)
- Effluent Treatment Plants (ETP)
- Renewable energy

The information and guidance TTBC develops is complementary to what is described in this guidance manual. The TTBC will be developing more detailed technical information on a wide range of wet processes as well as information on the availability of technologies in Bangladesh. TTBC can be contacted via ttbc@ifc.org.

5. Limitations & Intentions

One of the main characteristics of the fashion industry is that production processes are not always standardised and it is difficult to make general statements. Therefore, these guidelines should not be understood as a comprehensive list of all options, or a definitive list of sustainable and non-sustainable processes. The sheer number of variables in place, including machine type and settings, machinery upkeep and maintenance, operator knowledge, chemical and auxiliary sources, processing recipes, etc., does not allow for strict quantitative values or definitions of which processes are sustainable, and how much more so than other processes. There may be cases where suggestions are not applicable or where processes have (or have not been) optimised and to which the guidelines do not apply. However, one guiding principle behind the development of this tool was the goal to “not let perfection be the enemy of the good”. These guidelines are a synthesis of research and first-hand experience, and sustainability advice is based on expected real-life situations.

A second guiding principle behind the development of this tool was to promote effective, collaborative communication between brands and suppliers. The overall aim of this guideline is to inform key players within brands about less-sustainable production processes and possible alternatives. This is intended to help start an active discussion within brands and their supply chain networks to promote sustainability, and support each party to continuously review and optimise the production process with better, more sustainable alternatives. The DSG is strictly a support document to facilitate discussion and encourage engagement among brands, technology service providers, and the chemical industry.

Finally, while this document is ultimately intended to facilitate decision-making, it is also an educational tool and will likely be used that way initially by most users.
6. Glossary

While many terms are defined throughout the DSG in footnotes, the following definitions of common terms may prove to be helpful to users:

- **AOX Compound**: Absorbable Organic Halogen. A possible result when chlorine comes into contact with organic substances in waste water. AOX compounds are toxic to aquatic life and persistent in the environment.

- **Azo**: a nitrogen-based compound commonly found in dyeing. Some azo dyes can break down to release harmful components called aromatic amines that can be carcinogenic or allergenic.

- **Bioaccumulative**: The tendency of a substance to be absorbed by living things faster than it can be broken down, leading to a build-up of the substance.

- **BOD**: Biochemical (or Biological) Oxygen Demand. BOD is an indicator of water pollution, along with COD. This is a measure of organic pollution levels in water which is expressed by the amount of oxygen needed by microorganisms to break down the organic matter polluting the water.

- **Carcinogenic**: Something having the potential to cause cancer in living organisms.

- **Caustic Soda**: Also called Sodium Hydroxide or lye, this is a very common chemical found in the textile industry which is used for many processes, including cotton processing and dyeing. It is corrosive and classified as hazardous.

- **Cleaner Production**: A system for achieving environmental improvements in manufacturing through saving resources and reducing negative impact. Cleaner Production emphasizes actions such as resource efficiency, good housekeeping and process optimisation.

- **COD**: Chemical Oxygen Demand. COD is an indicator of water pollution, along with BOD. This is a measure of pollution levels in water which is expressed by the amount of dissolved oxygen needed to break down all pollution in a chemical way (chemically oxidized).

- **Detox Campaign**: A campaign launched in 2011 by Greenpeace intended to link global clothing brands with water pollution in manufacturing regions of the world. The campaign pushes for supply chain transparency and the stated goal is to achieve zero discharge of hazardous chemicals in manufacturing of apparel by 2020.

- **DSG**: Decision Support Guidance: This manual, which is intended to educate product teams and guide them toward more conscious and sustainable decision making.

- **Endocrine Disruptor**: Chemicals that can disrupt hormone systems in mammals, potentially leading to cancers, developmental problems, problems with reproduction, or birth defects.

- **Enzyme**: A protein that initiates and speeds up a reaction. Enzymes can be natural or engineered, and are required by living things for actions such as digestion, as well as being used in manufacturing.

- **ETAD**: Ecological and Toxicological Association of Dyes and Organic Pigments Manufacturers, this group represents manufacturers on issues related to health and the environment.
• **ETP**: Effluent Treatment Plant or waste water treatment plant. This is a structure for treating industrial waste water before releasing it into surface waterways.

• **Fit-for-purpose**: A quality assessment approach that considers the intended use of a product in determining the appropriate quality measures.

• **Liquor ratio**: Comparison of how much water to how much textile material is used in exhaust dyeing (a type of dyeing which takes place in a water bath). Liquor ratio is for example used in machinery specifications; a machine with a lower liquor ratio needs less water per kg of material processed and can therefore be considered more efficient.

• **MRSL**: Manufacturing Restricted Substances List. This is a tool used by brands to highlight to their supply chain partners which chemicals are restricted during the manufacture of their products.

• **MSDS**: Material Safety Data Sheet. A document that outlines the safety precautions and concerns relevant to each chemical in use.

• **Mutagenic**: Something having the physical or chemical ability to cause mutations in the DNA of in living things.

• **Persistent Chemical**: A chemical pollutant that does not readily break down in the environment and may bioaccumulate and lead to environmental or human health problems.

• **REACH**: Registration, Evaluation, Authorisation and Restriction of Chemicals. This is legislation in the EU that governs production and use of chemicals in multiple industries as well as residual chemicals in products, including textiles.

• **Reprotoxic**: Characteristic of some hazardous chemicals that interfere with normal fertility and preproduction.

• **RSL**: Restricted Substances List. This is a tool used by brands to highlight to their supply chain partners which chemicals are restricted on final products.

• **Silicosis**: Inflammation and scarring in the lungs from the inhalation of silica dust. Accelerated progression of the disease and hundreds of deaths have been linked to sandblasting of denim.

• **TTBC**: Textile Technology Business Center. A physical office located at the BGMEA headquarters in Dhaka intended to be a resource for the textile industry in implementing the more sustainable options highlighted by the PaCT programme.
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In Bangladesh, knitwear (jersey) accounts for almost 50% of exports of readymade garments. Jersey, also classified as weft knits or circular knits, includes T-shirts and polos, lightweight sweaters, tops, knitted dresses and underwear. Jersey is a light-weight material; the fabric weight of these garments is usually not more than 220g/m². Knit garments can be fibre dyed (melange), yarn dyed or fabric dyed. Most of the light knits produced in Bangladesh are fabric dyed which is why in this version of the DSG we are focusing on this product category. One aspect, unique to Bangladesh, is that a large proportion of the light weight knits are produced in vertical, composite units with in-house dyeing owned by the garment manufacturer. This can make it easier for a brand to engage and start the dialogue to implement changes, than it would be in more fragmented supply chains.

The steps to consider to reduce the environmental impact of jersey processing are the following:

- **Colour and design choices (brand)**
- **Pre-treatment (scouring and bleaching)**
- **Dyeing**
- **Finishing, printing**

It is estimated that the textile sector in Bangladesh consumes about 750 billion litres of groundwater annually, equalling the annual water need for 45 million people in Bangladesh. Good practice for water consumption is generally considered to be about 60 litres per kilogram for dyeing; with global averages of around 100 litres per kilogram. Ground water extraction by the industry contributes to water shortages, such as the Dhaka water table dropping two meters every year.

The major sustainability concerns associated with jerseys include water use, as well as water pollution from chemicals including dyestuffs and auxiliaries. One key issue is the use of overflow rinsing in post-dye treatments where huge quantities of running water are used. Also, excessive energy consumption adds to the environmental impact. Additionally, more than two million tons of wastewater is discharged daily. While textile effluent as per the Bangladesh regulations should be treated and part of the industry is indeed compliant, today water emissions of untreated, partially treated or insufficiently treated effluent are also still common. This makes the textile sector in Bangladesh the largest contributor to surface water pollution. Furthermore, water pollution significantly affects the lives of the 12 million people living in and around Dhaka.

The amount of water required for the dyeing of jerseys is considerable. While in Bangladesh front runners produce in line with good practice, PaCT’s experience indicates that average water consumption in Bangladesh is roughly in the range of 100 – 250 litres per kilogram of fabric, which is significantly less efficient than water consumption rates in other manufacturing countries. Most fabrics are dyed in jet dyeing machines where the liquor ratio (the amount of fabric to water in one bath) can vary from 1:4 to 1:10, depending on the machine, fabric types, colour and operator know-how, or priorities. Although we are starting to see a change, and frontrunners with state of the art resource measurement and monitoring systems do exist, typically in Bangladesh, water consumption is not accurately monitored or measured.

Increasing costs of inputs and increasing awareness of the environmental impact of wet processing have led to a range of (technological) developments that provide options for an improved environmental impact. Brands and retailers can, through the choices they make, also influence this impact. This section of the DSG supports in considering the environmental impact of choices that can be made. These range from combining process steps, reducing water, energy and process time, to switching to high fixation dyestuffs.
Decisions that will impact the ultimate environmental impact of a product begin early, in the design stage, and continue throughout product development. Selection of colours, dyestuffs and dyeing process can have a major impact on the sustainability profile of an end product.

To achieve a desired end colour, an initial scouring and bleaching process will happen at the fibre, yarn, or fabric level. Also dyeing can happen at the yarn, fabric, or garment level. Additionally, some fabrics or garments are finished and/or printed. Each step is accompanied by an additional layer of environmental impact, as each step is potentially high in water, energy, and hazardous chemical use.

Water baths are used for many techniques. These water baths must often be heated, which requires energy. Hazardous chemicals are common in dyeing and finishing; even chemicals that we do not think of as hazardous, such as salt, are used in such huge quantities to move the dissolved dyestuffs from the water into the fabric, that they do become an environmental issue. The resulting waste water, which is contaminated with chemicals, unfixed (residual) dyestuff, and salt, must be heavily treated before being released back into the environment, requiring yet more energy. This all contributes to the large environmental footprint.

Additionally, salt presents a specific problem because in traditional textile industry effluent treatment systems salt cannot be removed; this can only be achieved through advanced and expensive membrane technology. Since this technology also allows for water recycling, we see the textile industry adopting this technology in water scarce areas or in areas where water is priced.

Some colours have an inherently greater environmental impact than others. Black, along with other deep and dark shades like navy blue, require more dye, and therefore often more water, energy and auxiliary chemicals than lighter shades. Red and turquoise are additional shades that are inherently more impactful in terms of water, energy and chemicals. Neutral colours are also considered to be among the least-sustainable shades: beiges and greys are notorious for a high degree of shade variation, resulting in re-dyeing of off-spec production and waste.

It is important to consider these general issues, and to be aware that there is a tangible environmental impact associated with each decision that is made or avoided. Further, it is important to remember that design does not necessarily need to be compromised; where sustainability is prioritised and where individuals are educated and empowered, decisions can be made that improve the sustainability and maintain the style of a product, or even open new avenues for creativity.

While dyeing and colour management are a key part of the following information, the DSG also covers scouring & bleaching, printing, and finishing.

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### Overview: Jersey

<table>
<thead>
<tr>
<th>Topic</th>
<th>Page</th>
<th>Comment</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Scouring &amp; Bleaching</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B1. Scouring</td>
<td>Pg 23</td>
<td>![✓] Aim for bioscouring, though colour limitations exist</td>
<td>Rather than being different types of whitening, the processes listed tend to be combined. Different processes and combinations of processes yield different degrees of whiteness. A balance must be struck between intensity of the process and the degree of whiteness needed, which could be quite different for different products. See Whitening Overview and detailed process pages for more information and quantitative degrees of whiteness achievable with different combinations.</td>
</tr>
<tr>
<td>B2. Bioscouring</td>
<td>Pg 24</td>
<td>![✓] Most sustainable scouring option</td>
<td></td>
</tr>
<tr>
<td>B3. Chlorine Bleaching</td>
<td>Pg 25</td>
<td>![Ø] Not common anymore. Should not be done</td>
<td></td>
</tr>
<tr>
<td>B4. Hydrogen Peroxide Bleaching</td>
<td>Pg 26</td>
<td>![✓] Good option- good whiteness achievable</td>
<td></td>
</tr>
<tr>
<td>B5. Enzyme-Assisted Bleaching</td>
<td>Pg 27</td>
<td>![✓] Best option for energy, though colour limitations exist</td>
<td></td>
</tr>
<tr>
<td>B6. Optical Brightening Agents</td>
<td>Pg 28</td>
<td>![Ø] Only needed for brightest whites</td>
<td></td>
</tr>
<tr>
<td><strong>Dyeing</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1. Direct Dye</td>
<td>Pg 30</td>
<td>![Ø] Risk of harmful compounds that can form</td>
<td>Overall, dyeing is one of the most resource-intensive processes. Actual water, energy, and chemical use will be determined by factors such as desired colour, quality requirements, machine type, operator expertise, and other factors. Discuss the impact of design/product development choices with suppliers.</td>
</tr>
<tr>
<td>C2. Reactive Dye</td>
<td>Pg 31</td>
<td>![ Ø] Aim for High Fixation Reactive Dye</td>
<td></td>
</tr>
<tr>
<td>C3. High Fixation Reactive Dye</td>
<td>Pg 32</td>
<td>![✓] Best option listed for jersey – saves water and energy</td>
<td></td>
</tr>
<tr>
<td>C4. Optical Brightening on Colour</td>
<td>Pg 33</td>
<td>![Ø] Not common, generally not needed: consider pros and cons before use</td>
<td></td>
</tr>
<tr>
<td><strong>Finishing</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D1. Biopolishing</td>
<td>Pg 35</td>
<td>![Ø] When used properly, can be a very good option. Know risks and challenges</td>
<td>Softening processes are additional steps that add to the environmental impact of a garment. This should be considered before &quot;defaulting&quot; to the use of softeners. Biopolishing is a process that can either add to or detract from the sustainability profile of a product, depending on how it is applied. Proper use may lead to improved look and durability.</td>
</tr>
<tr>
<td>D2. Conventional Silicone Softening</td>
<td>Pg 36</td>
<td>![Ø] Take a considered approach. Ensure safe chemicals are used.</td>
<td></td>
</tr>
<tr>
<td><strong>Printing</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E1. PVC Plastisol Inks</td>
<td>Pg 38</td>
<td>![Ø] Risk of chemicals hazardous to health (phthalates)</td>
<td>As with dyeing, printing is a potentially intensive step that varies greatly based on the ink type used, as well as the application process. Many other options exist as well. Digital printing is a particularly interesting option, though not yet common in Bangladesh. For all printing, proper waste water treatment must be in place to water used to rinse printing screens.</td>
</tr>
<tr>
<td>E2. PA/PU Conventional Inks</td>
<td>Pg 39</td>
<td>![Ø] Solvent is hazardous, substitute with other options</td>
<td></td>
</tr>
<tr>
<td>E3. PVC-Free Plastisol Inks</td>
<td>Pg 40</td>
<td>![✓] Aim for this process or PA/PU Water-Based Inks</td>
<td></td>
</tr>
<tr>
<td>E4. PA/PU Water-Based Inks</td>
<td>Pg 41</td>
<td>![✓] Aim for this process or PVC-free Plastisol</td>
<td></td>
</tr>
<tr>
<td>E5. Silicone-Based Inks</td>
<td>Pg 42</td>
<td>![✓] Can be a good option, particularly for stretch</td>
<td></td>
</tr>
</tbody>
</table>

**Key:**  
- ![✓] Recommended  
- ![Ø] Not recommended  
- ![Ø] Know the risks and the alternatives
A. Colour Management

Colour Management refers to a practice of intentionally monitoring, optimising, and ordering the processes related to dyeing. A robust colour management strategy will address both brand-level and supplier-level responsibilities, and should cover the following points:

**Brand Level**
- Using consistent dyehouses for a single shade/colour
- Reducing the number of shades to a minimum
- Ensuring that dyehouses strive for right-first-time dyeing
- Tailoring shade-variation tolerance to the product as well as the selected colour
- Ensuring a consistent and transparent shade approval process is used to minimise re-dyes or rejected products

**Factory Level**
- Ensuring that process order is optimised, such as sequencing dyeing processes to progress from light colour runs to deeper shades to minimise the need for rinsing and colour contamination
- Monitoring and improving right-first-time dyeing rates
- Reusing process water from later rinsing stages\(^1\)
- Ensuring dyeing processes are optimised. Dyestuff manufacturers can often offer support.

**OHS Considerations:**
Dyeing processes have various OHS considerations. See following sections for more detail per process.

**Effluent Considerations:**
Effluent considerations vary by process. See following pages for more detail. In general, pollution load can be decreased by reducing dark colours. Process water can sometimes be reused, or partially treated and then reused.

\(^1\) 60-70% of total water consumption at dyeing and printing mills comes from rinsing (NRDC, “The Textiles Industry Leaps Forward with Clean by Design: Less Environmental Impact with Bigger Profits,” April 2015, p.14).
## A. Colour Management

<table>
<thead>
<tr>
<th>Designer/Product Developer: Things to Consider</th>
<th>Buying/Sourcing/Merchandising: Options and Implications</th>
<th>QA/Fabric Manager: Supporting Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Consider whether the number of shades used within a collection can be minimised</td>
<td>• Consider whether your shade variation tolerance can be adjusted to follow a fit-for-purpose approach</td>
<td>• Map supply chain and maintain an accurate view of suppliers to verify where wet processing takes place. Initiate the dialogue with suppliers that environmental impacts are important to your company (e.g. resource use and emissions)</td>
</tr>
<tr>
<td>• Take a considered approach to dark shades and minimise where possible</td>
<td>• Ensure colour approval process is consistent and transparent. Where possible, avoid visual colour approval and shift to instrumental colour measurement; aim for 'pass/fail' approvals rather than 'like/dislike'</td>
<td>• Ensure internal colour management processes are in place and properly maintained</td>
</tr>
<tr>
<td>• Generally speaking, more resource intensive colours include black, navy, red, turquoise, beige, and grey. Very deep shades (for example deep black) require more water for rinsing and will result in more residual chemicals in the effluent</td>
<td>• Encourage cooperative sourcing across divisions to ensure that colours/shades are minimised and standardised as much as possible, and dyeing can be done in bulk</td>
<td>• Ensure strategic suppliers have a colour management system in place</td>
</tr>
<tr>
<td>• Navy and some other shades of blue dyestuffs are at a higher risk of containing heavy metals²</td>
<td>• Try to use excess fabrics that have already been developed and purchased before developing new fabrics</td>
<td>• Monitor right-first-time dyeing rates and support standardising procedures</td>
</tr>
<tr>
<td>• Try to avoid the need for custom dyed components</td>
<td>• Consistently source specific shades from specific dyehouses where processes have been optimised to reduce off-spec production to a minimum</td>
<td>• Encourage the selection of product- and colour-appropriate quality requirements</td>
</tr>
<tr>
<td>• Yarn changes, which are more likely to happen when brands are late in ordering or paying, causing suppliers to purchase smaller, separate batches of yarn, lead to reduced Right-first-time dyeing rates and greater environmental impact</td>
<td></td>
<td>• Ensure colour approval process is consistent and transparent. Where possible, avoid visual colour approval and shift to instrumental colour measurement; aim for 'pass/fail' approvals rather than 'like/dislike'</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Optimise and then standardise difficult shades (black, red, turquoise, and neutrals) as well as additional key shades so that processing is consistent and efficient</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Monitor internal sourcing decisions to ensure that key/difficult shades are sourced from specific dyehouses where processes have been optimised</td>
</tr>
</tbody>
</table>

² This chemical (group) is among those that are listed on the Priority 11 group of chemicals prioritized for elimination by the Detox Campaign
Scouring or bleaching processes are very common, particularly for yarns, fabrics, or garments that will ultimately be dyed a light or a bright shade. Most fibres, including raw cotton, are not white to begin with, and fibres can be coated in synthetic lubricants, natural oils, waxes or pectins, or contaminated with other things that could interfere with subsequent processing. Scouring is done to remove these impurities, and then bleaching is done to further whiten the material in preparation for dyeing. Optical brightening may be done when the final garment will be bright white. When comparing these processes, it is important to remember that they are often combined with one another depending on the desired outcome. This is likely to all be done in the same water bath, but energy and chemical intensity will be impacted. The next page illustrates common combinations. The numbers shown represent the range of whiteness commonly achievable using the International Commission on Illumination (CIE) scale, where greater whiteness receives a higher number. A CIE score of around 60 is moderately white, whereas a score of around 80 would be very white. A score around 50 or below indicates a low degree of whiteness.

### Icon Key
When comparing scouring and bleaching processes:

- **= Lower impact**
- **= Moderate impact**
- **= Higher impact**

### Water / Energy / Chemicals

<table>
<thead>
<tr>
<th>Process</th>
<th>Water</th>
<th>Energy</th>
<th>Chemicals</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>B3. Chlorine Bleaching (CIE 75-85)</td>
<td>![ ]</td>
<td>![ ]</td>
<td>![ ]</td>
<td>25</td>
</tr>
<tr>
<td>B5. Enzyme-Assisted Bleaching (CIE 55-65)</td>
<td>![ ]</td>
<td>![ ]</td>
<td>![ ]</td>
<td>27</td>
</tr>
</tbody>
</table>

**Key:**

- **= Recommended**
- ![ ] = Know the risks and the alternatives
- ![ ] = Not recommended

³ When combined with an initial bleaching process that is able to achieve sufficient initial whiteness
# B. Scouring & Bleaching Combinations

As bleaching is often done using several processes combined, the below table illustrates common combinations.

<table>
<thead>
<tr>
<th>Combination</th>
<th>Key</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scour + Chlorine (CIE 75-85)</td>
<td>Ø</td>
<td>Chlorine should be avoided</td>
</tr>
<tr>
<td>Scour + Chlorine + OBA (CIE 120-135)</td>
<td>Ø</td>
<td>Additional chemical treatments required to neutralise chlorine before OBA treatment. Chlorine bleach should be avoided.</td>
</tr>
<tr>
<td>Scour + Hydrogen Peroxide (CIE 65-80)</td>
<td>✓</td>
<td>Commonly found combination for light and bright shades</td>
</tr>
<tr>
<td>Scour + Hydrogen Peroxide + OBA (CIE 120-140)</td>
<td>!</td>
<td>Commonly found combination for full white articles. Ensure OBAs come from reputable source. OBAs only needed for bright white.</td>
</tr>
<tr>
<td>Bioscour + Hydrogen Peroxide (CIE 70-75)</td>
<td>✓</td>
<td>Recommended combination for dull or bright shades</td>
</tr>
</tbody>
</table>

**Key:** ✓ Recommended ‼ Know the risks and the alternatives Ø Not recommended
Scouring is done as a first step for many natural materials, like cotton, to remove naturally occurring waxes, pectins, and other impurities from the raw material. It requires high temperatures, corrosive chemicals like sodium hydroxide (caustic soda), and other auxiliaries. Chemical scouring must be followed by neutralisation. Caustic soda attacks the impurities, but also weakens the cellulose, reducing the strength and weight. Weight loss is around 4-8%.

**Recommendation:** Substitute with bioscouring (next page) where possible.

### Designer/Product Developer:
**Things to Consider**
- Be aware that lighter shades require more intensive pre-treatments

### Buying/Sourcing/Merchandising:
**Options and Implications**
- Scouring weakens the strength and reduces the weight of fibres like cotton (typical is up to 8%)
- Chemical scouring may increase the need for later silicone softening. Bioscouring may eliminate the need for this step
- Enzyme scouring can result in greater dye uptake and brighter colours

### QA/Fabric Manager:
**Supporting Implementation**
- Conventional chemical scouring places greater demand on an ETP than enzyme scouring
- Enzyme-based bioscouring can save energy, chemicals, and potentially time (around 30%). Bioscouring can also result in a 30% reduction in BOD levels. Implementing a policy to bioscour when final product will be medium to dark coloured can save money as well as resources

### OHS Considerations:
**Effluent Considerations:**
Waste products from scouring contribute to a high biological oxygen demand (BOD).
**B2. Scouring & Bleaching: Bioscouring**

Bioscouring is similar to scouring, but replaces chemicals like sodium hydroxide with enzymes such as pectinase. Enzymes break down the waxes and pectins at a lower temperature, they work very quickly and they can even be applied in a water bath with other processes.

Weight loss is around 4-8% in conventional scouring; this can be cut in half in bioscouring. Additionally, the need for softeners may be reduced or eliminated.

**Recommendation:** ✓ Use where possible.

**OHS Considerations:**

**Effluent Considerations:**
Compared to conventional scouring, bioscouring achieves reduced BOD (30%), and COD.

---

**Designer/Product Developer: Things to Consider**

- Be aware that lighter shades require more intensive pre-treatments

**Buying/Sourcing/Merchandising: Options and Implications**

- Bioscouring retains strength better than conventional scouring since the cotton is able to retain its original shape. Therefore, the product may ultimately have a longer lifespan
- Bioscouring is best for medium to dark shades as it is not as effective as conventional scouring for achieving whiteness
- Chemical scouring may increase the need for later silicone softening. Bioscouring may eliminate the need for this step
- Enzyme scouring can result in greater dye uptake and brighter colours

**QA/Fabric Manager: Supporting Implementation**

- Conventional chemical scouring places greater demand on an ETP than enzyme scouring
- Enzyme bioscouring can save energy, chemicals, and time (around 30%). Bioscouring can also result in a 30% reduction in BOD levels. Implementing a policy to bioscour when final product will be medium to dark coloured can save money as well as resources
- According to enzyme manufacturers, using bioscouring and eliminating bleaching can lead to further savings of 5-10% of dye (compared to starting from fully bleached white) when dyeing medium and dark shades. This is a result of the gentler scouring process resulting in greater overall dye uptake.
B3. Scouring & Bleaching: Chlorine Bleaching

Chlorine bleach, often used in a two-step process also using hydrogen peroxide, can achieve a very high degree of whiteness (CIE 75-85). However, the chlorine bleaching process, mainly using sodium hypochlorite and sodium chlorite, can lead to compounds that are highly toxic, cancer-causing, and disruptive of human growth and development, and chlorine is moreover toxic to fish.

Chlorine bleaching today has largely been replaced by the less impactful bleaching systems, such as hydrogen peroxide bleaching (H₂O₂).

**Recommendation:** Ø Can and should be avoided.

**OHS Considerations:**
Causes severe skin burns and eye damage. May cause respiratory irritation. Hazardous gases/vapours produced are hypochlorous acid, chlorine and hydrochloric acid. Hazardous decomposition products: Chlorine gas. Chlorine can react with organic matter to release AOX compounds. Proper safety equipment must be provided in line with the MSDS.

**Effluent Considerations:**
Some AOX compounds in waste water can be very toxic to aquatic life with long lasting effects.

---

**Designer/Product Developer: Things to Consider**
- Be aware that bright whites, especially for synthetic fibres, are more at risk for chlorine bleach use

**Buying/Sourcing/Merchandising: Options and Implications**
- When bleaching is required, specify hydrogen peroxide bleach on your purchase order, or see options on overview table
- Make it clear to supply chain partners that reducing environmental impact is a priority so they can suggest appropriate alternatives

**QA/Fabric Manager: Supporting Implementation**
- Discuss bleaching practices with suppliers to confirm that chlorine bleach alternatives (peroxide or reductive bleaching) are in place. Restrict the use of chlorine bleaching
- Consult leading chemical companies for advice on non-chlorine alternatives
- Manage colours and fabric mills in a way to avoid unnecessary bleaching of fabrics that will ultimately be dyed a darker colour
- Ensure suppliers practice good chemical management to avoid hazardous combinations

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4 International Commission on Illumination Index
### B4. Scouring & Bleaching: Hydrogen Peroxide Bleaching (and Cleanup)

Bleaching is a pre-treatment of textiles designed to destroy impurities and colouring compounds in order to prepare fabrics for dyeing and further processing. Bleaching is particularly important for materials to take on brighter light shades such as pastels. It might not always be necessary, or might not require a chemically-intensive process, for some darker shades.

When done properly, hydrogen peroxide bleaching is a much more sustainable alternative to chlorine bleaching, and is widely available. While typical CIE\(^5\) index scores of 75-85 are common for chlorine bleaching, hydrogen peroxide bleaching can achieve similar results, with a range of about 70-80. Hydrogen peroxide bleach must be fully neutralised. Chemical ‘peroxide killers’ are available, though a better option is enzymatic bleach cleanup, which uses catalase enzymes.

**Recommendation:** Promote use over chlorine bleach where possible, though aim for enzyme-assisted bleaching.

<table>
<thead>
<tr>
<th>Designer/Product Developer: Things to Consider</th>
<th>Buying/Sourcing/Merchandising: Options and Implications</th>
<th>QA/Fabric Manager: Supporting Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Be aware that bright whites, especially for synthetic fibres, are more at risk for chlorine bleach use</td>
<td>• Discuss bleaching systems with suppliers; ensure that chlorine bleaching is not the standard and that hydrogen peroxide bleaching is used</td>
<td>• Manage colours, fabric mills, orders, and payments in a way to avoid unnecessary bleaching of fabrics that will ultimately be dyed a darker colour or separate processing of yarns for a single product</td>
</tr>
<tr>
<td>• Works well on cellulosics, wool, and silk</td>
<td>• Where possible, request low temperature enzymatic bleaching (eg: for products that will be dyed in medium, dark, or dull shades)</td>
<td>• Hydrogen peroxide bleaching is common practice and should be easily available from suppliers</td>
</tr>
</tbody>
</table>

**OHS Considerations:**
Strong oxidizer. Causes eye and skin irritation and possible burns. Corrosive. Proper safety equipment must be provided as guided by MSDS information.

**Effluent Considerations:** n/a

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\(^5\) International Commission on Illumination
B5. Scouring & Bleaching: Enzyme-Assisted Bleaching

A number of enzyme-assisted bleaching products are available on the market, such as Gentle Power Bleach™ from Huntsman Textile Effects with DuPont enzyme technology. Dystar and Novozymes also have enzyme-based bleaching products. TTBC can be contacted for more information. Generally, these products use enzymes to assist the bleaching process, which is based on hydrogen peroxide. This allows for a lower temperature, which saves energy. Enzymes also damage the fibre less than conventional chemical-based bleaching, leading to stronger and more durable fabrics. However, there are limitations on the whiteness that can be achieved with these types of processes. Whiteness levels of CIE6 55-65 are typical, which is considered to be moderate whiteness, where hydrogen peroxide achieves a high degree of whiteness (CIE 70-80).

Recommendation: ☑ Promote use where possible.

OHS Considerations:
Inappropriate handling of enzymes may cause formation of dust or aerosols. Inhalation of dust/aerosols may induce sensitization in susceptible individuals. Proper safety equipment must be provided in line with MSDS.

Effluent Considerations:
Enzyme preparations are biodegradable and classified as "non-dangerous" to the environment.

Designer/Product Developer: Things to Consider

- Enzyme bleaching damages the fibre less than conventional chemical-based bleach formulations, leading to a softer, smoother, and bulkier feel

Buying/Sourcing/Merchandising: Options and Implications

- Where possible, request enzymatic bleaching (eg: for products that will be dyed in medium, dark, or dull shades)
- Enzymes are in compliance with Oko-Tex, bluesign, Eu Ecolabel, REACH, etc. For GOTS certified organic products, GMM7-derived enzyme use is not permitted. Enzymes from non-GMM sources are available, though they may be more expensive and less effective.
- Consider costs holistically—while expense per kg may go up, savings can often be found to offset this by using less product, or by savings in water, energy, and/or other auxiliary chemicals

QA/Fabric Manager: Supporting Implementation

- Manage colours and fabric mills in a way to avoid unnecessary bleaching of fabrics that will ultimately be dyed a darker colour
- In many cases, enzyme bleaching can be used with existing equipment (closed discontinuous machinery and automatic dosing systems)
- Support suppliers in implementing enzyme-assisted bleaching. Vendors of new solutions are usually willing to support in trials
- Mills can save water and energy, offsetting higher cost of bleaching formulation, and potentially reducing costs overall
- Can often be combined with other processes, such as bio-polishing, in a single water bath

6 International Commission on Illumination
7 GMM: Genetically Modified Micro-organism. These micro-organisms are used to manufacture industrial enzymes at scale. The enzymes themselves are not genetically modified.
B6. Scouring & Bleaching: Optical Brightening Agents (OBA)

For full white products, optical brightening is generally done in combination with bleaching. Optical Brightening Agents (OBAs) absorb UV light and emit blue light, making the colour appear whiter. Optical brightening may also be done on dyed garments to attain a brighter appearance. While optical brightening, as an isolated process, is not particularly resource-intensive, some formulations only provide a subtle and short-lived whitening effect that fades/washes out (some are susceptible to degradation in sunlight). Others are based on hazardous chemicals. About 80% of all optical brighteners are based on stilbene derivatives, which are suspected of causing developmental and reproductive defects. However, if proper care is taken when selecting OBAs, these problems can be avoided. GOTS approved formulations are available. Use a reputable chemical supplier.

**Recommendation:** Use intentionally and with caution. Ensure reputable source.

**OHS Considerations:**
Optical brightening agents may be particularly harmful when in contact with eyes. Proper safety equipment must be provided. Some brighteners have been proven to cause allergic skin reactions or eye irritation in sensitive people. Some are linked to developmental and reproductive defects.

**Effluent Considerations:**
Prevent material from entering floor drains, sewers or any body of water. They are known to be toxic to fish and other animal and plant life and have been found to cause mutations in bacteria.

**Designer/Product Developer:**
- Consider the degree of whiteness necessary for each product – avoid defaulting to “bright” white

**Buying/Sourcing/Merchandising:**
- Make it clear to supply chain partners that reducing environmental impact is a priority so they can suggest appropriate alternatives
- Make sure optical brightening isn’t being done without a clear reason

**QA/Fabric Manager:**
- Consider restricting the use of optical brightening agents to particular circumstances
- Ensure products are sourced from reputable companies. TTBC can support
The sustainability concerns related to dyeing can be quite serious. Dyeing is one of the most resource intensive processes. The type of dye and method of application depend on many factors, including the composition of the fibre, the stage of manufacturing, performance requirements, and the desired effect.

Dyeing typically requires high temperatures and often repeated rinsing steps are needed. Not only does this require more water and energy, but it leads to highly polluted waste water. Where process water is not highly polluted, as with the later stages of rinsing, there is the opportunity to reuse the water, but this is not often done. Selecting the most appropriate dyeing process requires consideration of the fibre, the product type, the quality requirements, and other factors alongside aesthetic and sustainability performance. Therefore, the processes below should, in most cases, not be considered to be directly interchangeable. Actual water and energy usage will vary based on the application method of the dye. For example, low-liquor ratio jet dyeing, which is a good option for both direct and reactive dye, reduces the amount of water and energy need. Cold pad batch dyeing, used with reactive dyes, drastically reduces water and energy usage since the dyestuff is applied using a mangle and pressure. It is also salt free. This is starting to become available in Bangladesh in 2016, though brand encouragement could speed uptake.

<table>
<thead>
<tr>
<th>Water / Energy / Chemicals</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1. Direct Dye</td>
</tr>
<tr>
<td>C2. Reactive Dye</td>
</tr>
<tr>
<td>C3. High Fixation Reactive Dye</td>
</tr>
<tr>
<td>C4. Optical Brightening Agents (OBA) on Colour</td>
</tr>
</tbody>
</table>

**Icon Key**
When comparing dyeing processes:
- ![Lower impact](image)
- ![Moderate impact](image)
- ![Higher impact](image)

**Key:**
- ✓ Recommended
- ! Know the risks and the alternatives
- Ø Not recommended
C1. Dyeing: Direct Dye

Direct dye, while not common for jersey, is often selected for pastels or lighter colours (and common for home textiles), and is considered to be cheap and easy to use. However, there is potential for hazardous chemicals to be used as auxiliaries as well as in the dyeing process, where dyes can react to release banned compounds called azo amines that are carcinogenic. Additionally, a chemical post-treatment (potentially with formaldehyde) may be required to improve colourfastness for darker shades. Direct dye is also often used for components and trims, again with the risk of releasing banned azo amines. This can be reduced or eliminated by using stock colours when possible.

**Recommendation:** Use with caution- ensure dyes come from reputable sources.

**OHS Considerations:**
Some direct dyes can split into banned carcinogenic azo amines. Proper safety equipment must be provided.

**Effluent Considerations:**
Water contaminated with auxiliary chemicals and residual colour must be treated in effluent treatment plants. Insufficient treatment has implications for the local environment, as well as local communities.

**Designer/Product Developer:**
Things to Consider

- Wherever possible use 100% cotton rather than blends with polyester as blended fabrics or garments with blended materials are much more difficult to dye correctly, leading to re-dyes and waste
- More commonly used for wool/cotton blends

**Buying/Sourcing/Merchandising:**
Options and Implications

- Specify on your purchase order that HFRD (high fixation reactive dyes) should be used rather than conventional reactive dye or direct dye where possible
- Direct dyes are susceptible to shade changes during chemical post-treatments, potentially leading to off-shades and waste
- Direct dyes are still in use for shading, specifically for garment and accessory dyeing – hence this is where problems might occur
- Make it clear to supply chain partners that reducing environmental impact is a priority so they can suggest appropriate alternatives

**QA/Fabric Manager:**
Supporting Implementation

- Start the dialogue with your supplier on the dyeing processes and the selection criteria
- Ensure dyeing processes have been optimised, particularly for standard shades
- Direct dyes are a common source of banned azo amines. Ensure that direct dyes used are sourced from reputable companies (ex: ETAD member or compliance with ETAD standards)
- Direct dyes are susceptible to shade changes during chemical post-treatments, potentially leading to off shades and waste
- Be aware of dyeing machinery and application methods. Discuss options with suppliers.

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8 This chemical (group) is among those that are listed on the Priority 11 group of chemicals prioritized for elimination by the Detox Campaign
9 ETAD: The Ecological and Toxicological Association of Dyes and Organic Pigment Manufacturers
Reactive dye accounts for the vast majority of shades in weft knit cotton fabric dyeing.

Reactive dyeing requires extremely high salt use to move the dye from the water bath into the fibre. Still, fixation rates are often less than 75%, requiring large quantities of heated water to remove unfixed dye through repeated rinsing. This is costly in terms of time and money, and leads to heavily coloured, salty waste water that must be extensively treated. Reactive dye wash-off is one of the most pressing sustainability concerns in Bangladesh due to the use of overflow rinsing and high water consumption. A better alternative would be high fixation reactive dyes (HFRD), detailed in the next section.

**Recommendation:** Substitute with High Fixation Reactive Dyes where possible. Pay attention to application method and aim for cold pad batch dyeing or low liquor ratio jet dyeing.

---

**OHS Considerations:**
Workers are at risk for inhaling dyestuff. Low-dust dyestuffs are preferred. Proper safety equipment must be provided.

**Effluent Considerations:**
Reactive dyeing results in high levels of salt and unfixed dye.

---

**Designer/Product Developer:** Things to Consider
- Wherever possible use 100% cotton rather than blends. Blended fabrics, or garments with blended materials, are much more difficult to dye correctly, leading to double dyeing processes, re-dyes and waste
- Cold pad batch dyeing can work on cellulosics, and works on both knitted and woven fabrics

**Buying/Sourcing/Merchandising:** Options and Implications
- Specify on your purchase order that HFRD should be used rather than conventional reactive dye where possible
- Make it clear to supply chain partners that reducing environmental impact is a priority so they can suggest appropriate alternatives

**QA/Fabric Manager:** Supporting Implementation
- Start the dialogue with your supplier on the type of dyeing systems in use and the parameters determining the choice
- Be aware of machinery and where possible, use low liquor ratio jet dyeing machinery (with a reduced water to fabric ratio) to save additional water, energy and chemicals or the best practice option of cold pad batch dyeing
- Consider possibility for purchase orders to include specific dyeing processes
- Ensure dyeing processes are optimised, starting with standard/common shades
- Ensure rinsing is not done with unchecked overflow systems
- Discuss whether rinse water from later rinsing stages can be reused
C3. Dyeing: High Fixation Reactive Dye (HFRD)

Reactive dye accounts for the vast majority of shades in weft knit cotton fabric dyeing. High fixation reactive dyes, which can often be used interchangeably, can achieve fixation rates of 90% or more, (compared to 75% with conventional) which can save significant resources. These dyes have more fixation groups, meaning that there is less unfixed dye to be rinsed out, saving water and energy. Newer formulations are noted for their high degree of colour-fastness.

Another option that is an improvement on conventional reactive dyes is “Low Salt” dyes. Fixation rates are similar to conventional reactives, but salt use is much lower. These are also called ‘High Substantivity’ dyes and are often designated with ‘LS’ (for Low Salt) in the name.

Recommendation: ☑ Promote use where possible. Pay attention to application method and aim for cold pad batch dyeing or low liquor ratio jet dyeing.

**OHS Considerations:**
Workers are at risk for inhaling dyestuff. Low-dust dyestuffs are preferred. Proper safety equipment must be provided.

**Effluent Considerations:**
Effluent will require significantly less treatment when HFRD are used compared to conventional reactive dyes.

### Designer/Product Developer: Things to Consider
- Wherever possible use 100% cotton rather than blends with polyester as blended fabrics or garments with blended materials are much more difficult to dye correctly, leading to re-dyes and waste

### Buying/Sourcing/Merchandising: Options and Implications
- Specify on your purchase order that HFRD should be used rather than conventional reactive dye or direct dye
- HFRD is in general more expensive, but smaller quantities are needed because the exhaust rate is higher, making the dye more efficient. Shorter cycle times require less energy and water and allow for an increase in production with existing machine capacity
- Even light colours may be more difficult to achieve because of quicker fixation. Consider implementing with dark shades first until mills are more accustomed to the quicker fixation.
- Turquoise and green are challenging or might not be available

### QA/Fabric Manager: Supporting Implementation
- Start the dialogue with your supplier on the dyeing system used. More information can be obtained from TTBC. With HFRD, mills can reduce water and energy, ultimately saving costs
- Consider implementing a policy requiring purchase orders to include specific dyeing processes
- Ensure dyeing processes have been optimised, particularly for standard/common shades
- Be aware of machinery and where possible, use low liquor ratio jet dyeing machinery to save additional water, energy and chemicals
- Ensure rinsing is not done with unchecked overflow systems
- Basic colours are available and several new shades are being developed per year
While not commonly done, optical brightening can be done on dyed fabrics as well as on whites. This process makes colours appear brighter. While optical brightening may not appear to be an environmentally impactful process, as it essentially requires the addition of a chemical into an existing water bath, it provides a subtle and short-lived effect that fades/washes out, yet has a water, energy, and chemical impact. About 80% of all optical brighteners are based on stilbene derivatives, which are suspected of causing developmental and reproductive effects. 

**Recommendation:** Ø Consider implementing restrictions.

**OHS Considerations:** Optical brightening agents may be particularly harmful when in contact with eyes. Proper safety equipment must be provided. Some brighteners have been proven to cause allergic skin reactions or eye irritation in sensitive people. Some are linked to developmental and reproductive defects.

**Effluent Considerations:** Prevent material from entering floor drains, sewers or any body of water. They are known to be toxic to fish and other animal and plant life and have been found to cause mutations in bacteria.

**Designer/Product Developer:** Things to Consider

- Consider the degree of brightness necessary for each product – avoid defaulting to OBA use

**Buying/Sourcing/Merchandising:** Options and Implications

- Make it clear to supply chain partners that reducing environmental impact is a priority so they can suggest appropriate alternatives

**QA/Fabric Manager:** Supporting Implementation

- Consider restricting the use of optical brighteners—take a considered approach and only use when necessary
- Promote sourcing OBAs from reputable companies that can ensure formulations are free from chemicals that are linked to environmental and human health and safety concerns
D. Finishing Overview

Finishing processes can vary, and may refer to value-added processes such as anti-bacterial treatments, or processes to improve the look or feel of a product, as detailed below.

<table>
<thead>
<tr>
<th>Icon Key</th>
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<tbody>
<tr>
<td>When comparing finishing processes:</td>
</tr>
<tr>
<td>🌿 = Lower impact</td>
</tr>
<tr>
<td>🍊 = Moderate impact</td>
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<td>🍊 🌿 = Higher impact</td>
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**Water / Energy / Chemicals**

<table>
<thead>
<tr>
<th>Process</th>
<th>Key</th>
<th>Impact</th>
<th>Page</th>
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<tbody>
<tr>
<td>D1. Biopolishing</td>
<td>!</td>
<td>🌿 🍊 🌿</td>
<td>35</td>
</tr>
<tr>
<td>D2. Silicone Softening</td>
<td>!</td>
<td>🌿 🍊 🌿</td>
<td>36</td>
</tr>
</tbody>
</table>

**Key:**  
✔️ Recommended  
❗ Know the risks and the alternatives  
◊ Not recommended
D1. Finishing: Biopolishing

Biopolishing, carried out on raw fabric and on garments, uses cellulase enzymes to remove loose fibres and dead cotton, leading to a softer look and feel. It imparts a permanent change to the fabric, but it does not involve chemical coatings or the application of gases and heat. Biopolishing is a double-action process; cellulase enzymes first weaken protruding cellulose fibres, and then mechanical action in a jet dyeing or washing machine removes the weakened fibres. The benefit of biopolishing is that, when used appropriately, it can reduce or eliminate pilling, which in turn lowers friction and can ultimately contribute to a longer garment life by improving colour retention and overall look and feel over time. It can be applied to all types of yarn. In Bangladesh, there has been some inappropriate use on poorer quality yarn, which can potentially give a higher-quality look that wears down very quickly, leading to a poor quality garment with a short life. For minimal water energy and chemical impact as shown above, biopolishing should be combined with dyeing in the same water bath. For more information, contact TTBC. It is recommended to discuss the pros and cons with your supplier and explore if the use of higher quality yarn could reduce the need for biopolishing. **Recommendation:** Discuss advantages and disadvantages—ensure properly implemented for a sustainability gain.

**OHS Considerations:** In some cases, enzyme processes can lead to the creation of inhalable dust, negatively impacting the ambient air quality for workers. Filters and rinsing system should be in place.

**Effluent Considerations:** Enzymes are biodegradable natural proteins that are used in low doses. Filters and lint traps should be used for rinsing water. Biopolishing is a favourable alternative to conventional finishing chemicals. It reduces BOD and COD compared to alternatives.

---

**Designer/Product Developer:** Things to Consider

- Keep in mind that there are various finishing processes available—be as flexible as possible in how the intended effect is achieved
- When used appropriately, biopolished fabrics may have improved performance in terms of drape and softness, as well as colour brightness
- Biopolishing leads to brighter-looking whites

**Buying/Sourcing/Merchandising:** Options and Implications

- Biopolished fabrics retain greater tensile strength compared to fabrics that have had other chemical or physical treatments
- When improperly implemented, can lead to weakened fibres and a shortened lifespan
- Biopolishing leads to weight loss, though not as much as harsher softening treatments
- Biopolishing helps protect the shape of the garment so that it does not distort after repeated launderings since yarns move more freely. This may prolong the life of the garment
- Discuss whether use of higher yarn quality will prevent pilling without added processing

**QA/Fabric Manager:** Supporting Implementation

- Best practice is to combine biopolish with enzyme bleach cleanup and dyeing in one bath. This reduces production time and saves chemical, energy and water usage, which means further cost savings for textile mills.
- Discuss with your supplier how the use of biopolishing contributes to inhalable dust formation and if mitigating measures can reduce OHS impact
D2. Finishing: Silicone Softening

Finishes are added to garments to provide features such as improved water repellence, water absorbency or softness. Silicone-based finishes can be used for most of these functions but are especially used as softeners. Silicone softeners are often applied as micro-emulsions to optimize absorption into the garment. They are often applied using a mangle, which is a set of rollers that uses pressure rather than a water bath. Silicone-based softeners are widely used, and may leave garments looking newer for longer (10-15 washes). However, some silicone types (such as Octamethylcyclotetrasiloxane, or D4) are environmentally toxic and hazardous to human health. Because softener stays on the fabric, any chemical that is not RSL-compliant (such as APEO, for example, which is used in many processes, including softening) may lead to product failures. Pay particular attention to what is in these formulations.

**Recommendation:** Ensure silicone comes from a reputable source and is efficiently applied.

**OHS Considerations:**
Slightly hazardous in case of skin or eye contact (irritant) and ingestion. Prevent contact with mucous membranes and do not inhale. D4 may cause long lasting harmful effects to aquatic life and is suspected of damaging fertility or the development of an unborn child. Proper safety equipment must be provided.

**Effluent Considerations:**
Silicone is not biodegradable

**Designer/Product Developer: Things to Consider**
- Keep in mind that there are many finishing processes available—be as flexible as possible in how the intended effect is achieved
- Specifying a treatment process at this stage may limit your options; focus on communicating the desired look
- Be aware of the impact of softeners when requesting a softening finish
- Makes the fabric appear to be a deeper colour than it is (shade blooming)

**Buying/Sourcing/Merchandising: Options and Implications**
- Certain types of silicone softeners might turn white fabrics yellow
- Silicone softeners may reduce a fabric's light fastness
- Make it clear to supply chain partners that reducing environmental impact is a priority so they can suggest appropriate alternatives

**QA/Fabric Manager: Supporting Implementation**
- Ensure that D4 silicone is never used
E. Printing Overview

The selection of a printing ink must be done with consideration toward the substrate/fibre, previous dyes used, ink type, ultimate aesthetic desired, placement and ease of application, stage of application (piece v. fabric, for example), and other factors as well as resource efficiency. Ink types listed below should not be considered to be interchangeable in most cases, but rather this information can be a starting point for a conversation aimed at achieving greater sustainability.

<table>
<thead>
<tr>
<th>Water / Energy / Chemicals</th>
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<tbody>
<tr>
<td>E1. PVC Plastisol Inks</td>
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<td>E2. PA/PU Conventional Inks</td>
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<tr>
<td>E3. PVC-Free Plastisol Inks</td>
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<tr>
<td>E4. PA/PU Water-Based Inks</td>
</tr>
<tr>
<td>E5. Silicone-Based Inks</td>
</tr>
</tbody>
</table>

**Icon Key**
When comparing printing processes:
- = Lower impact
- = Moderate impact
- = Higher impact

**Key:**
- ✓ Recommended
- ! Know the risks and the alternatives
- Ø Not recommended
**E1. Printing: PVC Plastisol Inks**

PVC-Plastisol is a polyvinylchloride (PVC) based printing paste formulation. It is an ink type commonly used for piece-prints, such as t-shirts with logos, or for printing on dark fabric. PVC-Plastisol is a non-biodegradable, water-insoluble ink that typically contains phthalates\(^{10}\), which are plasticisers. A class of these called ortho-phthalates are classified as hormone disrupters and may be carcinogenic. Phthalates are restricted through most brands’ RSLs. PVC has long been a topic of debate by environmental groups because of the chlorine used in production of PVC and the hazardous chemicals that are formed during waste incineration. For these and other reasons, groups like Greenpeace call for a ban of PVC.

**Recommendation:** Ø Consider implementing restrictions and substitute with PVC-Free Plastisol.

**OHS Considerations:**
Many plastisol prints are solvent based. Workers are at risk of inhaling solvents. Ortho-phthalates are hormone disrupters and likely carcinogenic. Proper safety equipment must be provided.

**Effluent Considerations:**
Piece-printing facilities might not use waste water treatment, particularly if they use solvent-based inks. Water from screen washing must be properly treated.

**Designer/Product Developer:**
**Things to Consider**
- Large stretchy images/logos/motifs are higher risk for plastisol
- Plastisol is often selected for achieving a light print on a dark coloured-background
- Plastisol prints may be felt as raised and plastic-y feeling, though they can also achieve a smooth feel. Plastisol prints will appear as a layer on top of the fabric, not integrated seamlessly into the garment

**Buying/Sourcing/Merchandising:**
**Options and Implications**
- On purchase orders, request PVC-free or phthalate-free inks when using screen printing
- If PVC-free or phthalate-free alternatives to plastisol are not available, aim for silicone-based ink alternatives
- Make it clear to supply chain partners that reducing environmental impact is a priority so they can suggest appropriate alternatives

**QA/Fabric Manager:**
**Supporting Implementation**
- Consider restricting PVC within your supply chain – this will substantially reduce the risk of phthalates, banned in most brands’ RSLs, as well.
- Discuss with your supplier where the screens for printing are washed and if the water is treated before disposal

---

\(^{10}\) This chemical (group) is among those that are listed on the Priority 11 group of chemicals prioritized for elimination by the Detox Campaign
Polyacrylate and polyurethane based inks are commonly used and may be a better alternative to PVC-plastisol when considering phthalates. However, the solvents used in the production of these inks, such as DMF (dimethylformamide) can be hazardous to human health.

**Recommendation:** Substitute with water-based alternatives where possible.

---

**OHS Considerations:**
DMF is thought to cause birth defects. In some industries, women are banned from working with DMF to avoid potential exposure. The human body does not break down and expel DMF easily.

**Effluent Considerations:**
A common problem for piece-printing facilities is that they do not have waste water treatment capabilities. Water used for washing screens should be treated.

---

<table>
<thead>
<tr>
<th>Designer/Product Developer: Things to Consider</th>
<th>Buying/Sourcing/Merchandising: Options and Implications</th>
<th>QA/Fabric Manager: Supporting Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The raised plastic feel of pvc-plastisol inks can be avoided with PA/PU inks</td>
<td>• On purchase orders, request water-based inks when using screen printing</td>
<td>• Discuss with your supplier where the screens for printing are washed and if the water is treated before disposal</td>
</tr>
<tr>
<td></td>
<td>• If water-based alternatives to plastisol are not available, aim for silicone-based ink alternatives</td>
<td>• Discuss OHS considerations and how these are handled</td>
</tr>
<tr>
<td></td>
<td>• Make it clear to supply chain partners that reducing environmental impact is a priority so they can suggest appropriate alternatives</td>
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</tbody>
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E3. Printing: PVC-Free Plastisol Inks

As detailed in section E1, PVC-Plastisol is a polyvinylchloride (PVC) based printing paste formulation. It is an ink type commonly used for piece-prints, such as t-shirts with logos, or for printing on dark fabric. PVC-Plastisol is a non-biodegradable, water-insoluble ink that typically contains phthalates\(^1\), which are plasticisers. A class of these called ortho-phthalates are classified as hormone disrupters and may be carcinogenic. Phthalates are restricted through most brands’ RSLs. PVC-free plastisol alternatives eliminate the use of phthalates along with eliminating PVC. This also avoids the environmental problems associated with PVC production. These inks are sometimes called acrysols.

**Recommendation:** ✅ Use in place of conventional plastisol where possible.

### Designer/Product Developer: Things to Consider

- These inks are improving over time, but may not achieve the same performance as conventional plastisol in some areas, such as bleed-blocking

### Buying/Sourcing/Merchandising: Options and Implications

- On purchase orders, request PVC-free or phthalate-free inks when using screen printing
- If PVC-free or phthalate-free alternatives to plastisol are not available, aim for silicone-based ink alternatives
- Higher ink costs may be offset by reduced risk of RSL non-compliance
- Make it clear to supply chain partners that reducing environmental impact is a priority so they can suggest appropriate alternatives

### QA/Fabric Manager: Supporting Implementation

- Consider restricting PVC within your supply chain – this will substantially reduce the risk of ortho-phthalates, banned in most brands’ RSLs, as well.
- Discuss with your supplier where the screens for printing are washed and if the water is treated before disposal

---

\(^1\) This chemical (group) is among those that are listed on the Priority 11 group of chemicals prioritized for elimination by the Detox Campaign
### E4. Printing: PA/PU Water-Based Inks

PVC-based plastisol inks or conventional PA or PU inks can be replaced with polyacrylate (PA) or polyurethane (PU) water-based inks.

Compared to PVC-plastisol, water-based inks significantly reduce the use of and worker exposure to potentially hazardous chemicals. Compared to conventional PA or PU inks, the potentially hazardous solvents are reduced or replaced, improving the chemical profile. Water-based inks must be cured, requiring slightly more energy than plastisol prints, but in turn do not present the OHS hazard of solvent based inks.

**Recommendation:** Use in place of conventional PA/PU inks or Plastisol where possible.

### Designer/Product Developer: Things to Consider

- If garments are stretched, water-based inks may not be able to stretch to the same degree, breaking the print and leaving areas that look worn or torn.
- Silicone-based inks (E5) are better able to stretch, though they are not as sustainable as water-based inks (they are not biodegradable).

### Buying/Sourcing/Merchandising: Options and Implications

- On purchase orders, request water-based inks when using screen printing
- If water-based alternatives to plastisol are not available, aim for silicone-based ink alternatives
- Make it clear to supply chain partners that reducing environmental impact is a priority so they can suggest appropriate alternatives

### QA/Fabric Manager: Supporting Implementation

- Discuss with your supplier where the screens for printing are washed and if the water is treated before disposal
- Water based inks must not be allowed to dry in the screen or they clog the mesh and ruin the screen
- Some water based inks might require more time and heat to cure

### OHS Considerations:

Some contain co-solvents along with water, such as formaldehyde. Proper safety equipment must be provided.

### Effluent Considerations:

A common problem for piece-printing facilities is that they do not have waste water treatment capabilities. Water used for washing screens must be properly treated.
E5. Printing: Silicone-Based Inks

Silicone-based inks are generally considered to be a good alternative to plastisol inks and can be used much in the same way, particularly for piece-prints and prints on darker fabric. Unlike plastisol inks, silicone based inks do not contain PVCs and plasticisers. Silicone-based inks can be cured at lower temperatures and in a shorter time than PVC-plastisol inks.

**Recommendation:** ☑ A better alternative than plastisol and PA/PU inks, though better to aim for water-based since silicone is not biodegradable.

**OHS Considerations:**
Slightly hazardous in case of skin or eye contact (irritant) and ingestion. Hazardous in case of inhalation. Screen cleaning solutions may be quite hazardous. Proper safety equipment must be provided. Proper ventilation and air extraction should be in place.

**Effluent Considerations:**
Prevent entry into sewers, waterways, etc. A common problem for piece-printing facilities is that they do not have waste water treatment capabilities. Water used for washing screens should be treated.

**Design/ Product Developer:**
Things to Consider

- Works particularly well on fabrics with a high amount of elastic fibres because prints can stretch along with the fabric

**Buying/ Sourcing/ Merchandising:**
Options and Implications

- On purchase orders, request silicone-based inks when using screen printing
- Silicone-based inks are generally more expensive than water-based and plastisol inks
- If water-based alternatives to plastisol are not available, aim for silicone-based alternatives
- Make it clear to supply chain partners that reducing environmental impact is a priority so they can suggest appropriate alternatives

**QA/ Fabric Manager:**
Supporting Implementation

- Curing silicone-based inks takes slightly less time than for plastisol and water-based inks
- Silicone-based inks must not be allowed to dry in the screen or they clog the mesh and ruin the screen—cleaning solutions can be quite hazardous
- Discuss with your supplier where the screens for printing are washed and if the water is treated before disposal
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i. Introduction to Sustainability Issues: Denim

Denim Processing in Bangladesh

In recent years, Bangladesh has become a key market for denim garment production. It is now the second largest exporter to the EU, after China, and the third largest to the US, after Mexico and China.

Denim production in Bangladesh is largely focused on the latter part of the process, including sewing and washing/finishing. Although the sector is further developing, dyeing, which occurs for denims at the yarn stage, is today largely out-of-scope for Bangladesh since most fabrics are imported from countries like Pakistan or China and they have been dyed earlier in the chain. The washing and finishing of denim garments, however, can have a major impact in terms of water, energy, and chemical use, as well as occupational health and safety. These techniques will be the focus of the coming pages.

Sustainability Impact

Much of the denim produced in Bangladesh is heavily finished to achieve a worn-in look and feel, or a particular design aesthetic. Indeed, denim products are among the most heavily processed of all garments, leading to greater water consumption and water contamination, chemical consumption, energy use, and occupational health and safety risks.

- **Water**: As in Bangladesh water is often perceived as being free\(^1\), most of the washing machines have no water metering capability or good gauges. This makes it difficult to estimate the water consumption, as well as the level of contamination. As numerous processing steps are required, many of them requiring water baths or rinsing steps, it is clear that water use is high. Many processes are done by hand, making it very difficult to standardise, optimise, and regulate processing.

- **Energy**: It is not uncommon for denim garments to go through 20 or more finishing steps, and many of these will require energy, such as for heating water baths, running machinery for physical abrasion, rinsing and drying, curing resins, etc. Denim washing processes rely heavily on steam as the main energy source for heating water in the washing process. Finishing recipes are likely to be quite customised, and again optimisation is likely to have not been addressed.

- **Chemicals**: Denim processing often involves the use of harmful chemicals, such as potassium permanganate and formaldehyde. An additional concern for denim is the use of chlorine or chlorine-based chemicals for bleaching. Residual chlorine can react with organic matter to form chlorinated organic substances, which may be discharged with the treated effluent and detected as AOX (absorbable organic halogen) compounds. Some of these are toxic to fish and other aquatic organisms at low concentrations and many are persistent with a tendency to bioaccumulate. The sheer number of processing steps used also adds to the high use of chemicals.

- **OHS**: Denim processing which includes harsh chemicals, handwork, and techniques such as sandblasting can include risks for workers. This ranges from exposure to harmful chemicals, to repetitive use injuries for hand work, to serious and deadly diseases such as silicosis\(^2\).

---

1 Water is generally perceived as being free because mills and factories often dig their own wells and therefore do not receive water bills. However, it takes energy to extract, heat, and treat the water. These costs are not always obvious, but they still exist. Over time, wells must be dug ever deeper as groundwater levels drop, impacting the wider community.

2 Silicosis is a potentially fatal disease that can be caused by inhalation of silica dust particles during sandblasting without proper safety equipment.
Denim production is an area where there is potential for significant cost savings, which can go hand-in-hand with sustainability. More sustainable processing techniques that require lower temperatures and less water consumption can lead to substantial cost savings for suppliers, along with a better sustainability profile. There is also considerable potential for time savings as the number of processing steps get reduced, or as older techniques are phased out. Additionally, denim is on the cutting-edge in terms of sustainability innovations. Several of these technological innovations, such as ozone and laser processing, will be covered in this guide.
ii. Denim Garment Finishing Overview

Garment finishing is a process that occurs on garments near the end of manufacturing to add a distinct effect to the product through mechanical or wet processes. Denim products are known for undergoing a large number of finishing processes to achieve the intended look. It is important to remember that denim finishing recipes are very complex and often based on many steps; therefore, the finishing process as a whole should be considered when optimising for sustainability.

Additionally, designers should be aware that there are many ways to achieve certain looks for finished products, and should be open to new processes, new combinations of processes, or new technology. One tip used throughout the DSG is to focus on communicating the desired look at the design stage rather than specifying a process (e.g. “acid wash”), and then at a later stage to work with supply chain partners to identify the best approach for achieving this look, taking sustainability performance into consideration. While this is different than the advice often used throughout the jersey section to specify a process, this is because denim finishing includes many steps and there are many different approaches that can be used to ultimately get to the same or similar result.

In this document, wet finishing processes (or processes that are likely to occur within a washing machine or be accompanied by washing) are covered first; this includes stone washing and garment dyeing. Abrasion techniques, which are the mechanical or chemical processes of scraping or eroding the fabric to achieve a used, worn out look, will also be covered. This includes sand blasting and laser finishing. Finally, 3D effects will be addressed.

Order in this document was selected in order to maximise comparability. However, in practice, typical ordering of processes might look more like this:

- Dyeing (including topping and bottoming)
- Sizing
- Localised Abrasion
- Desizing/Scouring
- Washing (rinse, shading, stone washing, etc.)
- Overdyeing
- Softening
- Drying
# Overview: Denim

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<tr>
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<th>Page</th>
<th>☑</th>
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<th>Ø</th>
<th>Comment</th>
<th>Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shading</strong></td>
<td></td>
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<td></td>
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<td></td>
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<tr>
<td>A1. Chlorine Bleach</td>
<td>Pg 50</td>
<td>☑</td>
<td>!</td>
<td>Ø</td>
<td>Hazardous chemical, can lead to ruined garments/waste</td>
<td>In practice, Enzyme and Ozone are likely to be more impactful than rinse because they are more likely to be done as one among many layered treatments, whereas rinse/rinse is generally a stand-alone. Bleach shading requires more water and energy, and uses harsh chemicals.</td>
</tr>
<tr>
<td>A2. Enzyme Shading/Bleaching</td>
<td>Pg 51</td>
<td>☑</td>
<td>!</td>
<td></td>
<td>Can combine processes to save resources</td>
<td></td>
</tr>
<tr>
<td>A3. Rinse</td>
<td>Pg 52</td>
<td>☑</td>
<td>!</td>
<td></td>
<td>Best option with least environmental impact</td>
<td></td>
</tr>
<tr>
<td>A4. Ozone</td>
<td>Pg 53</td>
<td>☑</td>
<td>!</td>
<td></td>
<td>When safely implemented, very resource efficient</td>
<td></td>
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<tr>
<td><strong>Stonewashing</strong></td>
<td></td>
<td></td>
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<tr>
<td>B1 Conventional Stonewash</td>
<td>Pg 55</td>
<td>!</td>
<td>!</td>
<td></td>
<td>Explore variety of alternative stonewashing options</td>
<td>Pumice stones lead to dust and fragments that must be washed out. Synthetic stones have the added advantage of being reusable. “Acid” wash requires harsh chemicals which may also need to be rinsed out and neutralized, increasing water and energy use. Dry stonewashing saves the most water, and could be combined with synthetic stones for the most resource savings. Enzymes can also be used for a stonewashed look, and water and energy savings are considerable if baths are combined.</td>
</tr>
<tr>
<td>B2. Acid Wash</td>
<td>Pg 56</td>
<td>!</td>
<td>!</td>
<td></td>
<td>Hazardous chemical use, high in waste</td>
<td></td>
</tr>
<tr>
<td>B3. Dry Stonewash</td>
<td>Pg 57</td>
<td>☑</td>
<td>!</td>
<td></td>
<td>Same machinery, saves water</td>
<td></td>
</tr>
<tr>
<td>B4. Synthetic Stone Stonewash</td>
<td>Pg 58</td>
<td>☑</td>
<td>!</td>
<td></td>
<td>Reusable stones reduce impact; aim for dry process</td>
<td></td>
</tr>
<tr>
<td>B5. Enzyme Wash</td>
<td>Pg 59</td>
<td>☑</td>
<td>!</td>
<td></td>
<td>Can combine processes to save resources</td>
<td></td>
</tr>
<tr>
<td><strong>Softening</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1. Desizing</td>
<td>Pg 61</td>
<td>!</td>
<td>!</td>
<td></td>
<td>Commonly done, aim for enzyme or size capture and re-use</td>
<td>Desizing creates highly polluted waste water which is very difficult to treat. Recapture and reuse of the sizing agent may be a possibility for improvement. Softeners applied to fabrics or garments can be applied in more or less efficient ways, though attention needs to be paid to the composition of the softener, as some types of silicone can be hazardous.</td>
</tr>
<tr>
<td>C2. Enzyme Desizing</td>
<td>Pg 62</td>
<td>!</td>
<td>!</td>
<td></td>
<td>Combine processes to save resources, improved waste water quality</td>
<td></td>
</tr>
<tr>
<td>C3. Silicone Softener</td>
<td>Pg 63</td>
<td>!</td>
<td>!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C4. Alternative Softener Application</td>
<td>Pg 64</td>
<td>!</td>
<td>!</td>
<td></td>
<td>Saves resources, reduced amount of chemicals needed</td>
<td></td>
</tr>
<tr>
<td><strong>Abrasion</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D1. Hand Scraping</td>
<td>Pg 66</td>
<td>!</td>
<td>!</td>
<td></td>
<td>Ensure OHS is a priority</td>
<td>These steps are generally done as one layer in many layers of finishing, and so they must be considered along with other processing steps. While Laser, Ice Blast, Hand Scraping, and Enzyme all score reasonably well in terms of water, energy and chemicals, it is important that worker safety must be considered in all. Sandblasting must be considered a high risk process because the way it is conducted often leaves workers vulnerable to serious health problems and even death.</td>
</tr>
<tr>
<td>D2. Sandblasting</td>
<td>Pg 67</td>
<td>!</td>
<td>!</td>
<td></td>
<td>When improperly done, can lead to worker death or injury</td>
<td></td>
</tr>
<tr>
<td>D3. Ice Blasting</td>
<td>Pg 68</td>
<td>!</td>
<td>!</td>
<td></td>
<td>Can replace the look of sandblasting</td>
<td></td>
</tr>
<tr>
<td>D4. Potassium Permanganate</td>
<td>Pg 69</td>
<td>!</td>
<td>!</td>
<td></td>
<td>Hazardous chemical, often combined with sand blasting</td>
<td></td>
</tr>
<tr>
<td>D5. Enzyme Abrasion</td>
<td>Pg 70</td>
<td>!</td>
<td>!</td>
<td></td>
<td>Light abrasion can be achieved in efficient combo process</td>
<td>Very efficient and creative tool. Requires time &amp; investment</td>
</tr>
<tr>
<td>D6. Laser</td>
<td>Pg 71</td>
<td>!</td>
<td>!</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>3D</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E1. Conventional Resins</td>
<td>Pg 73</td>
<td>!</td>
<td>!</td>
<td></td>
<td>If 3D looks are required, aim for formaldehyde-free</td>
<td>3D effects require extra chemical application, often with formaldehyde, as well as high-energy curing. Aim to avoid this process. Both types will weaken fabric strength.</td>
</tr>
<tr>
<td>E2. Formaldehyde-Free Resins</td>
<td>Pg 74</td>
<td>!</td>
<td>!</td>
<td></td>
<td>Reduces hazardous chemical and energy use</td>
<td></td>
</tr>
<tr>
<td><strong>Tinting / Overdyeing</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>F1. Sulphur Dye Tinting</td>
<td>Pg 76</td>
<td>!</td>
<td>!</td>
<td></td>
<td>Relatively low impact – will be done along with indigo dyeing</td>
<td>Pre-reduced sulphur dye is slight improvement on conventional sulphur dye, though both are likely to be used on continuous machinery for yarn dying, saving resources. This is not likely to be done in Bangladesh and is included for information. Reactive and direct overdyeing, though not common, require considerable water and energy. Reactive dye will require lots of salt; direct dyes are at risk for banned azo amines. Though not common, aim to use HFRD.</td>
</tr>
<tr>
<td>F2. Sulphur Dye Overdyeing</td>
<td>Pg 77</td>
<td>!</td>
<td>!</td>
<td></td>
<td>Aim for pre-reduced for some resource savings</td>
<td></td>
</tr>
<tr>
<td>F3. Pre-reduced Sulphur Overdyeing</td>
<td>Pg 78</td>
<td>!</td>
<td>!</td>
<td></td>
<td>Most efficient of common options</td>
<td></td>
</tr>
<tr>
<td>F4. Direct Overdye</td>
<td>Pg 79</td>
<td>!</td>
<td>!</td>
<td></td>
<td>Risk of exposure to hazardous azo compounds</td>
<td></td>
</tr>
<tr>
<td>F5. Reactive Overdye</td>
<td>Pg 80</td>
<td>!</td>
<td>!</td>
<td></td>
<td>Consider high fixation reactive where reactive must be used</td>
<td></td>
</tr>
</tbody>
</table>

Key:
- ☑ Recommended
- ! Know the risks and the alternatives
- Ø Not recommended
A. Shading Overview

In practice, Enzyme and Ozone are likely to be more impactful than rinse because they are more likely to be done as one among many layered treatments, whereas rinse is generally a stand-alone. Bleach shading requires more water and energy, and uses harsh chemicals.

<table>
<thead>
<tr>
<th>Shading Process</th>
<th>Water Impact</th>
<th>Energy Impact</th>
<th>Chemicals Impact</th>
<th>Key</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1. Chlorine Bleach Shading</td>
<td></td>
<td></td>
<td></td>
<td>! Not recommended</td>
</tr>
<tr>
<td>A2. Enzyme Shading/Bleaching</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>! Recommended</td>
</tr>
<tr>
<td>A3. Rinse</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>! Know the risks and the alternatives</td>
</tr>
<tr>
<td>A4. Ozone Shading</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>! Recommended</td>
</tr>
</tbody>
</table>

**Icon Key**

When comparing shading processes:

- ![Lower impact](image)
- ![Moderate impact](image)
- ![Higher impact](image)

**Key:**

- ✓ Recommended
- ![Lower impact](image) Not recommended
A1. Shading: Chlorine Bleach Shading

While denim is available in many shades and colours, the majority comes in traditional shades of blue. Most denim begins as yarn that has been dyed a single shade of dark indigo blue before being woven with undyed yarn into fabric that is then made into jeans. The variation in shades comes from extensive processing intended to lighten this base colour. Bleach is conventionally used to alter the colour of dyed denim. While hydrogen peroxide may be used, common bleaching agents include chlorine-based bleaching formulas which can be hazardous for humans and the environment. Alternatives include enzyme, ozone and laser shading (see the next sections for more information on potential alternatives).

**Recommendation:** Substitute wherever possible.

**OHS Considerations:**
Can cause severe skin burns, eye damage, and respiratory irritation. Hazardous gases are produced; ensure proper extraction and remediation. May cause pain on contact. Proper safety equipment must be provided.

**Effluent Considerations:**
AOX compounds can develop in waste water when chlorine contacts organic material. These compounds are very toxic to aquatic life with long lasting effects.

<table>
<thead>
<tr>
<th>Designer/Product Developer: Things to Consider</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Lighter colours generally require more processing unless lighter shades have been arranged for during yarn-stage dyeing</td>
</tr>
<tr>
<td>- Where the final desired colour is lighter overall, work with fabric manager to arrange for denim fabrics that have been dyed to a lighter base shade</td>
</tr>
<tr>
<td>- Keep in mind that the fewer finishing steps applied to the garment, the better the sustainability profile</td>
</tr>
<tr>
<td>- Specifying a treatment process at this stage may limit your options; focus on communicating the desired look so buying/sourcing/merchandising can work with suppliers on identifying sustainable ways to achieve the look</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Buying/Sourcing/Merchandising: Options and Implications</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Explore with your suppliers which alternatives to bleach shading they offer and what the implications are (e.g. look, feel, quality, price)</td>
</tr>
<tr>
<td>- On your product specification, request enzyme shading or ozone finishing to lighten base colours rather than bleach shading</td>
</tr>
<tr>
<td>- Where bleach is the only option, request if possible that hydrogen peroxide bleach is used rather than chlorine, and request for enzymatic combination systems</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>QA/Fabric Manager: Supporting Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Communicate with designers and arrange for denim fabrics that are dyed to a lighter base shade when heavy shading or bleached looks are desired. Rich “baby blue” shades can be achieved this way, though contrast may be less than with conventional processing. Strength, however, will likely be improved</td>
</tr>
<tr>
<td>- Consider restricting the use of chlorine bleach</td>
</tr>
<tr>
<td>- Chlorine bleach damages machinery, shortening its lifespan</td>
</tr>
<tr>
<td>- Chlorine bleach damages standard stretch fibres</td>
</tr>
</tbody>
</table>
A2. Shading: Enzyme Bleaching/Shading

Enzymes (such as laccase, which attacks indigo) can replace bleaching chemicals, eliminating them from the process entirely. Enzymatic shading is also gentler on machinery than chemicals, meaning machines can last longer. Enzyme use reduces energy consumption compared to conventional bleaching since enzymes do not need to be in as hot of a water bath to perform (50-60 degrees Celsius is common) and they do not need a separate water bath. They are often added to water baths that are already required for other steps. Fabrics treated with enzymatic shading generally acquire a softer, bulkier and brighter look.

**Recommendation:** ✔️ Use where possible.

**OHS Considerations:**
Poor handling of enzymes in powder form may cause formation of dust or aerosols. Repeated inhalation may cause allergic reactions. Eye, skin, mouth, and throat irritant. Resulting cotton dust is also a problem. Proper safety equipment must be provided.

**Effluent Considerations:**
Enzymes are biodegradable and classified as "non-dangerous" to the environment.

---

**Designer/Product Developer:**
**Things to Consider**

- Where the final desired colour is lighter overall, work with fabric manager to arrange for denim fabrics that have been dyed to a lighter base shade; this will save resources in dyeing as well as finishing
- Keep in mind that the fewer finishing steps applied to the garment, the better the sustainability profile
- Specifying a treatment process at this stage may limit your options; focus on communicating the desired look so buying/sourcing/merchandising can work with suppliers on identifying sustainable ways to achieve the look

**Buying/Sourcing/Merchandising:**
**Options and Implications**

- Enzymes are in compliance with Öko-Tex, bluesign, EU Ecolabel, REACH, etc. For GOTS certified organic products, GMM\(^1\)-derived enzyme use is not permitted. Enzymes from non-GMM sources are available, though they may be more expensive and less effective
- This technique works well for denim dyed with indigo or sulphur dyes, as well as for cotton or cotton blends, such as those with elastane
- Enzymes are roughly as expensive as conventional bleaching and shading in terms of cost. Savings will come from reduced energy and chemical use
- Enzyme processing is very common
- Arrange for denim fabrics that are dyed to a lighter base shade when heavy shading is required. Rich "baby blue" shades can be achieved this way. Where greater contrast is needed, enzyme bleaching is a good option.
- Some heavily faded looks might be hard to achieve with enzyme shading – look for newer formulations such as Denilite Cold from Novozymes, which can achieve better bleach and fashion effects

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\(^1\) GMM: Genetically Modified Micro-organism. These micro-organisms are used to manufacture industrial enzymes at scale. The enzymes themselves are not genetically modified.
A3. Shading: Rinse

Dark denim, finished with a simple rinse wash, retains a deep blue colour. The purpose of the rinse is to remove unfixed indigo, to soften the material, and to remove the sizing agent. If this sizing agent, often a starch, is left in the denim, it would be considered ‘raw’ denim and could have a stiffer feel, but a “cleaner” footprint. Softening agents (such as silicones—see section C) are also sometimes added to a rinse finish. These softeners can sometimes intensify the dark shade of the denim as well as soften the hand feel. They may also increase the risk of yellowing over time, depending on the auxiliaries added (surfactants, emulsifiers, etc.) which may make the indigo more susceptible to decomposition. Resins or fixing agents may be applied to improve rubbing fastness on rinse-finished denim, though these added finishes will have an impact on the overall sustainability of the garment.

Recommendation: Use where possible.

OHS Considerations: Softening agents may cause skin, eye and respiratory irritation. Proper safety equipment must be provided.

Effluent Considerations: Sizing residues are the main contributor to BOD and particularly COD levels. Water-soluble size\(^4\) can be reclaimed and recycled.

**Designer/Product Developer: Things to Consider**

- Keep in mind that the fewer finishing steps applied to the garment, the better the sustainability profile.
- When opting for simple dark rinsed denim, consider if raw denim would be an option.
- Additional finishing steps may have implications for altering or sacrificing colour (can intensify, or can lead to yellowing over time as the garment fades).
- Specifying a treatment process at this stage may limit your options; focus on communicating the desired look so buying/sourcing/merchandising can work with suppliers on identifying sustainable ways to achieve the look.

**Buying/Sourcing/Merchandising: Options and Implications**

- On product specifications, request that chemical softening agents are not used during rinsing to minimize the chemical impact.
- If a softening step cannot be avoided, discuss with your supplier whether another process can be used instead of chemical softening (See sections on alternative stonewashing, and alternative softener application techniques).
- Rubbing fastness may be an issue for rinse finished denim. However, fastness can be improved using dry ozone treatments. See section A4 for more detail.

**QA/Fabric Manager: Supporting Implementation**

- Consider restricting the use of chemical softeners.
- Ensure that softener + auxiliary combination which may encourage yellowing are not used; these will likely shorten the garment’s lifetime as consumers will replace garments that have irreversibly yellowed.
- Ensure that rinse process is mechanically optimized.
- Encourage suppliers to reclaim and recycle sizing agents.

\(^4\) This includes water soluble starch, PVA (Polyvinylalcohol), polyacrylic, CMC (carboxymethylcellulose) and others (or their blends).
A4. Shading: Ozone Shading

Ozone exposure can be used to achieve a faded worn effect on fabrics and is often used on denim products. This process works by exposing the garments to a blend of oxygen and ozone gas called ‘Plasma’ in a specialised high pressure chamber. Ozone finishing can save up to two thirds of the water and energy used to achieve similar looks, while avoiding 80% of the chemicals used in conventional denim finishing. Some ozone processing does require water, and other systems are dry. Ozone processing at different stages can produce different effects. Ozone gas is extremely toxic, and proper safety systems must be in place.

**Recommendation:** Use where possible.

**OHS Considerations:**
Ozone gas is extremely toxic and can pose immediate danger to life and health. Proper safety equipment must be provided including safety measures to prevent worker contact with ozone gas, ventilation, and extraction.

**Effluent Considerations:**
The ozone plasma can be broken down completely into free oxygen.

**Designer/Product Developer:**
- It can be difficult to replicate bleached styles; it is important to start the design and production development process based on ozone samples
- Ozone machines can produce a range of effects, from subtle to intense shading
- Handfeel is likely to be softer

**Buying/Sourcing/Merchandising:**
- Up to 55% time-saving potential
- Reproducibility may be difficult
- Applicable to cotton only

**QA/Fabric Manager:**
- An ozone finishing machine requires an investment of approx. €90,000–€150,000
- Be aware that dry garments will react differently to ozone than wet or damp garments
- A good resource to ensure safe ozone practices is the Levi Strauss & Co Ozone Safety Requirements document
Stonewashing involves tumbling garments with abrasive stones in order to get a worn look and soft feel. Conventional stonewashing, and even “dry” stonewashing can require a surprising amount of water due to the need for multiple rinsing steps in order to remove dust and stone particles. Synthetic stones result in less dust and stone fragments, reducing the need for rinsing, and they have the added advantage of being reusable. "Acid" wash requires harsh chemicals which may also need to be rinsed out and neutralized, increasing the footprint of the process. Dry stonewashing combined with synthetic stones has the potential to save the most water. Enzyme washing can also be used to achieve a stonewashed look, and when enzymes are added to existing wash steps, water savings are considerable.

### B. Stonewashing Overview

<table>
<thead>
<tr>
<th>Process</th>
<th>Impact</th>
<th>Key</th>
<th>Water / Energy / Chemicals</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1. Conventional Stonewash</td>
<td>!</td>
<td><img src="image" alt="Lower impact" /></td>
<td><img src="image" alt="Moderate impact" /></td>
<td><img src="image" alt="Higher impact" /></td>
</tr>
<tr>
<td>B2. Acid Wash</td>
<td>Ø</td>
<td><img src="image" alt="Not recommended" /></td>
<td><img src="image" alt="Not recommended" /></td>
<td><img src="image" alt="Not recommended" /></td>
</tr>
<tr>
<td>B3. Dry Stonewash</td>
<td>✓</td>
<td><img src="image" alt="Recommended" /></td>
<td><img src="image" alt="Recommended" /></td>
<td><img src="image" alt="Recommended" /></td>
</tr>
<tr>
<td>B4. Synthetic Stonewash</td>
<td>✓</td>
<td><img src="image" alt="Recommended" /></td>
<td><img src="image" alt="Recommended" /></td>
<td><img src="image" alt="Recommended" /></td>
</tr>
<tr>
<td>B5. Enzyme Wash</td>
<td>✓</td>
<td><img src="image" alt="Recommended" /></td>
<td><img src="image" alt="Recommended" /></td>
<td><img src="image" alt="Recommended" /></td>
</tr>
</tbody>
</table>

**Key:** ✓ Recommended   ! Know the risks and the alternatives   Ø Not recommended

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**Icon Key**
When comparing stonewashing processes:

- ![Lower impact](image) = Lower impact
- ![Moderate impact](image) = Moderate impact
- ![Higher impact](image) = Higher impact
Stone washing is one of the oldest, yet most in-demand, effects used in the denim industry. Essentially, stones (generally pumice stones) are added into a washing machine along with water and denim garments (which are generally treated with resins first, see section E). The stones tumble with the garments, scraping the fabric and removing dye. This is a non-specific treatment and it is possible to over-treat and therefore ruin a significant portion of the fabric or garments, which can happen has stone size and quality can vary. Stone washing also uses large amounts of water since multiple rinses need to be done afterward, and it damages equipment and reduces the lifespan of machinery. It can also emit large amounts of pumice dust in the air. Additionally, pumice stones must be mined and transported, adding to the environmental impact of this process. Many alternatives are available however.

**Recommendation:** Substitute where possible. There are many options for achieving a similar look.

**OHS Considerations:**
Pumice stone dust can be released into the work environment, which can cause respiratory irritation if inhaled. Proper safety equipment must be provided.

**Effluent Considerations:**
Suspended solids (from ground pumice stone) will pass into effluent and is often regulated and limited.

**Designer/Product Developer: Things to Consider**
- Keep in mind that there are many alternatives to conventional stonewashing available (dry stonewashing, synthetic stones, alternative ‘stone’ materials, enzyme processing; see coming sections)—be as flexible as possible in how the intended effect is achieved
- Specifying a treatment process at this stage may limit your options; focus on communicating the desired look so buying/sourcing/merchandising can work with suppliers on identifying sustainable ways to achieve the look

**Buying/Sourcing/Merchandising: Options and Implications**
- See if your suppliers can use reusable stones or stone-alternatives. Silicate, plastic, rubber, Perlite and concrete stones can be used, with varying effects
- Stonewashing reduces weight & strength
- Find out whether water can be reduced or removed from stone washing (see B3)
- Some effects can be achieved using alternative processes, such as laser finishing (D6), ozone finishing (A4), or enzyme washing (B5). Discuss possibilities with suppliers
- Cellulase enzymes may contribute to backstaining issues

**QA/Fabric Manager: Supporting Implementation**
- Discuss the alternatives to conventional stone washing with suppliers; some alternatives are very simple such as reducing or removing water from the stonewashing process (see B3 for additional details). Check and test alternatives with suppliers. Changes in the process will often lead to changes in the final look
- Reusable stones can save costs (mining, transport, regular purchase of new abrasive stones)

---
5 A type of volcanic glass
6 Where loosened indigo from the blue warp fibre attaches to the white weft fibre, decreasing contrast. Short ozone treatments can be used to combat backstaining.
B2. Stonewashing: Acid Wash

Acid washing is a process that results in a high-contrast and randomly coloured and bleached look. It is a combination of a chemical process and a mechanical process. Pumice stones are soaked in chlorine bleach (such as hypochlorites) or potassium permanganate before being tumbled with garments, leading to a random, splotchy look. The environmental footprint is similar to stone washing, including high water usage due to multiple rinsing steps needed, with an additional chemical impact. Chlorine and potassium permanganate (PP) both present safety concerns. PP exposure can lead to pulmonary oedema, as well as negative impacts on fertility.

Recommendation: Consider restricting.

OHS Considerations:
Pumice stone dust can be released into the work environment, which can cause respiratory irritation if inhaled. Chlorine bleach causes severe skin burns and eye damage. May cause respiratory irritation. Hazardous gases/vapours are produced. May cause immediate pain on contact. See section D4 for details on potassium permanganate. Proper safety equipment must be provided.

Effluent Considerations:
Suspended solids (from ground pumice stone) will pass into effluent; this is often regulated and limited. Chlorine bleach can lead to the formation of AOX compounds in waste water. These are very toxic to aquatic life with long lasting effects.

Designer/Product Developer: Things to Consider
- Keep in mind that there are many denim finishing processes available—be as flexible as possible in how the intended effect is achieved
- Specifying a treatment process at this stage may limit your options; focus on communicating the desired look so buying/sourcing/merchandising can work with suppliers on identifying sustainable ways to achieve the look

Buying/Sourcing/Merchandising: Options and Implications
- Some effects can be achieved using alternative processes, such as laser finishing, ozone finishing, or enzyme (cellulase) abrasion. Discuss possibilities with suppliers
- Cellulase enzymes may lead to backstaining issues (where loosened indigo from the blue warp fibres attaches to the white weft fibres, decreasing contrast). Short ozone treatments can be used to combat backstaining

QA/Fabric Manager: Supporting Implementation
- Consider restricting the use of chlorine bleach
- Consider heavily restricting or banning the use of potassium permanganate
- Discuss with suppliers whether sustainable alternatives have been implemented, and present alternative stone washing, laser, ozone, and enzyme finishing as options

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1 Absorbable organic halogen
B3. Stonewashing: Dry Stone Wash

Dry stonewashing was developed by Levi Strauss & Company. Levi’s encourages others to adopt this practice as well. This process does not use water in the actual stonewashing cycle, though multiple rinsing steps afterwards will still likely be needed. This method does not require any additional machinery, and is achieved simply by removing water from the equation. Garments are tumbled with stones (or stone alternatives) as they would be in normal stonewashing, just without the water. The abrasion level is likely to be higher than processes including water—this should be tested and optimised before bulk production. If dry stonewashing was combined with synthetic or alternative stones that did not leave dust and stone fragments that needed to be removed with washing cycles, water usage could go down to a green level.

Recommendation:
- Use where possible. Aim to combine with synthetic stones for additional savings.

OHS Considerations:
Pumice stone dust can be released into the work environment, which can cause respiratory irritation if inhaled. Proper safety equipment must be provided.

Effluent Considerations:
Suspended solids (from ground pumice stone) will pass into effluent; this is often regulated and limited.

Designer/Product Developer: Things to Consider
- Keep in mind that there are many denim finishing processes available—be as flexible as possible in how the intended effect is achieved
- Specifying a treatment process at this stage may limit your options; focus on communicating the desired look so buying/sourcing/merchandising can work with suppliers on identifying sustainable ways to achieve the look

Buying/Sourcing/Merchandising: Options and Implications
- On product specifications, request dry stonewashing rather than conventional; washing times and/or stone type or grade may need to be adjusted
- Varying the type of material used for the ‘stone’ (pumice, concrete, rubber, tennis balls, etc) can vary the intensity of the effect from highly abraded to lightly softened. See B4 for more details
- This method does not require additional machinery. Dry stonewashing may damage machinery more in comparison to wet stonewashing. Discuss this with your supplier.
- This method saves drying time and energy
- Discuss alternative stone types with your suppliers, and what effects they can achieve with different materials; highlight that many alternative stones are reusable. Reusable stones can save costs (mining, transport, regular purchase of new abrasive stones)

QA/Fabric Manager: Supporting Implementation
To overcome the shortcoming of pumice stones, synthetic stones have been developed. These are made of abrasive material such as silicate, plastic, rubber or concrete. Alternatives to pumice stones are much more durable than their natural counterparts, and can be reused up to 300 times depending on the type of stone used. They also achieve greater levels of reproducibility and inflict less damage on equipment. Synthetic stone washing may not achieve the same results as conventional and there may be limitations on what can be achieved. If dry stonewashing was combined with synthetic or alternative stones that did not leave dust and stone fragments that needed to be removed with washing cycles, water usage could go down to a green level.

**Recommendation:** Use where possible. Aim to combine with dry stonewashing for additional savings.

**OHS Considerations:**
Varies based on material used

**Effluent Considerations:**
Varies based on material used

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**Designer/Product Developer:**
**Things to Consider**
- Keep in mind that there are many denim finishing processes available—be as flexible as possible in how the intended effect is achieved
- Specifying a treatment process at this stage may limit your options; focus on communicating the desired look so buying/sourcing/merchandising can work with suppliers on identifying sustainable ways to achieve the look

**Buying/Sourcing/Merchandising:**
**Options and Implications**
- Greater reproducibility than conventional stone washing
- More experimentation may be required initially in order to achieve the desired look

**QA/Fabric Manager:**
**Supporting Implementation**
- Inflicts less damage on equipment than conventional stone washing
- No special equipment required
- Discuss alternative stone types with your suppliers, and what effects they can achieve with different materials; highlight that many alternative stones are reusable. Reusable stones can save costs (mining, transport, regular purchase of new abrasive stones)
**B5. Stonewashing: Enzyme Wash**

As with shading and abrasion, specialised enzymes can be used in a wash to simulate the look of light to moderate stonewashing. Laccase enzymes target indigo where cellulose enzymes target the cotton itself. Enzyme washing receives a green score in water usage because it is likely to be done in an existing water bath already required for another step. However, if that is not the case, water usage goes up to yellow. Enzymatic processing is gentler on machinery than chemicals, meaning machines can last longer. While some enzymes can work at lower temperatures, these may be difficult to find, particularly in Bangladesh, so this type of enzyme washing earns a moderate score for energy usage. Fabrics treated with enzymatic shading generally acquire a softer, bulkier and brighter look.

**Recommendation:** Use where possible.

**OHS Considerations:**
Poor handling of enzymes in powder form may cause formation of dust or aerosols. Repeated inhalation may cause allergic reactions. Resulting cotton dust can also pose a problem. Proper safety equipment must be provided.

**Effluent Considerations:**
Enzymes are biodegradable and classified as "non-dangerous" to the environment.

<table>
<thead>
<tr>
<th>Designer/Product Developer: Things to Consider</th>
<th>Buying/Sourcing/Merchandising: Options and Implications</th>
<th>QA/Fabric Manager: Supporting Implementation</th>
</tr>
</thead>
</table>
| • Very heavily stonewashed looks might be hard to achieve with enzyme shading  
• Specifying a treatment process at this stage may limit your options; focus on communicating the desired look so buying/sourcing/merchandising can work with suppliers on identifying sustainable ways to achieve the look | • Enzymes are in compliance with Öko-Tex, bluesign, EU Ecolabel, REACH, etc. For GOTS certified organic products, GMM*-derived enzyme use is not permitted. Enzymes from non-GMM sources are available, though they may be more expensive and less effective.  
• This technique works well for denim dyed with indigo or sulphur dyes, as well as for cotton or cotton blends, such as those with elastane | • Enzymes can be used in combination with other washing steps. A good example is enzyme desizing combined with enzyme wash for abrasion ("Denimax Core"). Savings will come from reduced energy consumption, as high heat is not required, and reduced chemical consumption, as well as higher efficiency  
• Enzyme processing is very common among denim mills  
• Unlike enzymes, chlorine is corrosive and damages machines, shortening their lifespan |

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*GMM: Genetically Modified Micro-organism. These micro-organisms are used to manufacture industrial enzymes at scale. The enzymes themselves are not genetically modified.*
C. Softening Overview

Softening can be done in several ways, and is done to alter the feel and the sometimes the drape of a garment. Raw denim that is truly raw and has not undergone any desizing or softening treatments has a distinctive stiff feel. Desizing, which is done for most wovens and for the vast majority of denim, removes the strengthening agent applied to yarns before weaving. This also removes the stiffness associated with most raw denim. Desizing, though not generally an avoidable process, is of concern because of the significant impact the process has on waste water. Oftentimes the strengthenener used is starch-based, which leads to water that is highly polluted and does not have much oxygen to support microbes that could break down the contaminants. Denim desizing is well known to cause this kind of problem, measured using COD (chemical oxygen demand) and BOD (biological oxygen demand). Recapture and reuse of the sizing agent is a possibility for improvement.

Softeners applied to fabrics or garments at a later processing stage can be applied in more or less efficient ways, though attention needs to be paid to the composition of the softener, as some types of silicone can be hazardous.

<table>
<thead>
<tr>
<th>Water / Energy / Chemicals</th>
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</thead>
</table>

**Key:**
- ✓ Recommended
- ![ ] Know the risks and the alternatives
- Ø Not recommended

**Icon Key**

When comparing softening processes:
- ![ ] = Lower impact
- ![ ] = Moderate impact
- ![ ] = Higher impact
# C1. Softening: Desizing

Size is a starch or synthetic compound added to yarn before weaving. It strengthens the yarn while also decreasing friction, which leads to less breakage during high tension and high speed weaving. Desizing is the process of removing size. The size must be removed before other processes such as dyeing or finishing take place or else the size will interfere with those processes. Removal depends on size composition, which could be starch or PVA (polyvinyl alcohol) or other compounds. It generally requires large quantities of very hot water and added chemicals, though desizing can sometimes be combined with other denim processing treatments to reduce water and energy use. After desizing, the starch or PVA goes into the wastewater, where it is very difficult to remove. Starch leads to high BOD and COD levels and large quantities of resulting sludge. PVA cannot be broken down, but it can be recycled.

**Recommendation:** This is generally a necessary process unless raw denim is being produced, but aim for size recapture and recycling or enzyme desizing and ensure proper wastewater treatment.

<table>
<thead>
<tr>
<th>Designer/Product Developer: Things to Consider</th>
<th>Buying/Sourcing/Merchandising: Options and Implications</th>
<th>QA/Fabric Manager: Supporting Implementation</th>
</tr>
</thead>
</table>
| • Raw denim that has not been de-sized is an option: this has a different feel and aesthetic – it may shrink more and the consumer may notice the reduced colour fastness. Size will still wash out over time during home washing by the consumer. | • Other than for raw denim, desizing is not a process that can simply be eliminated. However, it is important to understand the process and to aim for size recovery and re-use.  
• Size recycling is not a common practice  
• Aim for enzymatic desizing where recycling is not an option  
• A new and therefore not yet common process from Jeanologia called “Desizing with the Atmosphere” uses ozone on dry garments to desize and prepare garments. Benefits include reduced need for later bleaching, cleaner waste water in subsequent steps, reduction in backstaining, and greater contrast. | • Size recovery is more achievable in vertically integrated units  
• Size is often applied by the dye house following the indigo yarn dye, often on the same machinery. Desizing, however, may not happen until after weaving and sewing, during finishing, which makes recovery a challenge  
• Support innovation in alternative sizing processes |

**OHS Considerations:** n/a

**Effluent Considerations:** Desizing a major contributor to contaminated waste water, particularly to high BOD and COD levels. The best option is to recycle sizing agents, or to use enzyme desizing which can reduce the waste water impact.
C2. Softening: Enzyme Desizing

Size is a starch or synthetic compound added to yarn before weaving. It strengthens the yarn while also decreasing friction, which leads to less breakage during high tension and high speed weaving. The size must be removed before other processes such as dyeing or finishing take place or else the size will interfere with those processes. Desizing is the process of removing size. Removal depends on size composition, which could be starch or PVA (polyvinyl alcohol) or other compounds. It generally requires large quantities of very hot water and added chemicals. After desizing, the starch or PVA goes into the wastewater, where it is very difficult to remove. Starch leads to high BOD and COD levels and large quantities of resulting sludge. Enzymes, such as amylase, which attack starch, can be used to desize with the benefit of less resource use, and a decreased contribution to the waste water. Enzymatic desizing is often combined with other processing steps, generally leading to a lower water and energy requirement than conventional desizing, and chemicals are replaced with enzymes.

Recommendation: Depending on size composition, enzymatic desizing, along with size recapture and recycling, are better alternatives to conventional desizing.

OHS Considerations: n/a

Effluent Considerations:
Desizing a major contributor to contaminated waste water, particularly to high BOD and COD levels. Enzyme desizing has a lower BOD/COD impact than conventional for starch-based size.

Designer/Product Developer: Things to Consider

- Raw denim that has not been de-sized is an option: this has a different feel and aesthetic – it may shrink more and the consumer may notice the reduced colorfastness. Size will still wash out over time during home washing by the consumer.

Buying/Sourcing/Merchandising: Options and Implications

- Other than for raw denim, desizing is not a process that can simply be eliminated
- Aim to combine with other processes for savings in resources and well as time
- A new process from Jeanologia called “Desizing with the Atmosphere” uses ozone on dry garments to desize and prepare garments. Benefits include reduced need for later bleaching, cleaner waste water in subsequent steps, reduction in backstaining, and greater contrast.

QA/Fabric Manager: Supporting Implementation

- Enzyme desizing for starch-based size can be combined with other enzyme processes, such as enzyme abrasion. This eliminates the need for multiple separate water baths, saving water and energy
- In vertically integrated units, aim for size recapture and recycling (for synthetic sizing agents)—the process will depend on the type of sizing agent used, which may be hard to trace when done in separate facilities
- Support innovation in alternative sizing/desizing processes
C3. Softening: Silicone Softener

Denim garments, which are generally rougher than other types of garments, often undergo a softening process to improve handfeel. Silicone-based softeners are the most commonly used type of softener. Some silicone types (such as D4) are environmentally toxic and hazardous to human health. It is important to be aware that softeners can sometimes intensify the dark shade of the denim (shade bloom) as well as soften the handfeel. They may also increase the risk of yellowing over time, depending on the auxiliaries added (surfactants, emulsifiers, etc.) which may make the indigo more susceptible to decomposition.

**Recommendation:** Take a considered approach.

**OHS Considerations:**
Slightly hazardous in case of skin or eye contact and ingestion. D4 may cause long lasting harmful effects to aquatic life and is suspected of damaging fertility/development of an unborn child. Proper safety equipment must be provided in line with the MSDS (material safety data sheet).

**Effluent Considerations:**
Generally stable in hard water. Do not drain in high quantities.

<table>
<thead>
<tr>
<th>Designer/Product Developer: Things to Consider</th>
<th>Buying/Sourcing/Merchandising: Options and Implications</th>
<th>QA/Fabric Manager: Supporting Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Keep in mind that the fewer finishing steps applied to the garment, the better the sustainability profile</td>
<td>• Softeners may alter a fabric’s light fastness</td>
<td>• Consider restricting the use of softeners—particularly D4</td>
</tr>
<tr>
<td>• Be aware that altering handfeel has implications for altering or sacrificing colour (can intensify, or can yellow over time)</td>
<td>• On product specifications, request that chemical softening agents not be used during rinsing to minimize the chemical impact</td>
<td>• Ensure that softeners which may encourage yellowing are not used; these will likely shorten the garment’s lifetime as consumers will replace garments that have irreversibly yellowed</td>
</tr>
<tr>
<td></td>
<td>• If a softening step cannot be avoided, discuss with your supplier whether ozone softening, or another process, can be used instead of chemical softening</td>
<td>• Promote use of innovative machinery (next section)</td>
</tr>
<tr>
<td></td>
<td>• If softening cannot be avoided, discuss whether it can be applied in a dryer to reduce water use, or if other alternative application techniques are available (see upcoming section)</td>
<td></td>
</tr>
</tbody>
</table>

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9 Octamethylcyclotetrasiloxane

10 TTBC can provide further information on this topic
Rather than using water baths to apply chemicals, particularly softening agents, it is possible to use water-saving alternative applications. These tend to be much more efficient in terms of the amount of product used as well. One option, from Jeanologia, uses a fine mist of bubbles, termed ‘nano-bubbles’. Their softening system was originally called e-soft. However, applications have grown beyond softening, and the technology is now referred to as e-flow. E-flow can replace conventional and often resource-intensive application processes, saving considerable amounts of water, energy, and chemicals. Another option is the called Kit-Batik by Tonnello. This process uses a special washing machine with an internal spray applicator that can precisely deliver softener using less product and less water. This technique is applicable to other processes as well.

**Recommendation:**  ✔ Use where possible.

### Designer/Product Developer: Things to Consider

- Keep in mind that there are many denim finishing processes available—be as flexible as possible in how the intended effect is achieved
- Specifying a treatment process at this stage may limit your options; focus on communicating the desired look so buying/sourcing/merchandising can work with suppliers on identifying sustainable ways to achieve the look

### Buying/Sourcing/Merchandising: Options and Implications

- Discuss with suppliers whether these application options are available

### QA/Fabric Manager: Supporting Implementation

- Support suppliers with uptake of alternative application technology. E-flow requires an investment in a relatively small addition to conventional washing machines. Kit-Batik requires the purchase of a particular Tonnello washing machine
- This technology has been expanded to other processes such as dye and resin application; work with your suppliers to prepare for implementation of this technology where possible

### OHS Considerations:

See above

### Effluent Considerations:

Zero liquid discharge is possible
D. Abrasion Overview

Abrasions, which can be done chemically, manually, or physically, are often used on denim to simulate natural wear and tear, and to achieve certain looks. Abrasion can result in a lighter overall color, whiter color in abraded areas, breakdown of the fabric, and even intentional tears and rips. Abrasion generally weakens the integrity of the product, often resulting in a shorter lifespan. These steps are more noted for their OHS risks than water, energy, or chemical use.

These steps are generally done as one layer in many layers of finishing, and so they must be considered along with other processing steps. It is very important that worker safety must be considered in all of these processes. Overall, enzyme abrasion will require a water bath whereas the other processes do not. While this requires more water and energy, it is generally combined with another step, minimizing the impact of the higher water and energy requirements. Potassium Permanganate spraying is often done in conjunction with other abrasion steps, and the chemicals are quite hazardous to workers. This must be followed by a neutralizing step that happens in a water bath, increasing water and energy requirements. Sandblasting must be considered a high risk process because the way it is conducted often leaves workers vulnerable to serious health problems and even death.

### Icon Key

When comparing abrasion processes:

- ![Lower impact](image)
- ![Moderate impact](image)
- ![Higher impact](image)

### Water / Energy / Chemicals

<table>
<thead>
<tr>
<th>Step</th>
<th>Key</th>
<th>Impact</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>D1. Hand Scraping</td>
<td>!</td>
<td><img src="image" alt="Lower impact" /></td>
<td><img src="image" alt="Moderate impact" /></td>
</tr>
<tr>
<td>D2. Sandblasting</td>
<td>Ø</td>
<td>n/a</td>
<td>Page 67 – <strong>Not Recommended</strong></td>
</tr>
<tr>
<td>D3. Ice Blasting</td>
<td>✓</td>
<td><img src="image" alt="Lower impact" /></td>
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</tr>
<tr>
<td>D4. Potassium Permanganate</td>
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</tr>
<tr>
<td>D5. Enzyme Abrasion</td>
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<td><img src="image" alt="Lower impact" /></td>
<td><img src="image" alt="Moderate impact" /></td>
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<tr>
<td>D6. Laser</td>
<td>✓</td>
<td><img src="image" alt="Lower impact" /></td>
<td><img src="image" alt="Moderate impact" /></td>
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</tbody>
</table>

**Key:**
- ✓ Recommended
- ! Know the risks and the alternatives
- Ø Not recommended
## D1. Abrasion: Hand Scraping

Abrasion is the treatment of garments to make them look used, worn-in and old. The fabric surface is mechanically or chemically abraded, meaning that it is intentionally scraped or roughed up. Denim abrasion may be done by hand using sand paper or electronic abrasive tools. This not only gives a worn-in or distressed look, but also compromises the strength of the garment, making it more prone to ripping and ultimately this can shorten the life of the garment, which is a sustainability issue. However, from an environmental (water, energy, chemical) perspective, hand scraping is a better alternative than some other finishing techniques from a wet processing perspective as water, energy, and chemical inputs are limited.

**Recommendation:** A good option when properly implemented—ensure OHS is a priority.

### OHS Considerations:
Manual hand scraping can require bending over for long periods of time and can lead to chronic back and arm pain. Workers using mechanical devices are subject to skin abrasion if lacking proper hand protection. Appropriate ventilation and extraction is needed to combat high levels of dust. Proper safety equipment must be provided.

### Effluent Considerations:

n/a

### Designer/Product Developer: Things to Consider
- Try to keep abrasion effects to a minimum to prolong a garment’s lifespan
- Keep in mind that there are many denim finishing processes available—be as flexible as possible in how the intended effect is achieved
- Specifying a treatment process at this stage may limit your options; focus on communicating the desired look so buying/sourcing/merchandising can work with suppliers on identifying sustainable ways to achieve the look

### Buying/Sourcing/Merchandising: Options and Implications
- Promote suppliers with better hand scraping facilities
- Laser (D6) may offer an alternative to hand scraping

### QA/Fabric Manager: Supporting Implementation
- Work places should be ergonomically correct and personal protective equipment available and in use

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11 Impacts from a worker health and safety perspective must also be considered here
D2. Abrasion: Sandblasting

Abrasion is the treatment of garments to make them look used, worn-in and old. The fabric surface is mechanically or chemically abraded, meaning that it is intentionally scraped or roughed up. Sandblasting can be performed mechanically using special sand in blasting cabinets where the process is controlled and the by-products are captured. However, the most common form of sandblasting is manual blasting, and natural sand, widely available at a low cost, is often used. The most common constituent of this sand is silicon dioxide, which in dust form normally contains about 90% free silica. These micro-sized particles can enter the lungs of workers and cause the incurable and potentially deadly pulmonary disease silicosis. It is now forbidden in many countries to use abrasives containing more than 0.1% free silica. Thus, aluminium silica, containing less than 0.1% free silica, is considered a quality alternative. However, since compliance with this standard is difficult to control across the whole industry, many brands prohibited all sandblasting in 2010, regardless of the silica content of the abrasive. It is important to understand that abrasion always weakens a garment, which will likely shorten its usable lifespan, thereby negatively impacting its sustainability profile.

**Recommendation:**

- Restrict.

**OHS Considerations:**

Sandblasting has been widely used in the industry until recently. Increasingly, brands have banned the process due to worker health issues due to the potential for severe lung damage and even death. If used, proper and advanced safety equipment must be provided, including enclosed blasting cabinets and sand with minimal silica content.

**Effluent Considerations:**

n/a

**Designer/Product Developer:**

Things to Consider

- Try to keep abrasion effects to a minimum to prolong a garment’s lifespan
- Keep in mind that there are many denim finishing processes available—be as flexible as possible in how the intended effect is achieved
- Specifying a treatment process at this stage may limit your options; focus on communicating the desired look so buying/sourcing/merchandising can work with suppliers on identifying sustainable ways to achieve the look

**Buying/Sourcing/Merchandising:**

Options and Implications

- On product specifications, highlight your brand’s ban on sandblasting
- On product specifications, request alternatives such as ice blasting, enzyme shading, or other techniques depending on desired look

**QA/Fabric Manager:**

Supporting Implementation

- If a ban is implemented, strictly enforce it
- The authors of the DSG advise against sandblasting, given the difficulty to control OHS hazards and the risk to fatal long disease. If sandblasting is permitted, ensure that blasting cabinets are used and all proper safety equipment is provided and the correct abrasion material is used
Ice blasting is a process where frozen dry ice (carbon dioxide) pellets are blown by a pressurised air stream onto garments to provide the characteristic “faded” look commonly achieved through sandblasting. This process is very useful as it provides an alternative to sandblasting, which is very dangerous for workers since the sand can enter the lungs causing respiratory diseases such as silicosis. The solid carbon dioxide pellets turn into a gas after hitting the surface of the garment, so there is no effluent or chemical clean-up process. While this process has been widely in use in manufacturing, such as for cleaning machinery, it is relatively new for denim abrasion. Recently, there has been an increase in brands adopting, and communicating about, the process. It is important to understand that abrasion always weakens a garment, which will likely shorten its usable lifespan, thereby negatively impacting its sustainability profile. While the process is quite fast (meaning low energy expenditure), the energy requirements for compressing the air (which are quite high) are taken into consideration here as well, earning a moderate score for energy overall.

**Recommendation:** Use as a substitute for chemical abrasion or sandblasting.

**OHS Considerations:**
Dry ice can cause burns if used without appropriate protective equipment. Eye and ear protection should be used with blasting machinery and workers need to be trained on OHS. Proper ventilation and extraction is important to remove excess carbon dioxide from the air; without proper ventilation, this can be a serious health concern for workers who may not be getting enough oxygen to breathe.

**Effluent Considerations:** n/a

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**Designer/Product Developer:**  
**Things to Consider**
- Traditionally sandblasted looks can often be achieved with ice blasting
- Try to keep abrasion effects to a minimum to prolong a garment’s lifespan
- Keep in mind that there are many denim finishing processes available—be as flexible as possible in how the intended effect is achieved
- Specifying a treatment process at this stage may limit your options; focus on communicating the desired look so buying/sourcing/merchandising can work with suppliers on identifying sustainable ways to achieve the look

**Buying/Sourcing/Merchandising:**  
**Options and Implications**
- Identify with your suppliers the alternatives to sanding they offer, including for example ice blasting
- On purchase orders, request ice blasted abrasion when purchasing worn-in or faded denim

**QA/Fabric Manager:**  
**Supporting Implementation**
- Bans intended to apply to sandblasting may inadvertently restrict ice-blasting as well (ex: if language restricts abrasive blasting); discuss ice blasting with suppliers and ensure that supplier requirements do not limit this option if it is to be requested
Abrasion processes are often combined with Potassium Permanganate (PP) spraying, which is used to enhance the contrast between white abraded areas (or the whiteness of the weft yarns) and the blue coloured areas. This chemical is a pink colour when applied, but ultimately results in brighter contrast and more visible whiskers or areas of fading. Potassium permanganate is a hazardous chemical and spraying should be done in specific spray booths, where rubber dummies are installed for holding garments and where contaminated air can be isolated and treated (when high concentrations are used). Sodium Metabisulphate, which is used for PP neutralization, is a hazardous chemical as well, with implications for OHS. Neutralizing the PP in a wash cycle increases the water and energy score. While this look can be difficult to replicate with alternative processes, new PP alternatives are now available that are receiving positive reviews from users.

**Recommendation:** 0 Consider restricting.

**OHS Considerations:**
Can cause severe eye and skin irritation, including blindness, respiratory problems, and burning. Inhalation of potassium permanganate may lead to pulmonary oedema. PP can impact fertility. May cause fire in or toxic gases when in contact with certain materials. Proper safety equipment must be provided. Proper spray booths must be used. Air must be treated with a water shower, and then water treatment. May be combined with sandblasting, which carries risks to workers (including silicosis). Provide MSDS12, SOPs13 and training in local language.

**Effluent Considerations:**
Very toxic to aquatic organisms, and may cause long-term adverse effects in the aquatic environment.

**Designer/Product Developer:**
**Things to Consider**
- Consider whether brighter areas of fading are necessary, given the environmental and OHS impact of the chemicals used.
- Consider laser processing to replace PP use. One example is “Light PP” from Jeanologia”

**Buying/Sourcing/Merchandising:**
**Options and Implications**
- Discuss with suppliers whether other process combinations can be a suitable alternative.

**QA/Fabric Manager:**
**Supporting Implementation**
- Consider restrictions of PP.
- If in use, ensure use of personal protective equipment and functioning water curtains.
- Consult TTBC for advice on PP alternatives, such as those available from Garmon (Avol Oxy White), DyStar, Jeanologia, and others.

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12 Material Safety Data Sheets
13 Standard Operating Procedures
Enzymes can replace chemicals and stones for generalised abrasion, and still achieve a soft, worn-in, and even frayed look. They do not allow for localised abrasion. Enzyme abrasion allows for reduced water consumption by combining processes and reducing the number of rinse cycles needed. Enzymes are also gentler on garments as well as machinery. Different enzymes can achieve different levels of abrasion, but cellulase enzymes are commonly used to essentially ‘eat’ away the outer layer of the cellulose fibre, resulting in thinner and whiter areas.

It is important to understand that abrasion always weakens a garment, which will likely shorten its usable lifespan, thereby negatively impacting its sustainability profile. Enzyme processes, including enzyme abrasion, are low in water and energy use when compared to other wet processes.

**Recommendation:**
- Use where possible as a substitute for chemical abrasion or sandblasting.

**OHS Considerations:**
Poor handling of enzymes may cause formation of dust or aerosols. Repeated dust inhalation may cause allergic reactions. Proper safety equipment must be provided.

**Effluent Considerations:**
Enzymes are biodegradable and classified as "non-dangerous" to the environment.

**Designer/Product Developer:**
**Things to Consider**
- Some heavily frayed looks might be hard to achieve
- Abrasion in a specific place only cannot be achieved with enzymes, just generalised abrasion
- Try to keep abrasion effects to a minimum to prolong a garment’s lifespan
- There are many denim finishing processes available—be flexible in how the intended effect is achieved
- Specifying a treatment process at this stage may limit your options; focus on communicating the desired look so buying/sourcing/merchandising can work with suppliers on identifying sustainable ways to achieve the look

**Buying/Sourcing/Merchandising:**
**Options and Implications**
- Enzymes are in compliance with Öko-Tex, bluesign, EU Ecolabel, REACH, etc. For GOTS certified organic products, GMM\(^14\)-derived enzyme use is not permitted. Enzymes from non-GMM sources are available, though they may be more expensive and less effective.
- Works well for indigo or sulphur dyed denim, as well as for cotton or cotton blends, such as those with elastane
- Discuss with suppliers if enzymes that target indigo rather than cellulose can be used; this will have less of a negative impact on durability
- If improper enzymes are used, there is a greater risk of backstaining, where loosened indigo from the blue warp fibres attaches to the white weft fibres, decreasing contrast. Short ozone treatments can be used to combat backstaining

**QA/Fabric Manager:**
**Supporting Implementation**
- Enzymes are roughly as expensive as conventional bleaching and shading in terms of cost when cost is considered holistically (with water and energy costs included, not just chemical or enzyme purchase costs). Savings will come from reduced energy and chemical consumption, as well as higher efficiency
- Chlorine is corrosive and damages machines, shortening their lifespan. Processes like stonewashing also reduce machinery lifespan. Enzymes are not corrosive and machinery will generally last longer

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\(^{14}\) GMM: Genetically Modified Micro-organism. These micro-organisms are used to manufacture industrial enzymes at scale. The enzymes themselves are not genetically modified.
Laser finishing is a computer controlled process for etching denim. This technique enables patterns such as lines, dots, images, text, pictures and the “moustaches”, “honeycombs” or “whiskers” to be created that replicate the natural process of denim fading. Due to the wide range of effects that laser finishing can achieve, it can potentially replace 60-70% of conventional laundry processes (according to manufacturers). While laser treated denim used to be easy to spot, advances in laser processing now allow for much more sophisticated effects, including mimicking different weaves as well as different finishes. Laser abrasion is a dry process saving up to 97.5% of the water used for conventional processes (according to manufacturers). Heavily laser-treated garments must be washed to remove ash residue. It is also a low energy process requiring approximately five kilowatts per laser, while using far fewer chemicals than traditional denim finishing, if any at all.

Recommendation: ✔ Use where possible.

OHS Considerations:
Eliminates workers’ exposure to harmful processes like sandblasting. Prevent physical contact with laser beam. Moderate risk of eye damage and burns to hands. Avoid inhalation of smoke fumes. Fabric may catch fire. Install appropriate fire extinguishers and ventilation. Proper safety equipment must be provided.

Effluent Considerations:
Often a dry process where no effluent is produced.

Designer/Product Developer: Things to Consider

- Laser processing has evolved well beyond the artificial effects that were produced early on
- Lasers can be used to achieve effects similar to abrasion or traditional denim looks, or more artistic fine details, including photo-based images. Different weaves can also be mimicked (e.g. a crosshatch effect)
- Planning for laser processing needs to take place from the design stage
- Laser finishing can be used as a creative tool to achieve designs that could not be realized using other denim finishing processes. Consider it a tool in the design toolbox

Buying/Sourcing/Merchandising: Options and Implications

- Identify if your suppliers can offer denim laser finishing
- Laser finishing is an automated system reducing the chance of human error and increasing productivity
- Reproducibility of effects is high
- Processing time for a pair of jeans can be reduced from 20 minutes to less than two minutes. If multiple machines are available, time savings can be achieved
- “Light Scraper” and “Light PP” are two processes from Jeanologia that give different effects using laser
- While many models are available on the market, an average laser system costs approximately USD 150,000
- Laser technology is commonly applied in denim finishing. TTBC can be contacted for information on availability / suppliers of laser equipment in Bangladesh
- Many laser machines include software programs for customizing the final effect. Training is also available on software use. However, in some cases, a graphic designer may need to be involved
E. 3D Overview

3-Dimensional effects are often added to further mimic the wrinkles, ridges, and lines of fading that authentic raw denim will acquire over time. Resins are often used to stiffen the fabric and allow for 3d looks to hold their shape. These reduce fabric strength and may also contain hazardous chemicals, as well as often increasing the energy footprint. It is best to avoid this added-on process wherever possible. Conventional and formaldehyde-free resins are presented below.

**Icon Key**

When comparing 3D processes:

- 🌿 = Lower impact
- 🧐 = Moderate impact
- 🍊 = Higher impact

<table>
<thead>
<tr>
<th>Water / Energy / Chemicals</th>
</tr>
</thead>
<tbody>
<tr>
<td>E1. Conventional Resins</td>
</tr>
<tr>
<td>E2. Formaldehyde-Free Resins</td>
</tr>
</tbody>
</table>

**Key:**  

- ✓ Recommended  
- 🎈 Know the risks and the alternatives  
- 🌿 Not recommended
E1. 3D: Conventional Resins

Three-dimensional effects such as wrinkles are achieved using resins. Sometimes, a template is placed beneath the fabric and the resin is ‘stamped’ in using heat and pressure, sealing in the wrinkles created by the template. Alternatively, resins can be sprayed on after a pair of jeans is manually bunched on a frame. These resins significantly reduce the strength of the garment, making it more likely to rip and ultimately reducing the lifespan of the garment. Older resins were often based on formaldehyde, a probable human carcinogen restricted under REACH. Newer formulations are lower in formaldehyde. Additionally, the process of curing (baking) resins requires very high temperatures leading to increased energy consumption.

**Recommendation:** Consider restricting.

**OHS Considerations:**
Resins can be a source of formaldehyde in small quantities that could be an irritant. Formaldehyde is also known as a carcinogen.

**Effluent Considerations:**
Algae and some invertebrates are susceptible to formaldehyde; however, responses differ widely. Whatever cannot be saved for recovery or recycling should be handled as hazardous waste and sent to an approved waste facility.

**Designer/Product Developer:**
**Things to Consider**
- Keep in mind that resin effects are temporary—this short-lived design choice can have serious sustainability implications and lead to reduced garment durability

**Buying/Sourcing/Merchandising:**
**Options and Implications**
- Resin treatments are responsible for decreasing the strength of the garment by approximately 60%, shortening the life of the garment
- On product specifications, request formaldehyde-free or low-formaldehyde resins
- Bio-based resins are also available; further increasing sustainability compared to conventional resins—avoiding a resin process is still the best option

**QA/Fabric Manager:**
**Supporting Implementation**
- Consider restricting processes that include formaldehyde
- Work with suppliers to swap conventional with formaldehyde-free resins; this should be cost neutral
- Some bio-based resins are GOTS, Öko-tex and/or bluesign approved and are therefore better alternatives than conventional
E2. 3D: Formaldehyde-Free Resins

Newer resin formulas made without formaldehyde are now available. These are compatible with GOTS, Öko-Tex 100 and Bluesign standards. They are also used in the same way as conventional resins, meaning that no new equipment is needed.

**Recommendation:** Use where possible as a substitute for conventional resins. Better option is to avoid use of resins.

<table>
<thead>
<tr>
<th>Designer/Product Developer: Things to Consider</th>
<th>Buying/Sourcing/Merchandising: Options and Implications</th>
<th>QA/Fabric Manager: Supporting Implementation</th>
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<tr>
<td></td>
<td>- On product specifications, request formaldehyde free resins</td>
<td>- Work with suppliers to swap conventional with formaldehyde-free resins; according to some manufacturers, this should be cost neutral, though brand experience indicates that prices can be higher</td>
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</tr>
</tbody>
</table>

**OHS Considerations:** n/a

**Effluent Considerations:** n/a

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15 More info on these standards can be found online, for example here: [http://www.made-by.org/consultancy/tools/wet-processing](http://www.made-by.org/consultancy/tools/wet-processing) or in the Ecotextile Labelling Guide
This bonus section covers different colouration options (instead or in addition to indigo) and is slightly different than previous sections.

Tinting happens on the indigo range as a minor pre- or post-indigo dyeing step. Since dyed denim is generally imported into Bangladesh, this section is mainly for background information.

Garment overdyeing is a completely separate process than can either replace indigo dyeing (more common) or layer on top of indigo dyed garments (less common). Overdyeing on white garments is quite fashion-driven and fluctuates in how common the process is. Overdyeing will require considerable water and energy, and reactive dye will require high amounts of salt where direct dyes are at (higher) risk for banned azo amines.
Denim that has been dyed with indigo at the yarn stage sometimes has a top or bottom layer of dye to tint the final product. Sulphur dyes are often used for this and different colours and different levels of application can be used to achieve different effects. When it is applied after indigo, it is called a sulphur “top”. In sulphur topping, the indigo forms a barrier around the core of the yarn, which remains white. Abrasion will reveal bluish/whitish colours. A sulphur “bottom” is when the sulphur is applied before the indigo. Abrasion will reveal the colour of the dye rather than the typical white. Sulphur dyes lead to highly contaminated waste water. Newer pre-reduced formulations (F3) are a better option.

**Recommendation:** A much more resource-efficient option than overdyeing, though the effect will be different. Aim for pre-reduced sulphur dyes.

**OHS Considerations:**
Sulphur compounds may irritate skin and eyes. May be fatal if inhaled. Causes respiratory tract irritation. Hydrogen sulphide, a highly toxic gas, may be present or released. Proper safety equipment must be provided in line with the MSDS such as PPE and spray cabins that minimize exposure.

**Effluent Considerations:**
Conventional sulphur dyes lead to salty effluent that is difficult to treat and can negatively impact local ecosystems. Ensure improved pre-reduced sulphur dyes are used to minimize the salt.

**Designer/Product Developer: Things to Consider**
- Sulphur dyes can mainly achieve dull colours, which are suited to more typical denim garment dyeing
- Effects of topping and bottoming can be soft and blurred, or the colour layers can remain distinct depending on application processes

**Buying/Sourcing/Merchandising: Options and Implications**
- The use of a steamer adds to the energy use, but can maintain a more distinct separation of the colours, which may be desirable in some cases
- Time, temperature, and concentration of wetting agents impact end look as well as sustainability—discuss process with suppliers
- On product specifications, request improved sulphur dyes rather than conventional

**QA/Fabric Manager: Supporting Implementation**
- Where sulphur topping is used, ensure that pre-reduced (improved) sulphur dye is used and proper OHS precautions are implemented
- Pre-reduced improved sulphur dyes are available from suppliers such as Archroma, DyStar, and others
In addition to the yarn-stage tinting described above, sulphur dye may also be used on garments white garments to add colour, or even indigo-dyed garments to give a certain cast, such as rust, green, or shades to mimic a vintage look. Conventional sulphur dyes lead to the production of waste water that is highly contaminated with salts and chemicals that can be harmful to the environment.

**Recommendation:** While the look is unique, garment overdyeing is resource intensive. Consider carefully before use and aim for pre-reduced sulphur dyes (next section).

**OHS Considerations:**
Sulphur compounds may irritate skin and eyes. May be fatal if inhaled. Causes respiratory tract irritation. Hydrogen sulphide, a highly toxic gas, may be present or released. Proper safety equipment must be provided in line with the MSDS such as PPE and spray cabins that minimize exposure.

**Effluent Considerations:**
Conventional sulphur dyes lead to salty effluent that is difficult to treat and can negatively impact local ecosystems. Ensure improved pre-reduced sulphur dyes are used to minimize the salt

**Designer/Product Developer:**
Things to Consider
- Sulphur dyes can mainly achieve dull colours, which are suited to more typical denim garment dyeing
- Consider whether yarn-stage tinting would achieve a desired look

**Buying/Sourcing/Merchandising:**
Options and Implications
- On product specifications, request improved pre-reduced sulphur dyes rather than conventional

**QA/Fabric Manager:**
Supporting Implementation
- Pre-reduced improved sulphur dyes are available from suppliers such as Archroma, DyStar, and others
Pre-reduced sulphur dyes offer some improvement to conventional sulphur dyes if garment dyeing must be done. Conventional sulphur dyes lead to the production of waste water that is highly contaminated with salts and chemicals that can be harmful to the environment. Pre-reduced sulphur dyes are an improved formulation where the reduction step is done by the dyestuff manufacturer, rather than the dye house, under more controlled conditions that allow for a cleaner process. The resulting dyestuff has a slightly lower chemical and salt impact on waste water, and ultimately the environment.

**Recommendation:** This is a better option than conventional sulphur if garment overdyeing must be done. Overdyeing is a resource-intensive process.

**OHS Considerations:**
Sulphur compounds may irritate skin and eyes. May be fatal if inhaled. Causes respiratory tract irritation. Hydrogen sulphide, a highly toxic gas, may be present or released. Proper safety equipment must be provided in line with the MSDS such as PPE and spray cabins that minimize exposure.

**Effluent Considerations:**
Conventional sulphur dyes lead to salty effluent that is difficult to treat and can negatively impact local ecosystems. Ensure improved pre-reduced sulphur dyes are used to minimize the salt.

**Designer/Product Developer:**
Things to Consider
- Sulphur dyes can mainly achieve dull colours, which are suited to more typical denim garment dyeing
- Consider the impact of additional dyeing processes during the design stage

**Buying/Sourcing/Merchandising:**
Options and Implications
- On product specifications, request improved pre-reduced sulphur dyes rather than conventional
- A wide range of shades is available using improved sulphur dyes, not just ‘traditional’ denim shades

**QA/Fabric Manager:**
Supporting Implementation
- Pre-reduced improved sulphur dyes are available from suppliers such as Archroma, DyStar, and others
Un-dyed yarn is sometimes used to make denim products that will be dyed at the garment stage. Additionally, denim that has been dyed at the yarn stage sometimes undergoes an additional dyeing treatment at the garment stage in order to tint the garment. Immersion in dye provides an overall effect, while dyes can also be sprayed on to achieve localised colouring.

Direct dyes require a chemically intensive application and fixation process. While the loose bonds formed here between the dye and the fibre may be preferable for denim tinting to allow for typical effects from abrasion and fading, the chemical footprint for this process is substantial, including binding agents, surfactants and post-treatment fixing agents. Direct dyes are also a common source of banned azo compounds\(^1\).

**Recommendation:** Use with caution.

**OHS Considerations:**
Risk of exposure to banned azo amines\(^9\). Ensure dyes are from a reputable supplier. Proper safety equipment must be provided.

**Effluent Considerations:**
Water contaminated with auxiliary chemicals and residual colour must be treated in effluent treatment plants. Insufficient treatment has implications for the local plant and animal life, as well as local communities.

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**Designer/Product Developer:**
**Things to Consider**

- Consider the impact of additional dyeing processes during the design stage

**Buying/Sourcing/Merchandising:**
**Options and Implications**

- On product specifications, request improved sulphur dyes rather than conventional direct dyes or conventional sulphur dyes for overdyeing
- A wide range of shades is available using improved sulphur dyes, not just ‘traditional’ denim shades

**QA/Fabric Manager:**
**Supporting Implementation**

- Ensure that direct dyes do not include banned azo compounds. Consult the TTBC for more information
- Where sulphur topping is used, ensure that the latest pre-reduced sulphur dye is used and proper OHS precautions are implemented

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\(^1\) This chemical is among those that are listed on the Priority 11 group of chemicals prioritized for elimination by the Detox Campaign as well as subject to REACH
Un-dyed yarn is sometimes used to make denim products that will be dyed at the garment stage. Additionally, denim that has been dyed at the yarn stage sometimes undergoes an additional dyeing treatment at the garment stage in order to tint the garment. Immersion in dye provides an overall effect, while dyes can also be sprayed on to achieve localised colouring.

Reactive dye is commonly selected when brighter colours must be achieved, though dark shades can be achieved as well. Reactive dyeing requires extremely high salt use to move the dye from the water bath into the fabric. Still, fixation rates are often less than 80%, requiring large quantities of heated water to remove unfixed dye through repeated rinsing. This is costly in terms of time and money, and leads to heavily coloured, salty waste water that must be extensively treated, and many mills are not capable of removing the salt, which then goes into local waterways.

**Recommendation:** Substitute where possible.

### OHS Considerations:
Workers are at risk for inhaling dyestuff. Low-dust dyestuffs are preferred. Proper safety equipment must be provided.

### Effluent Considerations:
Effluent often loaded with high levels of salt and unfixed dye.

### Designer/Product Developer:
**Things to Consider**

- Consider the impact of additional dyeing processes during the design stage

### Buying/Sourcing/Merchandising:
**Options and Implications**

- On product specifications, request improved pre-reduced sulphur dyes rather than conventional sulphur dyes or high fixation reactive dyes (Jersey C3) rather than conventional reactive dyes for overdyeing
- High Fixation Reactive Dye is not as commonly used for denim shading/tinting as sulphur-based dyes
- A wide range of shades is available using improved sulphur dyes, not just ‘traditional’ denim shades

### QA/Fabric Manager:
**Supporting Implementation**

- Discuss with your supplier the option to use high fixation reactive dyes (see section C3 in the Jersey DSG for more details). While these are an improvement upon reactive dyes, they may not work for some garment dyeing applications