Annex 5

Annex 5.1

Matrix of EU IPPC Textile BREF BAT techniques

IMPRO LCA improvement options		**BREF Best Available Techniques (BAT)**	**Estimated improvement potential**			**Technical notes**
			Energy	**Water**	**Chemicals**	
1. Generic improvements	1.1 Improve machine maintenance	*See Generic BAT: Management (below)*	-	-	-	-
	1.2 Use automated chemical dosing systems	Automated preparation and dispensing of chemicals (p-236, see also p-317)	*Not specified*	Residual liquor reduction >90%	-11.2% (by cost)	These systems improve 'right first time performance' to 2-3% of production, reducing the need for reworks and shade adjustment, and minimising liquor residues.
	1.3 Use on-line monitoring or fuzzy logic	*See Generic BAT: Management (below)*	-	-	-	-

	Not highlighted by IMPRO	Generic BAT: Management	-	-	-	A combination of environmental awareness training, good practices for maintenances and cleaning, following MSDS instructions, avoidance of spillages and process input/output monitoring.
		Generic BAT: Dosing and dispensing of chemicals	-	-	-	Installation of automatic systems which meter the exact amounts of chemicals, auxiliaries and water required.
		Generic BAT: Selection and use of chemicals	-	-	-	Avoid where possible or adopt a risk-based approach in order to ensure the lowest overall environmental risk.
		Generic BAT: Selection of incoming fibre raw material	-	-	-	Obtain knowledge from suppliers about substances applied to fibres e.g. preparation agents, sizes, knitting oils.

		Generic BAT: Water & energy management	-	-	-	A combination of monitoring, flow control, well-documented production procedures, optimised production scheduling and efficient machinery and process technology. The latter range from basic energy efficiency measures (e.g. pipe insulation) to low liquor ratio dyeing processes.
		Generic BAT: Management of waste streams	-	-	-	Separate collection of unavoidable waste in bulk/returnable containers.
2. Pre-treatment	2.1 Combine processes e.g. bleaching and scouring	Application of the oxidative route for efficient universal size removal (P-288)	*Not specified*	*Not specified*	*Not specified*	Application of hydrogen peroxide to remove sizing agents, resulting in less energy and water use and degradation of effluent.
3. Fabric formation	3.1 Alternative knitting technologies	*Not covered*	**-**	**-**	**-**	
4. Washing and rinsing	4.1 Replace chemicals with enzymes	Enzymatic after soaping in reactive dyeing (p-317)	*Not specified*			Serves to remove unfixed dyestuff. Eliminates one hot rinsing step.

	4.2 Replace bleaching, rinsing and washing technologies	Water & energy conservation in batch washing and rinsing (p-395)	*Not specified*	Drain and fill: -50 to 75%	-	Two methods are covered – drain and fill and smart rinsing.
		Water & energy conservation in continuous washing and rinsing (p-397)	*Not specified*	Dyeing:10-15 l/kg fabric (up to -33%) Printing: 15-20 l/kg	-	A number of measures are listed – water flow control, increased washing efficiency, introduction of heat recovery equipment.
	4.3 Horizontal washers versus vertical washers	*No corresponding BAT technique*	-	-	-	-
5. Dyeing	5.1 Use low liquor ratio dyeing machines	Equipment optimisation in batch dyeing (p-343)	Winch beck - 30% Airflow jet - 23% Softflow - 11 to 37% Single rope - 35%	*- 40 to 40%* > 50% - 50% - 35%	> 40%	Factors highlighted include liquor ratio, separation of dye bath and rinsing water, rinsing efficiency, cycle duration and improved textile/liquor contact. Automatic systems and controllers, indirect heating/cooling and hoods and doors are also highlighted.
	5..2 Continuous versus non continuous dyeing	*Highlighted but not specifically compared*	- 75%	- 25%		Data from Schramm and Jantschgi (1999)

	5.3 Consider cold pad batch dyeing	*No corresponding BAT technique*	-	-	-	-
	5.4 Use dye machine controllers	Equipment optimisation in batch dyeing (p-343)	-	-	-	*See above*
	5.5 Recycle or reuse water during process steps	Optimising water consumption in textile operations (p-239)	*Data provided for separate BAT*	*50-100 l/kg woven fabric*	-	Describes a series of measures to control and reduce consumption and to reuse water, which will in turn influence energy use.
		Water re-use/recycling in batch dyeing processes (p-355)	- *33%*	- *33%*	-	Applicable to batch and continuous dyeing processes.
		Avoiding batch softening (p-379)	*Not specified*	*Not specified*	-	Facilitates the reuse of the dye/rinse bath water in batch processes as cationic softeners are not used.
	5.6 Near market options – electrochemical and supercritical CO_2 dyeing	*Highlighted as an emerging BAT technique*	-	-	-	-

	Not highlighted by IMPRO	Exhaust dyeing of cellulosic fibres with high-fixation polyfunctional reactive dyestuffs (p-320)	- 40%	- 40%	-	Significant improvements in the level of dye fixation can be achieved. Less rinse water and energy are required as a result.
6. Printing	6.1 Consider digital instead of pigment or traditional printing	Ink-jet digital printing for flat fabric (p-371)	- 80%	*Not specified*	- 60% COD	Dye and printing paste preparation if avoided completely. Afterwashing and drying is still required for dye printing. Sample printing achieves the greatest efficiency improvements. *See data from Tieprint project (2002)*
7. Wastewater treatment	7.1 Recycle effluent water	Treatment of mixed waste water with about 60% water recycling (p-414)	Energy is required for desalination	- 60%	50% salt recovery	Treated wastewater is passed through an active carbon filter and desalinated by reverse osmosis.
		Recycling of textile waste water by treatment of selected streams with membrane techniques (p-422)	-	- 60%	- 50% COD	Membrane and carbon filters can be used to treat effluents and, subject to analysis, then return them for use in processes.

	Not highlighted by IMPRO	Treatment of textile wastewater in activated sludge system with low food-to-micro organisms ratio (F/M)	Energy is required for aeration	-	-	Optimised use of aerobic biological treatment techniques in order to break down hardly biodegradable substances. An F/M ratio of <0.15 kg BOD5//kg MLSS per day is required.
8. Finishing	*Not highlighted by IMPRO*	Minimisation of energy consumption of stenter frames (p-373)	- 15 to 30% (individual measures)	-	-	Each textile substrate is treated on average 2.5 times in a stenter. Measures highlighted include optimised exhaust air flow, heat recovery, insulation, heating systems and burner technology.

Annex 5.2

Industry process efficiency case studies

Case study 1

Retailer policy – Marks & Spencers textile processing policies

Production stages	Dyeing, printing and finishing
Main criteria areas	- General best practices - Chemical management - Pre-treatment processes - Colours and dyeing - Drying - Printing - Wastewater treatment - Energy and water management
Verification systems	- Completion of a self-audit which must be reviewed every 18 months. - Second party site visits and audits arranged by Marks & Spencers. - Third party auditing of energy use and management systems (Eco-factories programme). - KPI's for energy, water and chemical use.
Quantified benefits	No published data – reference can be made to measures identified in BREF and NRDC documents

Marks & Spencers are a UK clothing retailer. The company has since 1998 operated strict policies and standards for the performance of wet processes and the management of quality along its supply chain. They are applied to dyeing, finishing and printing processes – those with which the company has the most direct commercial influence and greatest 'visibility' down the supply chain. The Company has initiated an 'eco-factory' programme in the UK and Sri Lanka. This focuses on basic energy management practices and requires completion of a third party audit of practices.

The companies policies and standards are verified by site visits and audits by the company. They are applied to tiers of the supply chain with which the company has direct commercial relationships (tier 1) and indirectly via these suppliers (tier 2 and 3) who must report on compliance. The Environmental and Chemical Policy (ECP) provides guidance covering a range of different production processes. In this respect it does not provide a set of specific operating parameters. The ECP highlights the following general management principles:

- All raw materials should be checked for conformance and consistency
- All dyes and chemicals must be accurately measured and weighed
- Selection of chemicals and dyes should consider toxicity, COD/BOD and other potential hazards
- There must be clear written Standard Operating Procedures for all processes

An overall emphasis is placed on quality management and 'right first time' production to avoid unnecessary use of chemicals and preparations and the need to reject batches of textile. All effluent must be treated in a multi-stage treatment plant – on-site or off-site – although limit values are not specified. A number of the guidelines mirror BREF BAT, such as Standard Operating Procedures and colour scheduling, whilst some represent innovations that the company has pioneered e.g. colour measurement. Specific reference is also made to the NRDC best practice guidance (also reviewed in this paper) in relation to the Eco-factories programme.

Marks & Spencers: Summary of ECP Technical guidance areas

General best practices

- Minimum standards for worker safety and machine maintenance
- Written Standard Operating Procedures and batch cards for all processes in order to ensure consistency
- Production planning and scheduling to improve on time delivery and reduce energy and water use e.g. scheduling of colours
- Installation of control systems to optimise process management and record process data

Chemical management

- There must be Material Safety Data Sheets for all chemicals and they must be stored and used according to MSDS guidance
- SVHC's must not be present in any chemicals used

Pre-treatment

- Consistent processes for bleaching and scouring
- Peroxide bleaching with careful removal prior to dyeing

Colour and dyeing

- Dye laboratory access to M&S instrumental colour measurement spectral standards linked to automatic dispensing equipment before the recipe is passed to bulk dyeing in computerised form
- Well managed and calibrated dye weighing and dispensing, with adequate worker protection
- Reduced strength tolerances for dyestuffs (+/- 2%)
- Reduction of salt in reactive dyeing through the use of high affinity dyes, automatic dosing systems and specific gravity checks
- Light fastness for pale shades should be ensured by washing-off instead of fixing
- Minimise temperatures during finishing of polyester and elastane fibres
- Reactive dyeing of wool and chlorine-free shrink proofing
- Preliminary checking of nylon fibres prior to dyeing in order to preserve fastness and to minimise finishing temperatures
- Consider whether fibre blends are necessary if they increase the complexity and energy use associated with dyeing
- Liquor ratio and pH controls to improve process consistency
- Continuous preparation, pad batch dyeing and wash-off are recommended
- On-line monitoring of the dyeing process for indigo dyeing (for denim)

Drying

- Maximise energy efficiency – maximise water removal prior to drying, install heat recovery, install moisture meters to avoid overdrying

Printing

- Automatic weighing and dispensing of colour and chemicals (as for dyes)
- Drying systems that are only activated when they are need e.g. IR dyers
- Re-use of printer paste that remains in the system
- Printing with dyes
- Responsible use of chemicals for caroussel panel prints because there is no wash-off stage

Waste-water treatment

- Manufacturing sites are responsible to ensuring that listed parameters achieve minimum compliance levels – COD, pH, ^{o}C, colour, TSS, TDS, specific metals and toxins - regardless of whether treatment is on or off site
- Reduce water and chemical consumption, select for ease of removal and increase dye fixation in order to reduce risks of overload
- Minimise salt consumption

Energy and water management

- Installation of metering and sub-metering for process areas and machine consumption
- Combined use of modern machinery, low liquor ratios, efficient rinsing technologies and water recycling
- Heat recovery from steam condensate, hot water and waste gases. Cool water can also be used for cooling.
- Management of water quality to maintain reactions
- Shorter lower temperature processes
- AC drives for pumps, blowers and pulleys
- Pipework and tank insulation
- Leak inspection

Case study 2

Industry-led certification - Bluesign criteria for textile manufacturers

Production stages	Any production stage can be certified
Main criteria areas	- Environmental, health and safety management - Chemicals and preparations - Energy and water management - Wastewater treatment - Air emissions
Verification systems	- Manufacturers must be 'system partners' (members) of Bluesign. - Second party certification is carried out by Bluesign Technologies and SGS International. - Random testing of fabric by independent laboratories is required.
Quantified benefits	No published data – see forthcoming study which compares Bluesign and EU Ecolabel certified products.

Bluesign is an independent certification system for all production processes associated with a final fabric product. It was established in 2000 and over 200 manufacturers are system partners. The system is based on the concept of 'intelligent input stream management' which focuses on the avoidance at source of chemical inputs which pose risks to health and the environment based on their toxicological properties.

The system evaluates and certifies whether the production processes avoid or restrict the use of specific substances or preparations. These are set out in a publicly available set of criteria. Production sites are subject to screening and inspection in order to determine the chemical inputs to the processes and output effluents to air and water. Good housekeeping is also addressed.

Bluesign also benchmarks processes against Best Available Techniques (BAT) in order to improve resource efficiency, however definitions and guidelines are not provided in publicy available criteria and it is understood that this is carried out by experts from Bluesign in conjunction with member companies and that reference may be made to the IPPC BREF.

Bluesign: Summary of technical criteria areas

Overarching criteria

- A management system to maintain all areas of environmental and health and safety is required, following the UN Global Compact
- Compliance with all relevant local, national and international legislation
- Employees must be educated and trained to increase competence and awareness
- Manufacturing must follow general good housekeeping principles
- Continuous improvement based on benchmarking of resource consumption and efficiency with reference to BAT techniques

Chemicals and preparations

- Only chemical components, production processes and technologies rated blue or grey under Bluesign can be used. Black rated cannot be used.
- Storage and handling should be carried out according to MSDS advice
- Workplace hazardous substance management should respect TRGS 900 limit values (a German system)

Energy and water management

- Water must be used in a responsible way
- The usage of chlorinated carriers, hypochlorite bleaching, chlorite optical brightener, APEO's, Chromium (VI) and permanganate and periodate bleaching or oxidising agents are banned
- Cooling water should be re-used as process water

Wastewater treatment

- COD elimination should be greater than 85% before direct discharge
- Wastewater treatment plant should have measurement instrumentation installed
- Residual discharges from dyeing and finishing should be minimised and where possible discharged separately
- Specific limit values are set for key parameters including – BOD, COD, pH, ^{o}C, colour, TSS, AOX, specific metals and toxins - regardless of whether treatment is on or off site

Air emissions

- Total in inorganic and organic emissions from a process or substrate should be below specific limit values
- Emissions to be regulated using a provided 'emissions factor concept' which is based on the calculation of total organic substance emissions
- Off-gas cleaning is always required for processes treating nylon and acrylic

Waste

- Textile waste should be avoided by process control and where unavoidable it should be recycled

Case study 3

Consumer-focussed certification – Oeko-tex 1000

Production stages	Any production stage can be certified.
Main criteria areas	- Environmental management - Oeko-Tex 100 certificates (30% products) - Air and water emissions - Hazardous substances - Process management - Energy management
Verification systems	Third party compliance audits and certification by accredited members of Oeko-tex International.
Quantified benefits	No published data.

Oeko-tex is an independent certification system for textile manufacturing sites. It is intended to work alongside Oeko-tex 100 which is a certification for products. Manufacturing sites can be certified against the Oeko-tex 1000 criteria Part A. In May 2012 there were 57 production sites across the world certified. Certified sites comprised spinners (22 %), yarn dyers (7 %), weavers (20 %), knitters (5 %), finishers (32 %) and final products (14 %).

Oeko-tex 1000: Summary of technical criteria areas

Organisational criteria

- Environmental management system including mapping of direct/indirect effects

Human-ecological criteria

- 30% of products must carry a valid Oeko-tex 100 certificate

Wastewater and exhaust air emissions

- Wastewater is to be treated to multiple stages and is scored according to a series of defined parameters for effluent discharged to water or public sewage treatment plant. Performance is graded in both cases.
- Sizes should be biodegradable based on OECD test definitions
- Air emissions requirements for Carbon Monoxide, dust, SO_2 and NO_x. Performance is graded for each emission.

Chemicals in production

- Compliance with a prohibited chemicals list
- Compliance with national legislative requirements for chemical handling and protection
- Sizing agents and spinning agents used should be declared to customers

Process management

- Compliance with specified prohibited technologies listed in the criteria

Energy use

- Optimal utilisation of energy using available processes and energy recovery and energy measurement for production units

Case study 4

Industry-led guidance – MADE-BY wet processing

Production stages	Pre-treatment, dyeing, printing
Main criteria areas	MADE-BY currently advise members on criteria to select from existing labels. A wet processing improvement process is proposed (see below).
Verification systems	No system is in place yet
Quantified benefits	The background study did not identify improvement metrics or benchmarks.

MADE-BY is a non-profit industry association established in 2004 with the aim of which is to improve environmental and social performance of the fashion industry. The association has sought to assist its members in understanding how they can influence their supply chain. This is particularly challenging given that they tend to have less resources and influence than the higher profile retailers and brands, but on the other hand they are still significant with typical turnovers around the 100m mark.

A study and survey was carried out for MADE-BY with the aim of identifying wet process benchmarks. The main finding of the study was that, for dyeing in particular, there are too many different colour, finish and process permutations to develop benchmarks within the scope of the study. It was also identified through a survey of MADE-BY members that their contact with wet processors is indirect via agents and garment manufacturers (the so-called 'cut make and trim' stage).

The main recommendation was a seven stage process designed to increase member engagement with their supply chain:

1. Transparency about suppliers and wet processing stages
2. Measurement of supplier performance using defined metrics
3. Impact calculation using measured data from suppliers
4. Process optimisation by suppliers in order to reduce inputs and impacts
5. Output management to minimise effluent impact on the environment
6. Input management to optimise chemical use and reduce impacts
7. Review findings from stages 1-6 in order to continuously improve

It is unclear at this stage the extent to which this approach will be developed further for use by members.

Case study 5

NGO guidance - NRDC textile mill best practices and dye house criteria

Production stages	Dyeing and finishing mills
Verification systems	Third party compliance audits and certification by accredited members of Oeko-tex International

The National Resource Defence Council (NRDC) is a US NGO. They have sought to highlighted the pollution risk from textile industries located in countries with poorly developed regulatory systems. As part of their 'Clean by Design' initiative they audited representative textile dyeing and finishing mills in China with a view to identifying practical measures they could take to reduce water, energy and chemical use.

Process and equipment sub-metering, good housekeeping and right first time dyeing were highlighted as overarching areas of focus. The initiative also resulted in the identification of ten best practices that together have been estimated could save a typical dyeing or finishing mill 25% water use and 30% fuel use. The estimated energy and/or water savings achieveable are summarised below.

NRDC textile mill best practice: Quantified potential energy and water savings

Best practice	Resources Saved	Cost estimate	Payback Period
Leak detection, preventive maintenance, improved cleaning	Water: 2-5% Energy: 1,5-5%	Insignificant	< 1 month
Reuse cooling water - from singeing - from air compressor system - from preshrink	Energy: 1,6-1,8% Water: 2-5% Water: 2% Water: 1%	$1,500	< 1 month
Reuse condensate	Water: 2-3% Energy: 0,8-3,2%	variable	1 month to 1 year
Reuse process water: - from bleaching - from mercerizing	 Water: 4% Water: 3%	$3,000 - $30,000	< 1 month
Recover heat from hot rinse water	Energy: 2-12%	$44,000 - $95,000	2 - 4 months
Prescreen coal	Energy: 3%	$35,000	5 months
Maintain steam traps	Energy: 1-5%	Insignificant	< 1 month

Insulate pipes, valves, and flanges	Energy: 0,01-0,5%	$4,500	< 1 month
Recover heat from smokestacks	Energy: 1%	$22,000	8 months
Optimise compressed air system	Electricity: 0,3-3%	Insignificant	< 1 month

Source: National Resource Defence Council (2010)

Eight additional areas of potential process improvement and optimisation to save energy, water and chemicals were also identified.

NRDC textile mill best practice: Summary of improvement measures

Overarching measure

- Metering of water, steam and electricity at process and equipment levels

Energy saving

- Recover heat from hot rinse water
- Maintain steam traps and condensate system integrity
- Insulation of pipes, valves and flanges
- Recovery of heat from stacks
- Reduction of compresses air leaks and system pressure

Water saving

- Leak detection and preventive maintenance
- Re-use of non-contact cooling water eg. singeing, pre-shrink, air compressors
- Re-use of steam condensate for washing or desizing
- Re-use water from pre-treatment processes e.g. bleaching, mercerising

Process optimisation

- Failure analysis in order to learn from mistakes achieving customer specifications
- Standardise and document methods and recipes so that colours and shades can be repeated
- Substitute enzyme technology in bleaching pre-treatment in order to reduce energy use by 30%
- Reduce salt based on optimisation of the needs of the dyeing process
- Use higher fixation dyes
- Improve machine utilisation for the most energy intensive processes e.g. dryers, stenters, bakers and steamers
- Schedule colours in order to reduce continuous dyeing machine cleaning
- Production inputs and outputs should be measured and monitored.
- The proportion of right first time dyeing should be monitored.

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