BAT Guidance Note
on Best Available Techniques
for the
Textile Processing Sector

(1st Edition)

ENVIRONMENTAL PROTECTION AGENCY

An Ghníomhaireacht um Chaomhnú Comhshaoil

PO Box 3000, Johnstown Castle Estate, Co. Wexford, Ireland

Telephone: +353 53 916 0600; Fax: +353 53 916 0699

E-Mail: info@epa.ie Website: www.epa.ie

Lo Call: 1890 33 55 99

Acknowledgements

The Environmental Protection Agency would like to acknowledge the assistance provided by the Clean Technology Centre in preparing the consultation draft document. A public consultation process was carried out as part of the preparation of this document. The comments/constructive criticism on the consultation draft guidance note offered by individuals and organisations particularly IBEC staff and representatives of the relevant sectoral groups, Office of Environmental Enforcement and Office of Climate, Licensing & Resource Use staff are gratefully acknowledged.

The Environmental Protection Agency would also like to acknowledge the assistance provided by Mr John Doheny, Office of Environmental Enforcement, for the use of the cover photograph from his personal portfolio.

ISBN: 1-84095-283-0 08/08/50

Price: Free

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1. INTRODUCTION

1.1 GENERAL

This Guidance Note is one of a series issued by the Environmental Protection Agency (EPA), which provides guidance on the determination of Best Available Techniques (BAT) in relation to:

– applicants seeking Integrated Pollution Prevention and Control (IPPC) licenses under Part IV of the Environmental Protection Agency Acts 1992 to 2007,

– existing Integrated Pollution Prevention and Control (IPPC) Licensees, whose licence is to be reviewed under the Environmental Protection Agency Acts 1992 to 2007,

– applicants seeking Waste Licenses under Part V of the Waste Management Acts 1996 to 2008,

– existing Waste Licensees, whose licence is to be reviewed under Waste Management Acts 1996 to 2008.

This Guidance Note shall not be construed as negating the installation/facility statutory obligations or requirements under any other enactments or regulation.

1.2 BAT GUIDANCE NOTE STRUCTURE

This Guidance Note has been structured as follows:

Section	Details
1	Introduction
2	Interpretation of BAT
3	Sector(s) Covered by this Guidance Note
4	Process Description, Risk to the Environment and Control Techniques
5	Best Available Techniques
6	BAT Associated Emission Levels
7	Compliance Monitoring

Where relevant, references are made to other detailed guidance; such as the reference documents (BREF) published by the European Commission, Agency Guidance Notes for *Noise in Relation to Scheduled Activities*, and the determination of BAT should be made giving regard to these.

The information contained in this Guidance Note is intended for use as a tool to assist in determining BAT for the specified activities.

2. INTERPRETATION OF BAT

2.1 STATUS OF THIS GUIDANCE NOTE

This Guidance Note will be periodically reviewed and updated as required to reflect any changes in legislation and in order to incorporate advances as they arise.

Techniques identified in these Guidance Notes are considered to be current best practice at the time of writing. The EPA encourages the development and introduction of new and innovative technologies and techniques, which meet BAT criteria and look for continuous improvement in the overall environmental performance of the sectors activities as part of sustainable development.

2.2 INTERPRETATION OF BAT

BAT was introduced as a key principle in the IPPC Directive, 96/61/EC. This Directive has been incorporated into Irish law by the Protection of the Environment Act 2003. To meet the requirements of this Directive, relevant Sections of the Environmental Protection Agency Act 1992 and the Waste Management Act 1996 have been amended to replace BATNEEC (Best Available Technology not Entailing Excessive Costs) with BAT.

Best available techniques (BAT) is defined in Section 5 of Environmental Protection Agency Acts, 1992 to 2007, and Section 5(2) of the Waste Management Acts 1996 to 2008 as the "most effective and advanced stage in the development of an activity and its methods of operation, which indicate the practical suitability of particular techniques for providing, in principle, the basis for emission values designed to prevent or eliminate or where that is not practicable, generally to reduce an emission and its impacts on the environment as a whole" where:

B ***'best'*** in relation to techniques means the most effective in achieving a high general level of protection of the environment as a whole.

A ***'available techniques'*** means those techniques developed on a scale which allows implementation in the relevant class of activity under economically and technically viable conditions, taking into consideration the costs and advantages, whether or not the techniques are used or produced within the State, as long as they are reasonably accessible to the person carrying on the activity.

T ***'techniques'*** includes both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned.

The range of BAT associated emission level values specified in Section 6 indicate those that are achievable through the use of a combination of the process techniques and abatement technologies specified as BAT in Section 5. The licensee must demonstrate to the satisfaction of the Agency, during the licensing process, that the installation/facility will be operated in such a way that all the appropriate preventative measures are taken against pollution through the application of BAT and justify the application of other than the most stringent ELV in the range.

At the installation/facility level the most appropriate techniques will depend on local factors. A local assessment of the costs and benefits of available options may be needed to establish the best option. The choice may be justified on:

- technical characteristics of the installation/facility;
- its geographical location;
- local environmental considerations;
- the economic and technical viability of upgrading existing installation/facility;

The overall objective of ensuring a high level of protection for the environment as a whole will often involve making a judgment between different types of environmental impact, and these judgements will often be influenced by local considerations. On the other hand, the obligation to ensure a high level of environmental protection including the minimisation of long-distance or transboundary pollution implies that the most appropriate techniques cannot be set on the basis of purely local considerations.

The guidance issued in this Note in respect of the use of any technology, technique or standard does not preclude the use of any other similar technology, technique or standard that may achieve the required emission standards and is demonstrated to the Agency to satisfy the requirement of BAT.

2.3 BAT HIERARCHY

In the identification of BAT, emphasis is placed on pollution prevention techniques rather than end-of-pipe treatment.

The IPPC Directive 96/61/EC and the Environmental Protection Agency Acts 1992 to 2007 (Section 5(3)), require the determination of BAT to consider in particular the following, giving regard to the likely costs and advantages of measures and to the principles of precaution and prevention:

(i) the use of low-waste technology,

(ii) the use of less hazardous substances,

(iii) the furthering of recovery and recycling of substances generated and used in the process and of waste, where appropriate,

(iv) comparable processes, facilities or methods of operation, which have been tried with success on an industrial scale,

(v) technological advances and changes in scientific knowledge and understanding,

(vi) the nature, effects and volume of the emissions concerned,

(vii) the commissioning dates for new or existing activities,

(viii) the length of time needed to introduce the best available techniques,

(ix) the consumption and nature of raw materials (including water) used in the process and their energy efficiency,

(x) the need to prevent or reduce to a minimum the overall impact of the emissions on the environment and the risks to it,

(xi) the need to prevent accidents and to minimise the consequences for the environment, and

(xii) the information published by the Commission of the European Communities pursuant to any exchange of information between Member States and the industries concerned on best available techniques, associated monitoring, and developments in them, or by international organisations, and such other matters as may be prescribed.

3. SECTOR COVERED BY THIS GUIDANCE NOTE

This Guidance Note covers the following activities under the First Schedule of the Environmental Protection Agency Acts 1992 to 2007:

8.5.1 The pre-treatment (operations such as washing, bleaching, mercerisation) or dyeing of fibres or textiles where the treatment capacity exceeds 10 tonnes per day.

8.5.2 The dyeing, treatment or finishing (including moth-proofing and fireproofing) of fibres or textiles (including carpet) where the capacity exceeds 1 tonne per day of fibre, yarn or textile material, not included in paragraph 8.5.1.

4. PROCESS DESCRIPTION, RISK TO THE ENVIRONMENT AND CONTROL TECHNIQUES

(Note: any reference to BREF in this document means the reference document on *Best Available Techniques for the Textile Industry, final document, published by the European Commission*, July 2003.)

4.1 DESCRIPTION OF PROCESS

This document covers the processing of textiles at the levels specified in Section 3 of the document. It covers those activities in the textile industry that involve wet processes.

The BREF document describes the sector under NACE 1997 classifications:

- Textile processing
- Industrial and other textiles (including Carpets and Wool Scouring)
- Home textiles

It also describes the principle operations involved. These are related to specific textile types.

4.1.1 Textile Types Covered

Eleven types of materials are included in the BREF (see BREF Sections 2.1.1 & 2.1.11). These are: polyester fibres, polyamide fibres, acrylic fibres, polypropylene fibres, elastane viscose, cupro, acetate, wool, silk, cotton and flax.

4.1.2 Chemicals and Auxiliaries

The BREF document (see BREF Section 2.1.2) reports more than 7,000 commercial products, based on 400 to 600 active ingredients.

4.1.3 Materials Handling and Storage

Section 2.1.3 of the BREF document outlines handling of basic fibrous raw materials, and basic chemical intermediates, and discusses metering, dilution, mixing, etc., as well as some protective measures.

4.1.4 Man-made Fibres - Fibre Manufacturing

Section 2.2 of the BREF document outlines the basic processes for manufacture of man-made fibres. These include melt spinning, dry spinning, and wet spinning, as well as drawing, texturing, crimping, cutting, and drying.

4.1.5 Natural Fibres – Fibre Preparation

BREF Sections 2.3.1 to 2.3.3 describe the preparation processes for wool, cotton, flax, and silk.

- Wool

  The standard processes described include opening and de-dusting, and scouring (with water), as well as scouring with solvents. The latter is not common. The water scouring process involves the washing with detergents and alkalis, as well as rinsing. The operations are typically carried out between 55^{o}C and 70^{o}C. The detergents used are normally synthetic non-ionic surfactants. Solvent cleaning and washing is described in Section 2.3.1.3 of the BREF, but is not included in this document, since the operations are so rare.

- Cotton and Flax

  Cotton is cleaner than wool, and hence initial operations are mainly dry (see BREF Section 2.3.2).

  Flax retting is a wet process, which can result in waste waters with a high BOD and COD content (see BREF Section 2.3.2).

- Silk

  The filament is submitted to a pre-treatment process to remove the silk gum (see BREF Section 2.3.3).

4.1.6 Yarn Manufacturing

- Section 2.4 of the BREF document describes the wool spinning process and the cotton spinning process – the latter also being used for man-made fibres.
- For the wool spinning process the operations are: combing, drawing and spinning (worsted process), carding and spinning (woollen process). In both the yarn is then twisted (if required), and prepared for further processing (e.g. by addition of lubricants).

4.1.7 Cloth Production

Spun and filament yarns are converted to: woven textiles, knitted textiles, and floor-coverings and non-woven fabrics (typical of the carpet industry).

- Woven textiles (see BREF Section 2.5.1):
  - Warping (winding onto beams)
  - Sizing (application of water solutions or dispersions for lubrication and protection. These are starches or synthetic polymers)
  - Weaving (assembly on a loom)
- Knitted textiles (see BREF Section 2.5.2):
  - Waxing (lubrication, usually with paraffin wax)
  - Knitting (knotting of yarn together with a series of needles)
- Textile floor coverings are the composite substrates made up of (see BREF Section 2.5.3):
  - A carrier layer
  - A pile yarn or face fabric
  - A pre-coating layer
  - A coating layer

  Carpets may be tufted, needle-felt, or woven.

4.1.8 Pretreatment

Pretreatment is carried out in order to remove foreign materials and ensure uniformity, improve the ability to absorb dyes, and relax tensions in synthetic fibres (see BREF Section 2.6). Pre-treatment comes immediately before dyeing (and printing).

The main pre-treatment steps for different fibres are:

- Cotton and cellulose fibres:
  - singeing (protruding fibres are removed by passing through a gas flame and quenching)
  - desizing and scouring; removal of sizing compounds by a variety of techniques (see BREF Section 2.6.1.1)

- Mercerising; to improve strength, dimensional stability, lustre, and dye uptake (see BREF Section 2.6.1.1)
- Bleaching (an obligatory step when material has to be dyed in pastel colours. Bleaching agents include hydrogen peroxide, sodium hypochlorite, sodium chlorite, peracteic acid, and optical brightening agents).

- Wool preparation before colouring

  Typical processes (see BREF Section 2.6.2) include:

  - Carbonising (removal of vegetable materials by treatment with a mineral acid – usually sulphuric acid)
  - Scouring (removal of spinning oils and sizing agents by washing with water containing detergents and a weak alkali, or by dry-cleaning. The latter is not so common)
  - Fulling (submission to friction under hot humid conditions to produce felting)
  - Bleaching (using hydrogen peroxide with an additional reductive bleaching, using foe example sodium dithionite)

- Silk pretreatment

  The processes of scouring, and weighting (see BREF Section 2.6.3)

  - Scouring (removal of sericin, natural oils, and organic impurities. Treatment in alkaline conditions is by far the most common)
  - Weighting (replacement of the weight loss due to sericin removal using tin tetrachloride, or grafting of vinyl monomers onto the silk).

- Pretreatment of Synthetic materials

  The processes of washing and thermofixing (see BREF Section 2.6.4)

  - Washing (removal of preparation agents or sizing agents using surfactants, complexing agents, or alkali)
  - Thermofixation (heat setting).

4.1.9 Dyeing

The BREF document describes the general principles of dying in (see BREF Section 2.7). More detailed information is given in annexes, namely Sections 8.6, 9, and 10.

Colour may be applied to a textile material by:

- Mass dyeing/gel dyeing: dye incorporated into a synthetic fibre during its production
- Pigment dyeing: insoluble pigment deposited onto the textile and then fixed with a binder
- Diffusion of a dissolved or partially dissolved dye into the fibre.

Dyeing can be carried out in batch or in continuous/semi-continuous mode. All involve the following steps:

- Preparation of the dye
- Dyeing
- Fixation
- Washing and drying

A wide range of dyestuffs can be used, namely

- Cellulose fibres
  - Reactive
  - Direct

- Vat
- Sulphur
- Azoic (napthol)

- Wool
  - Acids (metal free)
  - Chrome
  - 1:1 and 1:2 metal complex
  - reactive
- Silk
  - As for wool but excluding the 1:1 metal complex dyes. In addition, direct dyes can be used.
- Synthetic fibres

  Depending on the type of fibre, differing techniques can be used. These include:
  - Disperse dyes
  - Acid dyes
  - Metal-complex dyes
  - Reactive dyes
  - Cationic dyes

4.1.10 Printing

As opposed to dyeing, which colours the whole substrate, printing applies colour only to certain areas to produce a pattern. Printing may be carried out using pigments (e.g. cellulose printing), or more commonly with dyes.

4.1.10.1 Chemicals used

Printing pastes are complex and, as well as pigments, incorporate a range of auxiliaries, such as:

- Oxidising agents (e.g. m-nitrobenzenesulphonate, sodium chlorate, hydrogen peroxide)
- Reducing agents (e.g. sodium dithionite, formaldehyde sulphoxylates, thiourea dioxide, tin (II) chloride)
- Discharging agents (e.g. anthraquinone)
- Substances with hydrotropic effect, e.g. urea
- Dye solubilisers (e.g. glycerine, ethylene glycol, butyl glycol)
- Resists for reactive resist printing (e.g. sulphonated alkanes)
- Defoamers (e.g. silicon compounds).

4.1.10.2 Printing equipment

Various types of printing equipment are used, including:

- Flat-screen printing
- Rotary-screen printing
- Roller printing
- Jet printing.

4.1.10.3 Finishing

Finishing covers a number of operations, which may be employed at the end of processing. These include:

- Easy-care treatments
- Water-repellent treatments
- Softening treatments
- Flame-retardant treatments
- Anti-static treatments
- Mothproofing treatments
- Bactericidal and fungicidal treatments
- Anti-felt treatments
- Oxidising treatments.

4.1.10.4 Coating and laminating

The basic steps in coating and laminating are as follows:

- The fabric is supplied full-width on a roll
- The fabric is fed under tension control to a coating or laminating heat zone
- After application of the coating auxiliary, the fabric is passed to a curing oven and then cooled.

4.1.10.5 Carpet back-coating

The following types of coating are used:

- Pre-coating
- Foam coating
- Textile back-coating
- Heavy coating
- Reinforcement
- Back finish.

4.1.10.5 Washing

Washing includes both washing with water and dry-cleaning (washing with solvent). The former basically consists of washing in warm water, using detergents, followed by rinsing. The latter is carried out in both open circuit and closed circuit machines.

4.1.10.6 Drying

Drying is a high energy producing step. Various drying techniques are employed in the industry. Examples include:

- Centrifugal extraction
- Mangling
- Evaporative drying
- Using a stenter (continuous hot air full drying machine)
- Hot-flue drying
- Contact drying (heated cylinder)
- Conveyor fabric dryer
- Airo-drying (specific machine for washing, softening, and drying on woven and knitted fabrics in rope form).

4.2 RISK TO THE ENVIRONMENT

The key environmental issues for the processing of textiles are emissions to water and water consumption, emissions to air, energy use, raw material consumption, and site remediation after cessation.

Of these emissions to water is the most important concern.

4.2.1 Water Consumption

Water is used in the process itself and for cooling requirements where necessary. It is used in almost all operations: scouring, sizing, dyeing, rinsing, washing, etc. Water ratios can vary, depending on operations: for example from 2–12 litres water / kg greasy wool in wool scouring and from 15–30 l/kg for yarn package dying and 30-60 l/kg for yarn package dye rinsing (see BREF Sections 3.2.1, 3.3.1.6, 3.3.5.3, 3.3.3.5.5, 3.4.1.1, & 3.4.1.2).

4.2.2 Emissions to Water

Emissions to water are considered the biggest environmental concern in the textile processing industry. This is because of the high water usage rates, but also because of the range of dyestuffs, auxiliary chemical additions, and their properties. Inherent contaminants, such as grease and vegetable contaminants, as well as oils used in the process are also major contributors.

Consequently, a range of parameters must be measured and controlled. These include BOD, COD, suspended solids, pH, organochlorines, organophosphates, toxicity, nitrogen, and selected metals and non-metals. In addition, colour can be a problem arising from the dyeing operation.

Nearly 90% of the organic raw material load entering the textile process ends up in the wastewater, the remaining amount being released to air.

4.2.3 Energy Use

The main areas of these processes where energy is consumed are in the heating of various baths (scouring, sizing, dyeing, rinsing, etc.), and in drying. Energy use can be high – for example, energy use for scouring may range fro 4.28 to 19.98 MJ/kg. This is closely related to water consumption.

4.2.4 Raw Material Consumption

A diversity of raw materials is consumed in these processes. These include auxiliary chemicals and dyestuffs, as well as natural substances such as greases. Up to 7,000 different chemicals may be used. The input of chemicals and auxiliaries added to the process can be up to 1 kg per kg of processed textiles (see BREF Sections 8 & 9). Section 1.4 of the BREF lists a number of specific chemicals due to their potential negative effects on the environment. These are: alkyl phenol ethoxylates, polybrominated diphenyl ethers and chlorinated paraffins, halogenated phenols and benzenes, mothproofing agents such as permethrin and cyfluthrin, sequestering agents such as EDTA, DTPA and NTA, chlorine and chlorine releasing compounds such as sodium hypochlorite and sodium dichloroisocyanurate, metal contaning compounds such as potassium dichromate, substances with carcinogenic potential, such as a number of aromatic amines, formed by the cleavage of some azo dyes, or vinylcyclohexene and 1,3 butadiene, carriers such as trichlorobenzene, o-phenlyphenol, etc.

It is estimated that more than 90% of organic chemicals and auxiliaries in pre-treatment and dyeing operations do not stay on the fibre, whereas the reverse is true in the finishing process. Nearly 90% of the organic raw material load entering the textile process ends up in the waste water, the remaining amount being released to air.

4.2.5 Waste

Wastes include solids, consisting mainly of sludges from on-site wastewater treatment, and spent solutions. The majority of process wastes would be classified as hazardous. Processes such as linishing and polishing would give rise to dust waste. Mills, which treat their wastewater by flocculation/precipitation, may produce 150-750 g waste/kg finished product. Waste yarns, fabrics are usually recycled.

4.2.6 Emissions to Air

Air emissions can include VOCs where solvents are used (e.g. in pigment printing pastes, cleaning with organic solvents, heat treatments, such as thermofixation, drying, curing). Emissions of CO_2, NO_X, SO_X, and particulates arise from on-site burning of fossil fuels to produce energy. Some particulates are also associated with loom operations.

4.2.7 Other Emissions

Other sources of emissions can include noise and odour but in general these are usually not significant for the processes involved. Some processes in the textile industry can be accompanied by odour emissions (see BREF Tables 3.59 & 3.60).

This Guidance Note does not cover noise emission sources. For guidance on measures in relation to noise, have regard to the Agency Guidance Note: Noise in Relation to Scheduled Activities.

4.3 CONTROL TECHNIQUES

The existing or possible measures for eliminating, reducing and controlling emissions from the textile-processing sector are described in this Section. References to more detailed descriptions in the BREF document are given.

4.3.1 General Preventive Techniques

The following general techniques can be applied to all activities involving Textile Processing Sector

- General Good Management Practices. These include: education and training of employees, equipment maintenance, operations audits, good practices in the storage, handling, dosing, and dispensing of chemicals, and improved knowledge of the chemicals and raw materials used (see BREF Section 4.1.1).

4.3.1.1 Minimisation / optimisation of chemicals used

As a first approach, the following general techniques should be used:

- Avoid the use of chemicals altogether, where the desired process result can be achieved without them
- Where this is not possible, adopt a risk-based approach to chemical selection.

These general principles lead to a series of possible measures, as follows:

- Regularly revise recipes to identify unnecessary chemicals
- Give preference to chemicals based on their environmental parameters (biodegradability, low toxicity, etc.) (see BREF Sections 4.3.1 & 4.3.2)
- Improve parameters such as process control, batch time, etc.

- Avoid/minimise surplus chemical use (e.g. by automated dosing)
- Optimise schedule (e.g. light shades before darker ones)
- Reuse mother baths where possible
- Recover vapour during delivery of volatile substances
- Bottom load to avoid splashing.

4.3.1.2 Minimisation of Water and Energy Consumption

Optimal use of water and energy should start from monitoring of water, heat, and power consumption (see BREF Section 4.1.2).

For wet processes, water and energy consumption are often related, because, to a great extent, energy is used to heat process baths.

The following techniques can minimise water and energy use in all activities involving wet textile processing:

- Installation of flow control devices and automatic stop valves
- Installation of automatic controllers for fill volume and temperature
- Substitution of overflow flood rinsing with smart rinsing
- Optimisation of scheduling (e.g. light shades before dark shades)
- Adjustment of pre-treatment to downstream quality requirements (e.g. bleaching is often not necessary if dark shades are produced)
- Combination of different wet treatments in one step (e.g. combined scouring and desizing) (see BREF Section 4.5.3)
- Water re-use (e.g. re-use of rinse water) (see BREF Section 4.6.22)
- Re-use of cooling water as process water and for heat recovery.

The following options are focussed specifically on energy savings:

- Insulation on pipes, valves, tanks, machines, etc. (see BREF Section 4.1.5)
- Optimisation of boiler house (condensate return, preheating of air supply, heat recovery from combustion gases)
- Segregation of hot and cold streams to facilitate heat transfer
- Installation of heat recovery system on waste off-gases (see BREF Section 4.8.1)
- Installation of frequency controlled electric motors
- Control of moisture content in circulating air and on textile instenters (see BREF Section 4.8.1)
- Proper adjustment of drying/curing temperatures and times.

4.3.2 Preventive Techniques for Specific Processes

The following preventive techniques can be applied to the stated textile processing activities.

4.3.2.1 Optimisation of Water Consumption

Because the sector is a water-intensive one, this is an important area. Many of the techniques are generic. Process specific analysis incorporates monitoring/recording at a machine process level. Maintenance and calibration is therefore important.

Overfilling and water displacement during fibre immersion can be reduced if automated ones replace manual procedures. 20% savings in water can be made.

Continuous dyeing is less water intensive than batch dyeing. Even in continuous mode, however, water intensity can be reduced by use of fluidyer, foam, or flexnip systems (see BREF Section 10.4.2). Liquor ratios can also be reduced in batch dyeing, by investment in appropriate technology (see BREF Sections 2.7.8.2 & 4.6.19).

Washing generally consumes more water than treatment. For both continuous and batch washing, machine manufacturers and dyestuff suppliers have made improvements (see BREF Sections 4.9.1 & 4.6.19). Major developments include transfer of typical continuous functions to batch operations. Examples are:

- In-process separation of the bath from the substrate
- In-process separation of the process liquor from the washing liquor
- Mechanical liquor separation to reduce carry-over and improve washing efficiency
- Internal countercurrent flow in the batch process
- Combining several steps, such as scouring /desizing, scouring /desizing / bleaching.

Re-use of water is now possible in batch operations. Machines are available with built-in facilities for waste stream segregation and capture (see BREF Sections 4.6.22 & 4.7.7).

4.3.3 Substitution Techniques

A major tenet of prevention is material substitution. There follows, a series of examples of such measures.

4.3.3.1 Man-made fibre preparation agents

Since man-made fibres cannot be manufactured without the use of auxiliaries, these should be examined. Synthetic additives can sometimes replace conventional mineral oil auxiliaries (see BREF Section 4.2.1).

4.3.3.2 Mineral oil substitution in wool spinning lubricants

The presence of such lubricant affects primarily emissions to water. Spinning oils and detergents may contribute up to 80% of the oxygen demand in dyehouse waste waters. Conventional mineral oils (which are not fully biodegradable) may be replaced by formulations based on glycol.

4.3.3.3 Mineral oil substitution in Knitted fabric Manufacture

Because of the use of needles, high levels of lubricant are required. These are conventionally mineral oils, which require removal by emulsification using detergents, emulsifiers, and antiredeposition agents. Hydrosoluble oils offer an easily washed out, biodegradable alternative, provided that the fabric is processed in a high efficiency washing machine (e.g. TVE-Escalé type).

4.3.3.4 Selection of Sizing Agents with Improved Environmental performance

Desizing accounts for 30-70% of overall COD load, and often produces difficult to degrade substances. Readily biodegradable/bioeliminable sizing agents are widely available. These are modified starches, galactomannans, polyvinyl alcohol, and certain polyacrylates. Specifically, latest generation polyacrylates can supply almost all the known requirements.

4.3.3.5 Insulation of High temperature Machines

It is reported that insulation can save up to 9% of total energy requirement on wet processing machines. An integrated approach is preferable to ad hoc measures.

4.3.3.6 Substitution for hazardous surfactants

The use of alkylphenol ethoxylate – free auxiliaries reduces toxicity and can improve effluent treatability.

4.3.3.7 Selection of biodegradable/bioeliminable complexing agents in pre-treatment and dyeing.

Several substitution examples are given in BREF Section 4.3.4.

4.3.3.8 Wool scouring with organic solvent

Results in pesticide free clean wool (see BREF Section 4.4.4).

4.3.3.9 Application of the oxidative route for efficient universal size removal

Use of hydrogen peroxide can remove all sizes, unlike, for example, enzymatic desizing which removes only starches. Use of H_2O_2 reduces water and energy consumption and improves effluent treatability (see BREF Section 4.5.2).

4.3.3.10 Enzymatic scouring

Replacement of traditional scouring agents by enzymes operating at mild conditions eliminates the need for sodium hydroxide and reduces rinse water consumption, as well as BOD and COD load (see BREF Section 4.5.4).

4.3.3.11 Substitution for sodium hypochlorite and chlorine containing compounds in bleaching operations

Use of hydrogen peroxide instead of hypochlorite results in no generation of carcinogenic adsorbable organic halogens (AOXs) (see BREF Section 4.5.5).

4.3.3.12 Exhaust dying of polyester and polyester blends with carrier free dyeing techniques or with the use of environmentally optimised carriers

Carriers are absorbed to a great extent into PES fibre. In dyeing and rinsing, a significant amount of carriers is emitted to waste water, and the remaining fraction may be emitted to air during subsequent drying, heatsetting and ironing. The application of High Temperature (HT) dyeing processes avoids the use of carriers.

However, due to the sensitivity of the wool substrate to high temperatures, it is still necessary to use carriers when dyeing polyester blends. In these cases chlorine-free substances based on benzylbenzoate and N-alkylpthalamide replace hazardous carriers. (see BREF Section 4.6.1).

4.3.3.13 Use of non-carrier PES fibres

Section 4.6.2 of the BREF document describes the properties of alternative polymers, such as polytrimethylene terepthalate (PTT).

4.3.3.14 Dispersing agents with higher bioeliminability in dye formulations

Dispersing agents do not have an affinity for the fibre and are, therefore, found in the final effluent. They are also added in significant amounts and have low biodegradability. They thus contribute to most of the recalcitrant organic load from dyeing and printing (see BREF Section 4.6.3).

4.3.3.15 After-treatment in PES dyeing

A dyeing after-treatment is required to ensure colourfastness in PES fibres and PES blends. This uses a reductive technique at temperatures lower than dyeing temperature and entails pH change and several rinses. Using an alternative reducing agent or dyes that can be cleared in alkaline medium by hydrolytic solubilisation, instead of reduction, affords significant water and energy savings, and/or lower oxygen demand in the wastewater (see BREF Section 4.6.5).

4.3.3.16 Dyeing with sulphur dyes

Sulphur dyes are used in dyeing cotton in medium to dark shades. Excess of sulphide from the dyestuff and reducing agent is responsible for aquatic toxicity and odour nuisances. Section 4.6.6 of the BREF document describes a range of new sulphur dyes and reducing agents, which improves the situation.

4.3.3.17 Enzymatic after-soaping in reactive dyeing

In reactive dyeing and printing, unreacted and hydrolysed dye is removed by a number of soaping and rinsing steps. These contribute significantly to energy, water, and chemical consumption. Section 4.6.8 of the BREF document describes an enzymatic treatment to remove the non-fixed dyestuff from the fibre and the exhausted dye bath.

4.3.3.18 Silicate-free fixation method for cold pad batch dyeing

Sodium silicate is often used in cold-pad batch dyeing, mainly to increase the pad liquor stability and to avoid selvage carbonisation. Use of sodium silicate gives rise to a number of problems, both with the textile surface and the effluent. Silicate-free alternatives are now available (see BREF Section 4.6.9).

4.3.3.19 Exhaust dyeing of cellulosic fibres with high-fixation polyfunctional reactive dyestuffs

Bifunctional reactive dyes offer improved levels of fixation in exhaust dyeing, resulting in reduced loss of dye in the effluent. The fixation of monofunctional reactive dyes with cellulose is approximately 60% with 70% exhaustion. With bifunctional dyes, 80% fixation rate and over 90% exhaustion rate is achieved (see BREF Section 4.6.10).

4.3.3.20 Chromium-free dyeing of wool

Section 4.3.4.14 of this BAT document describes low-chrome dyeing. Until recently, the use of chrome dyes was thought of as unavoidable for certain types of wool articles, in particular for dark shades. Quite recently, new reactive dyestuffs have been put on the market that can provide levels of fastness comparable to those achievable with chrome dyes (see BREF Section 4.6.16).

4.3.3.21 Urea substitution and/or reduction in reactive printing

Urea is used in reactive printing paste (up to 150 g/kg paste) and in printing pastes for vat dyes (25 g/kg paste). It can be substituted or reduced by controlled addition of moisture, applied either as foam or by spraying a defined quantity of water mist. This results in reduction in the discharge of urea, ammonia, and nitrate (see BREF Section 4.7.1).

4.3.3.21 Formaldehyde-free or formaldehyde-poor easy-care finishing agents

Easy-care finishing is mainly carried out on cellulosic fibres and their blends. The compounds used are synthesised from urea, melamine, cyclic urea derivatives and formaldehyde. The process may release free formaldehyde in both the process and on the fabric. The European eco-label scheme sets a limit of 30 ppm for products that come into contact with the skin. Low-formaldehyde and formaldehyde-free products are available, along with optimised catalysts (see BREF Section 4.8.2).

4.3.3.22 Use of fully closed-loop installations for fabric washing (scouring) with organic solvent

Organic solvents can be used instead of water for scouring operations. They offer advantages in terms of energy use (lower specific heat and latent heat of vaporisation), water consumption, auxiliary use, and organic load to waste-water treatment. However, they have potential for air and water emissions, as well as waste, and so require specific recovery equipment (e.g. closed-loop charcoal filters, air or steam strippers and adsorption, sludge stills) (see BREF Section 4.9.3).

4.3.4 Reduction Techniques

In the Prevention hierarchy, reduction follows elimination and substitution. The following reduction techniques are important:

4.3.4.1 Minimising Sizing Agent Add-on by pre-wetting the Warp Yarns or by compact spinning

Lower quantities and better uniformity of sizing can be achieved by running warp yarn through hot water followed by squeeze rollers before sizing. Similarly, reductions of as much as 50% can be achieved by pneumatic compaction of fibres.

4.3.4.2 Minimisation of organochlorine, organophosphate and synthetic pyrethroid ectoparasiticides by substitution

The former are not legal in many places and so are difficult to control. The latter are difficult to substitute, due to lack of uniformity in their use. Manufacturers and producers should engage in dialogue.

4.3.4.3 Emission Factor Concept (emissions to air)

Auxilliary based substance emission factors make it possible to calculate emissions from a given recipe. Hence reduction measures can be adopted (see BREF Annex IV for typical emission factors, & Table 3.44 for sample calculation).

4.3.4.4 Use of integrated dirt removal/grease recovery loops in wool scouring

These measures can result in water use reduction of 25%-50% (see BREF Section 4.4.1). Using a closed loop system combined with evaporation and incineration, allows recovery of water and energy (see BREF Section 4.4.2).

4.3.4.5 Minimising energy consumption in wool scouring

Fitting a heat exchanger to the dirt/grease recovery flowdown is recommended. Other techniques are outlined in Section 4.4.3 of the BREF document.

4.3.4.6 One step de-sizing, scouring and bleaching of cotton fabric

New auxiliaries formulations and automatic dosing allow combination of the three operations, resulting in significant reductions in water and energy use (See BREF Section 4.5.3).

4.3.4.7 Minimising consumption of complexing agents in hydrogen peroxide bleaching

Section 4.5.6 of the BREF document outlines the chemistry and techniques involved.

4.3.4.8 Optimisation of cotton warp yarn pre-treatment

Optimisation leads to reduced water consumption (see BREF Section 4.5.8).

4.3.4.9 One-step continuous vat dyeing in pastel to pale shades

A reduction from six to three steps, using specially selected vat dyes with a low tendency to migration (see BREF Section 4.6.4).

4.3.4.10 Minimisation of dye liquor losses in pad dyeing techniques

Main emissions in pad dyeing come from discharge of the residual dyeing liquor in the pad, pumps and pipes at the end of each lot. Reduction of these losses can be achieved by (see BRE Section 4.6.3):

- Carrying out the impregnation step in a nip
- Minimising the capacity of the dip trough
- Controlled dosage of the input raw materials
- Dosing of the padding liquor based on measurement of the pick up.

4.3.4.11 Exhaust dyeing with low-salt reactive dyes

Exhaust dyeing of cellulosic fibres requires high amounts of salt to improve exhaustion. Several dye manufacturers have developed innovative dye ranges and application processes that only need about two-thirds as much salt (see BREF Section 4.6.11).

4.3.4.12 Omitting the use of detergents in after washing of cotton dyed with reactive dyes

Many dyehouses carry out hot rinsing and omit the use of detergents in rinsing after reactive dyeing. Product quality is not negatively affected and there is a reduction in material consumption and pollutant load (see BREF Section 4.6.12).

4.3.4.13 Alternative process for continuous (and semi-continuous) dyeing of cellulosic fabric with reactive dyes

An alternative process, which requires no additional substances such as urea, sodium silicate and salt, or long dwell time to fix the dyes (see BREF Section 4.6.13).

4.3.4.14 pH-controlled dyeing techniques

Fibres such as wool, polyamide and silk contain weak acid and weak base groups, and thus show zwitterionic characteristics at pH levels close to the isoelectric point. Such fibres can be dyed by imposing a pH profile at iso-temperature, instead of a temperature profile at iso-pH. This allows avoidance of special organic levelling agents, as well as lower time and energy use (see BREF Section 4.6.14).

4.3.4.15 Low-chrome and ultra-low-chrome afterchroming methods for wool

Chrome dyes represent about 30% of the global market. In the application of chrome dyes, inefficient chroming methods can lead to the discharge of chromium in spent dye liquors. The use of low-chrome (stoichiometric) and ultra-low (substoichiometric) chrome dyeing techniques helps minimise the amount of residual chromium in the effluent (see BREF Section 4.6.15).

4.3.4.16 Emission reduction in dyeing wool with complex dyestuffs

In the dyeing of wool fibre and combed tops, in cases where afterchrome substitution is not possible, metal complex dyes can be used under optimised conditions (especially pH control). Alternative auxiliaries and acids are used. This results in higher fixation and exhaustion rates (see BREF Sections 4.6.1.17 & 4.3.4.1.4).

4.3.4.17 Use of liposomes as auxiliaries in wool dyeing

Using liposomes as auxiliary products in wool dyeing allows good dyebath exhaustion, eliminates the use of electrolytes, reduces energy consumption, and results in lower COD in the waste-water (see BREF Section 4.6.18).

4.3.4.18 Equipment optimisation in batch dyeing

Conservation of energy, water and chemicals is improved by using new machine technologies. Key factors are: liquor ratio, rinsing efficiency, and cycle duration. Additional features include: automated dosing and cycle control, automated liquor level and temperature control, indirect heating and cooling, and full closure of machines (see BREF Section 4.6.19).

4.3.4.19 Equipment optimisation applied to winch beck dyeing machines

Winch beck dyeing machines are important in dyeing in piece voluminous textiles, such as carpets, upholstery, terry towels, and tubular fabrics (see BREF Section 4.6.20).

4.3.4.20 Equipment optimisation applied to jet dyeing machines

New concepts have been introduced in jet machines, which can significantly improve not only the productivity, but also the environmental performance of the dyeing process for fabrics that are treated in rope form.

Section 4.6.21 of the BREF document describes these improvements according to the following categories:

- Airflow jet dyeing machines (See BREF Section 4.2.21.1)
- Soft-flow dyeing machines with no contact between the bath and the fabric (see BREF Section 4.2.21.2)
- Single-rope flow dyeing machines (see BREF Section 4.2.21.3).

4.3.4.21 Reactive two-step printing

Section 4.3.3.21 of this BAT document describes urea substitution in conventional one-step printing with reactive dyes. An alternative is to use a two-step process, consisting of:

- Padding of the printing paste
- Intermediate drying
- Padding with alkaline solution of fixating agents
- Fixation by means of superheated steam
- Washing

The process is carried out without urea (see BREF Section 4.7.2).

4.3.4.22 Volume minimisation of printing paste supply in rotary screen printing machines

The volume of rotary screen printing systems depends on the diameter of the pipes and the squeegee as well as on the pump design and the pipe length. The volume of the supply system is extremely significant and may even exceed the amount of paste printed on the fabric. Printing paste systems have to be cleaned at each change of colour or pattern, resulting in a considerable amount of printing paste entering the wastewater.

Optimised systems use smaller components and thus require smaller volumes in the system (see BREF Section 4.7.4).

4.3.4.23 Reduction of water consumption in cleaning operations

The equipment used around screen printing machines requires careful cleaning before it can be used for new colours. There are several ways of reducing water consumption, as follows (see BREF Section 4.7.7):

- start/stop control of the printing belt
- mechanical removal of printing paste
- re-use of the cleanest part of the rinsing water from the cleaning of the squeegees, screens, and buckets
- re-use of the rinse-water from the cleaning of the printing belt.

4.3.4.24 Digital jet printing of carpet and bulky fabric

Jet printing today is a full digital technique, resulting in reduced water consumption, less trial and error and reduction of material losses (see BREF Section 4.7.8).

Inkjet printing can be used for applying colour to the surface of light fabrics. It is currently only suitable for small runs and requires pre-application of urea. The main environmental benefit is that dye residues are minimised (see BREF Section 4.7.9).

4.3.4.25 Minimisation of energy consumption in stenter frames

It is estimated that in fabric finishing, each textile substrate is treated on average 2.5 times in a stenter (e.g. for heat setting, drying, thermosol processes and finishing).

Energy savings are achieved by a number of techniques, as follows (see BREF Section 4.7.9):

- Optimising exhaust airflow through the oven
- Heat recovery
- Insulation
- Choice of heating system (direct and indirect)
- Burner technology
- Optimised nozzles and air guidance systems.

4.3.4.26 Avoiding batch softening

In batch processing, softening agents are often applied after dyeing, directly in the dyeing machine. This limits the choice of softening agents to environmentally harmful cationic agents and also results in losses. Alternative techniques are the application of softeners by pad mangles or by spraying and foaming applications. Cationic softening agents can be avoided and chemical losses are reduced (see BREF Section 4.8.3).

4.3.4.27 Minimisation of emissions in the application of mothproofing agents

Section 4.8.4 of the BREF document gives a comprehensive description of the problems associated with the application of insect repellents (mothproofing agents). The description includes general techniques for the reduction of emissions, as well as specific modifications for different processes.

The techniques listed take the following forms (see BREF Section 4.8.4):

- General practices applicable to the majority of processes, e.g. material handling and storage and selection of the correct application rate
- Specific process modifications which include, for example, changes to the chemistry of the process or the substitution of interfering chemicals
- Alternative processes such as the use of specialised machinery dedicated to insect-repellant application
- On-site pre-treatment of specific waste water streams.

4.3.4.28 Water and energy conservation in batch washing and rinsing

Optimisation of washing efficiency can conserve considerable amounts of water and energy.

In batch processes typical washing and rinsing techniques include:

- Drain and fill rinsing
- Overflow or "flood" rinsing.

Of these, drain and fill is the more efficient. Lower liquor ratios and more rinses improves the situation.

Smart rinsing is a further improvement. It is a variation on overflow rinsing. It requires lower liquor ratios and operates with an outlet weir lower than in the traditional system, as well as matching feed to outlet rates (see BREF Section 4.9.1).

4.3.4.29 Water and energy conservation in continuous washing and rinsing

In continuous operating mode, washing after dyeing printing, etc. consumes greater quantities of water than the dyeing and printing steps themselves. Water and energy conservation can be achieved by increasing rinsing efficiency and by good housekeeping measures. The main efficiency measures are (see BREF Section 4.9.2):

- Water flow control (e.g. water metres, automatic stop valves)
- Increasing washing efficiency, including counter-current rinsing and reduction of carry-over into the next step
- Use of heat recovery systems.

4.3.5 Techniques for Recovery and Recycling

4.3.5.1 Recovery of sizing agents in pre-treatment by ultrafiltration

Sizing agent concentrations of 20-30 g/l are increased to 150-350 g/l. This allows re-use of the concentrate in sizing. The permeate can be re-used as washing machine water (see BREF Section 4.5.1).

4.3.5.2 Recovery of alkali from mercerising

Cotton yarn is mercerised with caustic soda. The textile substrate is then rinsed resulting in 'weak lye' with lower caustic soda concentration. This can be concentrated by evaporation for re-use (see BREF Section 4.5.7).

4.3.5.3 pH controlled dyeing techniques

The technique outline in section offers new opportunities for recycling and recovery of spent dye baths, because dyeing can be started at the "treatment temperature".

4.3.5.4 Water re-use/recycling in batch dyeing processes

Dyebath reconstitution and subsequent re-use or re-use of rinse water presents opportunities for minimisation of water consumption. Several techniques may be used (see BREF Section 4.6.22). However, the cooling and reheating of the bath can waste energy. This is due to the necessity (usually) to start the dyeing process at 50°C. New technologies allow dyeing to start at process temperatures by controlling the chemical potential of the dye. The technique is suitable for wool dyeing with acid dyes, acrylic dyeing, and for cotton in the case of sulphur dyeing or reactive exhaustion dyeing processes (see BREF Section 4.6.22).

4.3.5.5 Recovery of printing paste from supply system in rotary screen printing machines

Printing paste remaining in the supply system of rotary screen printing machines can be recovered by using a ball inserted into the system, transported to the end, and then pressed back by controlled air pressure after the print run. The paste can thus be collected for re-use (see BREF Sections 4.3.4.21 & 4.7.5).

4.3.5.6 Recycling of residual printing pastes

Printing pastes have traditionally been prepared manually, making it difficult to consistently re-use residues (because of uncertainties in their exact composition). Today, computer-aided systems offer more opportunities for recycling of the pastes. Since the compositions are stored electronically, the formulation of new pastes can take into account the amount, composition, and durability of the residues to be re-used (see BREF Section 4.7.6 which also briefly outlines a manual method of re-use of residuals).

4.3.5.7 Recycling of textile waste water by treatment of selected streams by membrane techniques

Membrane techniques can be used for the treatment of segregated streams to allow water reclamation and re-use closely integrated with the process. Section 4.10.4 of the BREF document outlines two case studies where membrane techniques are applied to effluents from dyeing operations.

4.3.5.8 Treatment and recovery of waste water containing pigment paste

For treatment of waste water pigment printing pastes (mainly from cleaning operations) with full re-use of permeate, the following steps have been described (see BREF Section 4.10.5):

- Coagulation to de-activate the organic dyes, binders and fixation agents
- Precipitation of the resulting coagulates
- Microfiltration of the precipitate.

The permeate is totally free of suspended solids and can be re-used for cleaning operations.

4.3.6 Treatment Techniques

Treatment of Waste Water

The following techniques can be applied to treat wastewater from activities involving Textile Processing.

4.3.6.1 Treatment of textile wastewater in activated sludge system with low food-to-micro organisms ratio (F/M)

Textile wastewater is a mixture of many different chemical compounds. These can broadly be classified into easily biodegradable, hardly biodegradable (recalcitrant), and non-biodegradable. The recalcitrant materials require a low F/M ratio (<0.15 kg BOD5/kg MLSS. D or even <0.05 for mineralisation below optimum temperatures). F/M is the most relevant design parameter. If they remain below the values given, hardly biodegradable materials are degraded. Almost complete nitrification is also achieved (see BREF Section 4.10.1).

Effluents containing non-biodegradable compounds should be pre-treated at source. In most cases, after the activated sludge process, further treatment steps are carried out (e.g. flocculation, precipitation adsorption) (see BREF Section 4.10.1).

4.3.6.2 Treatment of mixed waste water with about 60% water recycling

It involves an activated sludge process in a series of loop reactors and clarifiers. Lignite coke is added to improve the process, and then again to adsorb dyestuffs. Flocculation/precipitation is required to remove the lignite coke. Suspended solids and some organics are removed by filtration. About one-third of the water is discharged to river. The remainder is further treated (activated carbon / reverse osmosis) (see BREF Section 4.10.2).

4.3.6.3 Combined biological, physical, and chemical treatment of mixed wastewater effluent

The PACT system of combined biological, physical, and chemical treatment. The limitations of the activated sludge system have been outline in Section 4.6.2 of this BAT document (i.e. inability to cope with non-biodegradable materials). This uses activated carbon in the activated sludge system. The carbon is recovered and regenerated (see BREF Section 4.10.3).

4.3.6.4 Other Waste water treatment methods

The BREF document describes the following methods:

- Treatment of selected and segregated, non-biodegradable waste by chemical oxidation (see BREF Section 4.10.7)
- Waste water treatment by flocculation/precipitation and incineration of resulting sludge (see BREF Section 4.10.8).

Treatment of Air Emissions

4.3.6.5 Summary of techniques

The BREF document outlines the following abatement techniques (See BREF Section 4.10.9):

- Oxidation techniques (thermal incineration, catalytic incineration)
- Condensation techniques (heat exchangers)
- Absorption techniques (wet scrubbers)
- Particulates separation techniques (electrostatic precipitators, cyclones, fabric filters)
- Adsorption techniques (e.g. activated carbon adsorption).

5. BEST AVAILABLE TECHNIQUES FOR THE TEXTILES PROCESSING SECTOR

5.1 INTRODUCTION

As explained in Section 2, this Guidance Note identifies BAT but obviously does so in the absence of site-specific information. Accordingly, it represents the requirements expected of any new activity covered by the Note, and ultimately the requirement expected of existing facilities, but exclude additional requirements, which may form part of the granting of a licence for a specific site.

The technical feasibility of the measures listed below has been demonstrated by various sources. Used singly, or in combination, the measures represent BAT solutions when implemented in the appropriate circumstances. These circumstances depend on plant scale, process type, etc.

5.2 GENERIC BAT (WHOLE TEXTILE INDUSTRY)

For all activities involved in textile processing, BAT is to do the following as relevant.

5.2.1 Management

- Install an Environmental Management System
- Implement environmental awareness and include it in all training programmes
- Produce an annual waste minimisation report showing efforts made to reduce specific consumption together with material balance and fate of all materials
- Apply good practice for maintenance and cleaning
- Store each chemical according to the manufacturer's MSDS and the horizontal BREF on storage
- Put in place measures to deal with spillage in the following order
  - Avoid
  - Contain
  - Clean-up

  Note: it should be impossible for spillages to enter surface waters or sewer
- Implement a monitoring system for process inputs and outputs (site and process level).

5.2.2 Generic Prevention Measures

For all textile processing, BAT is to do the following:

5.2.2.1 Dosing

Install automated dosing and dispensing systems (see BREF Section 4.1.3).

5.2.2.1 Selection and use of materials

Where possible avoid the use of chemicals. Where not possible adopt a risk based approach (see BREF Sections 4.3.1 and 4.3.2 for some selection tools).

- For **surfactants,** substitute alkylphenol ethoxylates and other hazardous materials (see BREF Section 4.3.3)

- For **complexing** agents, avoid their use in pre-treatment and dyeing by
  - Softening of fresh water
  - Using a dry process to remove iron particles from the fabric before bleaching
  - Remove iron from inside fabrics by acid demineralisation or non-hazardous reductive agents (see BREF Section 4.5.6)
  - Apply hydrogen peroxide under optimal controlled conditions (see BREF Section 4.5.6)
  - Select biodegradable or bioeliminable complexing agents (see BREF Section 4.3.4)
- For antifoaming agents
  - Minimise or avoid their use by using bathless airjets or re-using treated bath
  - Select anti-foaming agents which are free of mineral oils and have high bioelimination rates (see BREF Section 4.3.5).

5.2.2.3 Selection of incoming raw materials

Table 5.1 of the BREF documents gives some criteria for such selection.

5.2.2.4 Water and energy management

BAT is to:

- Monitor water and energy consumption (see BREF Section 4.1.2)
- Install flow control devices and automatic stop valves on continuous machinery (see BREF Sections 4.1.4 & 4.9.2)
- Install automatic controllers for fill volume and temperature in batch machines (see BREF Sections 4.1.1 & 4.6.19)
- Establish well documented work procedures to avoid wastage due to inappropriate work practices (see BREF Section 4.1.4)
- Optimise production scheduling (see BREF Section 4.1.1)
- Investigate the possibility of combining different treatments into a single step (see BREF Sections 4.1.1 & 4.1.4)
- Install low- and ultra-low- liquor ratio machinery in batch processes (see BREF Sections 4.6.19 to 4.6.21)
- Improve washing efficiency (see BREF Sections 4.9.1 & 4.9.2)
- Re-use cooling water as process water (see BREF Section 4.1.1)
- Investigate possibilities for water re-use and recycling by systematic characterisation of process streams (see BREF Section 4.5.8, 4.6.22 outlines options)
- Fit hoods and covers to ensure full closure of machinery that could give rise to vapour losses (see BREF Sections 4.1.1 & 4.6.19)
- Insulate pipes, valves, tanks and machines (see BREF Section 4.1.5)
- Optimise boiler houses – e.g. re-use of condensate, etc. (see BREF Sections 4.1.1, 4.4.3 & 4.8.1)
- Heat recovery from water and exhaust gases (see BREF Sections 4.1.1, 4.4.3, 4.8.1 & 4.6.22)
- Install frequency controlled electric motors (see BREF Section 4.1.1).

5.2.3 Generic Management of Waste Streams

BAT is to

- Collect separately unavoidable solid waste
- Use bulk or returnable containers.

5.3 BAT – Preventive Measures for Specific Unit Processes and Operations

BAT is presented on a unit process basis, as follows:

5.3.1 Wool Scouring

This covers both aqueous and organic wool scouring.

5.3.1.1 Wool scouring with water

BAT is to:

- Select fibre according to BAT measures in Table 5.1 of the BREF document
- Substitute alkylphenol ethoxylates detergents with alcohol ethoxylates or other biodegradable substitutes (see BREF Section 4.3.3)
- Use dirt removal/grease recovery loops of high capacity (see BREF Section 4.4.1). BAT associated values for water consumption are 2 to 4 l/kg of greasy wool for medium to large mills (processing 15,000 tonnes/year of greasy wool) and 6 l/kg for small mills. Recovery of 25%-30% of the grease estimated to be present in the wool scoured
- Reduce energy consumption to 4-4.5 MJ/kg greasy wool processed (3.5 MJ/kg thermal energy and 1 MJ/kg electrical energy) (see BREF Section 5.2.1).

5.3.1.2 Scouring with organic solvent

Scouring with organic solvent is considered BAT if all measures to minimise fugitive losses and prevent groundwater contamination are taken (see BREF Section 2.3.1.3).

5.3.2 Textile Finishing and Carpet Industry

A. Pretreatment

5.3.2.1 Removing knitting lubricants from fabric

BAT is one of the following:

- Select knitted fabric that has been processed using water soluble and biodegradable lubricants. Remove them by water washing (see BREF Section 4.2.3)
- Carry out the thermofixation step before washing and treat stenter frame air emissions by dry electrofiltration with energy recovery and separate oil collection (see BREF Section 4.10.9)
- Remove the non water-soluble oils using organic solvent washing. Section 4.9.3 of BREF describes subsequent requirements. Persistent pollutants are destroyed in-loop (e.g. by advanced oxidation processes).

5.3.2.2 Desizing

BAT is one of the following:

- Select raw material processed with low add-on techniques and more effective bioeliminable sizing agents, combined with efficient washing systems and low F/M waste water treatment (see BREF Sections 4.2.4, 4.2.5, and 4.10.1)
- Adopt an oxidative route when it is not possible to control the source of raw material (see BREF Section 4.5.2)

- Combine desizing/scouring and bleaching in one single step (see BREF Section 4.5.3)
- Recover and re-use sizing agents by ultrafiltration (see BREF Section 4.5.1).

5.3.2.3 Bleaching

BAT is to:

- Use hydrogen peroxide bleaching with techniques to minimise use of hydrogen peroxide stabilisers (see BREF Section 4.5.6) or using bioeliminable/biodegradable complexing agents (see BREF Section 4.3.4)
- Use sodium chlorite for flax and bast fibres (cannot be bleached with hydrogen peroxide alone). A two step hydrogen peroxide – chlorine dioxide bleaching is the preferred option (ensure elemental chlorine-free chlorine dioxide is used (see BREF Section 4.5.5)
- Limit the use of sodium hypochlorite to cases where high whiteness has to be achieved and to fragile fabrics (see BREF Section 5.2.2 for precautions).

5.3.2.4 Mercerising

BAT is to either:

- Recover and re-use alkali from mercerising rinse water (see BREF Section 4.5.7), or
- Re-use the alkali containing effluent in other preparation treatments.

B. Dyeing

5.3.2.5 Dosing and dispensing of dye formulations

BAT is to do all the following:

- Reduce the number of dyes (e.g. using trichromatic system)
- Use automated systems (only consider manual systems for dyes that are used frequently)
- In long continuous lines, with high dead volume. Give preference to decentralised automated stations, with no premixing and automatic cleaning.

5.3.2.6 General BAT for batch dyeing processes

BAT is to:

- Use machinery fitted with automatic controllers of fill volume, temperature, and other cycle parameters, indirect heating and cooling, hoods and doors (to minimise vapour loss)
- Choose machines that are most fitted to the size of the lot to be processed (see BREF Section 4.6.19)
- Select new machinery in accordance with the recommendations in Section 4.6.19 of the BREF document (e.g. low- or ultra-low liquor ratio, reduced cycle duration, etc.)
- Substitute overflow rinsing with drain and fill or, for fabrics – smart rinsing (see BREF Section 4.9.1)
- Re-use rinse water for the next dyeing and re-use the dyebath where technically feasible.

5.3.2.7 BAT for continuous dyeing processes

BAT is to reduce losses of concentrated liquor by:

- Using low add-on liquor application systems and minimising dip trough volumes when pad dyeing
- Adopting on-line separate stream dispensing systems with mixing immediately prior to application
- Using improved systems for dosing padding liquor (see BREF Sections 4.6.7 & 5.2.2)
- Using counter current washing and reducing carry-over (see BREF Section 4.9.2).

5.3.2.8 PES and PES blends dyeing with disperse dyes

BAT is to:

- Avoid the use of hazardous carriers (see BREF Sections 4.6.2, 4.6.1, & 5.2.2 for techniques and priorities)
- Substitute sodium dithionite in PES after treatment (see BREF Section 4.6.5 for alternatives)
- Use optimised dye formulations containing bioeliminable dispersing agent (see BREF Section 4.6.3).

5.3.2.9 Dyeing with sulphur dyes

BAT is to (see BREF Section 4.6.6):

- Replace conventional powder and liquid sulphur dyes with stabilised non-pre-reduced sulphide free dyestuffs or with pre-reduced liquid dye formulations with a sulphur content of less than 1%
- Replace sodium sulphide with sulphur-free reducing agents or sodium dithionite, in that order of preference
- Adopt measures to ensure that only the strict amount of reducing agent needed to reduce dyestuffs is consumed
- Use hydrogen peroxide as preferred oxidant.

5.3.2.10 Batch dyeing with reactive dyes

BAT is to:

- Use high fixation, low-salt reactive dyes (see BREF Sections 4.6.10 & 4.6.11)
- Avoid use of detergents and complexing agents in rinsing and neutralisation steps after dyeing (see BREF Section 4.6.12).

5.3.2.11 Pad-batch dyeing with reactive dyes

BAT is to:

- Use dyeing techniques that perform at a level equivalent to those described in section 4.6.13 of BREF
- Avoid the use of urea and to use silicate-free fixation methods (see BREF Section 4.6.9).

5.3.2.12 Wool Dyeing

BAT is to:

- Substitute chrome dyes with reactive dyes or, where that is not possible, use ultra-low chroming methods (see BREF Section 4.6.15)
- Ensure minimum discharge of heavy metals to waste water when dyeing wool with metal complex dyes

- Give preference to pH control methods when dyeing with pH-controllable dyes (acid and basic dyes) (see BREF Section 4.6.14).

C. Printing

5.3.2.13 Process in general

BAT is to:

- Reduce printing paste losses in screen dyeing (see BREF Sections 4.7.4, 4.7.5, & 4.7.6 and this BAT document Sections 4.3.5.5 & 4.3.5.6)
- Reduce water consumption in cleaning operations (see BREF Section 4.7.7)
- Use digital ink-jet printing machines for short runs for flat fabrics. It is not considered BAT to flush with solvent to prevent blocking while the printer is in use (see BREF Section 4.7.9)
- Use digital jet printing machines for printing carpet and bulky fabrics (see BREF Section 4.7.8).

5.3.2.14 Reactive printing

BAT is to avoid the use of urea by either:

- The one-step process with controlled moisture addition (see BREF Section 4.7.1), or
- The two step process (see BREF Section 4.7.2)

(see BREF Section 5.2.2 for limitations (silk and viscose)).

5.3.2.15 Pigment printing

BAT is to use optimised printing pastes to fulfil the following requirements

- Thickeners with low emission of VOC. Emission value: <0.4 g Org.-C/kg textile (assuming 20 m^3 air/kg textile)
- APEO free and high degree of bioeliminability
- Reduced ammonia content. Emission value: 0.6 g NH3/kg textile (assuming 20 m^3 air/kg textile).

D. Finishing

5.3.2.16 Process in general

BAT is to:

- Minimise residual liquor by using minimal application techniques (e.g. foam application)
- Minimise energy consumption in stenter frames (see BREF Section 4.8.1 for techniques)
- Use low air emission optimised recipes (see BREF Section 4.3.2 for "emission factor concept").

5.3.2.17 Easy care treatment

BAT is to use formaldehyde-free cross-linking agents in the carpet sector, and formaldehyde-free or formaldehyde-poor (<0.1% formaldehyde content in formulation) for the textile industry.

5.3.2.18 Mothproofing treatments

(i) Process in general

BAT is to:

- Adopt appropriate material handling procedures (see BREF Section 4.8.4.1)
- Ensure 98% transfer efficiency
- When insect repellent is applied from a dye bath, additional measures must be adopted (see BREF Section 4.8.4.1)

(ii) Specific measures must be adopted depending on the method of mothproofing. BAT is described for the following operations:

- Mothproofing of yarn produced via the dry spinning route (see BREF Section 4.8.4.2)
- Mothproofing of loose fibre dyed / yarn scoured production (see BREF Section 4.8.4.3)
- Mothproofing of yarn dyed production (see BREF Section 4.8.4.4).

E. Washing

5.3.2.19 Washing

BAT is to:

- Substitute overflow washing/rinsing with drain-fill methods or smart rinsing (see BREF Section 4.9.1)
- Reduce water and energy consumption in continuous processes by:
    - Installing high-efficiency washing machinery (see BREF Section 4.9.2 & Table 4.38)
    - Use fully closed-loop equipment when halogenated organic solvent cannot be avoided (see BREF Section 4.9.3).

5.4 BAT – Measures for Effluent Treatment

5.4.1 General

BAT is:

- Treatment of waste in an activated sludge system at low F/M ratio (see BREF Section 4.10.1)
- Pre-treatment of highly loaded (COD> 5000 mg/l) selected and segregated single waste water streams containing non-biodegradable materials by chemical oxidation (see BREF Section 4.10.7).

For specific streams, e.g. wastes containing pigment pastes, azo-dyes (see BREF Sections 4.10.5 & 4.10.6).

Additional physical-chemical treatments may be necessary, if concentrated waste-streams containing non-biodegradabe compounds cannot be treated separately. These include:

- Tertiary treatment (e.g. adsorption followed by incineration) (see BREF Section 4.10.1)
- Combined biological, physical, and chemical treatment (e.g. addition of activated carbon to activated sludge system) (see BREF Section 4.10.3)
- Ozonation of recalcitrant compounds prior to activated sludge treatment (see BREF Section 4.10.1).

5.4.2 For Effluent Treatment in the Wool Scouring Sector (Water-Based Process)

BAT is to:

Combine the use of dirt removal/grease recovery loops with evaporative effluent treatment with integrated incineration of the resulting sludge and full recycling of water and energy for (see BREF Section 4.4.2):

- New installations
- Existing installations with no on-site treatment
- Installations seeking to replace life-expired effluent treatment plant.

5.4.3 Sludge Disposal

BAT is to:

- Use the sludge for brick-making (see BREF Section 4.10.2)
- Incinerate the sludge with heat recovery (suitable environmental protection measures taken).

Further information on a number of waste gas and wastewater treatment techniques can be found in the BREF document on *Common Waste Water and Waste Gas Treatment/Management Systems in the Chemical Sector*, EIPPCB, February 2003.

6. BAT ASSOCIATED EMISSION LEVELS

6.1 EMISSION LEVELS FOR DISCHARGES TO AIR

The BAT-associated emission levels for emissions to air are as follows:

Table 6.1 BAT associated emission levels for emissions to air

Constituent Group or Parameter	Emission Levels (mg/m^3)
Volatile organic compounds (VOCs) used in activities covered by the Solvents Regulations (S.I 543 of 2002)	Refer to the BAT Guidance Note on Best Available Techniques for solvent use in coating cleaning and degreasing
Particulate matter	5 - 50
Isocyanates (as NCO)	0.1
Total Organic Carbon (as C)	50 or mass flow 0.5kg/hr
Formaldehyde	20
Other	Note 1

Note 1: Any relevant polluting substances as specified in Schedule to S.I. No. 394 of 2004: EPA (Licensing)(Amendment) Regulations, 2004.

Activities at the installation shall be carried out in a manner such that emissions of odours do not result in significant impairment of, and/or significant interference with amenities or the environment beyond the installation boundary.

6.2 EMISSION LEVELS FOR DISCHARGES TO WATER

The following table sets out emission levels that are achievable using BAT for wastewater treatment. However establishing emission limit values within a licence for direct discharges to surface water from wastewater treatment plant and stormwater discharges must ensure that the quality of the receiving water is not impaired or that the current Environmental Quality Standards (EQS) are not exceeded.

All discharges to sewer are subject to approval from the Water Services Authority.

Compliance with the Water Framework Directive (2000/60/EC) is required where relevant, in particular Article 16.

Table 6.2: BAT associated emission levels for discharges to water*

For activities using well-developed water conservation techniques alternative emission limit values may be calculated based on the loads arising from these levels.

Constituent Group or Parameter	**Emission Levels**	**Percentage Reduction** Note 3	**Notes**
pH	6 - 9 pH units		
Toxic units	5 TU		1
BOD5	20 - 50mg/l	> 90%	
COD	160mg/l	> 80%	
Total Suspended solids	10 - 35mg/l		
Total Ammonia (as N)	10mg/l		
Total Nitrogen (as N)	5 - 25mg/l	> 80%	2, 4
Total Phosphorus (as P)	2mg/l	> 80%	4
Oils, Fats and Greases	10mg/l		
Mineral Oil (from interceptor)	20mg/l		
Mineral Oil (from biological treatment)	1.0mg/l		
Metals			5
Priority Substances (as per Water Framework Directive)			5
Organochlorine pesticides (as Cl)			5
Mothproofing agents (as Cl)			5
Organophosphorus pesticides (as P)			5
Adsorbable organic halogen compounds (AOX)			5
Other			5, 6
Fish Tainting	No Tainting		

* All values refer to daily averages based on a 24-hour flow proportional composite sample, except where stated to the contrary and for pH, which refers to continuous values. Levels apply to effluent prior to dilution by uncontaminated streams, e.g. storm water, cooling water, etc.

* Temperature measured downstream of a point of thermal discharge must not exceed the unaffected temperature by more than 1.5°C in salmonid waters and 3°C in cyprinid waters (Freshwater Fish Directive 79/659/EEC).

Note 1: The number of toxic units (TU) = 100/x hour EC/LC50 in percentage vol/vol so that higher TU values reflect greater levels of toxicity. For test regimes where species death is not easily detected, immobilisation is considered equivalent to death.

Note 2: Total Nitrogen means the sum of Kjeldahl Nitrogen, Nitrate N and Nitrite N.

Note 3: Reduction in relation to influent load.

Note 4: Limits will depend on the sensitivity of the receiving waterbody.

Note 5: BAT associated emissions levels are highly dependent on production process, wastewater matrix and treatment. These parameters shall be considered on a site-specific basis when setting emission limit values.

Note 6: Any relevant polluting substances as specified in Schedule to S.I. No. 394 of 2004: EPA (Licensing)(Amendment) Regulations, 2004.

7. COMPLIANCE MONITORING

The methods proposed for monitoring the emissions from these sectors are set out below. Licence requirements may vary from those stated below due to site location considerations, and scale of the operation.

7.1 MONITORING OF EMISSIONS TO AIR

- Stack sampling periodically, as required by licence, taking account of the nature, magnitude and variability of the emission and the reliability of the control techniques. Typically, this will be once per annum for particulates.
- Continuous monitoring of adsorption, condensation plant for VOC.
- Annual monitoring of boiler stack emissions for SOx, NOx, CO and particulates, as required by the licence, taking account of the nature, magnitude and variability of the emission and the reliability of the controls
- Monitoring of boiler combustion efficiency in accordance with the manufacturer's instructions at a frequency determined by the Agency
- Periodic monitoring for other parameters as determined by the Agency.

7.2 MONITORING OF AQUEOUS EMISSIONS

- Establish existing conditions prior to start-up, of key emission constituents, and salient flora and fauna.
- Daily, or where deemed necessary, continuous monitoring of flow and volume. Continuous monitoring of pH. Monitoring of other relevant parameters as deemed necessary by the Agency (such as BOD, COD, metals, etc.), taking account of the nature, magnitude and variability of the emission and the reliability of the control techniques.
- Monitoring of influent and effluent from the wastewater treatment plant to establish percentage BOD reduction and an early warning of any difficulties in the waste water treatment plant, or unusual loads.
- The potential for the treated effluent to have tainting and toxic effects should be assessed and if necessary measured by established laboratory techniques.
- Periodic biodegradability checks where appropriate on effluents to municipal waste treatment plants, both prior to start-up and thereafter.

7.3 MONITORING OF EMISSIONS TO GROUNDWATER

There should be no direct emissions to groundwater, including during extraction and treatment of groundwater.

7.4 MONITORING OF SOLID WASTE

- The recording in a register of the types, quantities, date and manner of disposal/recovery of all wastes.
- Leachate testing of sludges and other material as appropriate being sent for landfilling.
- Annual waste minimisation report showing efforts made to reduce specific consumption together with material balance and fate of all waste materials.

Appendix 1

PRINCIPAL REFERENCES

1. E.C.

1.1. Council Directive 96/61/EC of 24 September 1996 concerning Integrated Pollution Prevention and Control.

1.2. Reference Document on Best Available Techniques for the Textiles Industry (July 2003).

1.3. Council Directive 96/61/EC of 11 March 1999 on the limitation of emissions of volatile organic compounds due to the use of organic solvents in certain activities and installations.

1.4. Draft Reference Document on Best Available Techniques for Surface Treatment using Organic Solvents (May 2004).

1.5. Final Draft Reference Document on Best Available Techniques on Emissions from Storage (November 2004).

1.6. Reference Document on the application of Best Available Techniques to Industrial Cooling Systems (December 2001).

1.7. Reference Document on Best Available Techniques in common wastewater and waste gas treatment/management systems in the chemical sector (February 2003).

2. IRELAND

2.1. Integrated Pollution Control Licensing BATNEEC Guidance Note For Textile Finishing (EPA 1997).

2.2. Integrated Pollution Control Licensing BATNEEC Guidance Note For Noise in Relation to Scheduled Activities (EPA No. LC 8 (1995)).

2.3. Guidance Note For Noise in Relation to Scheduled Activities - 2ND Edition (EPA (2006)).

APPENDIX 2

GLOSSARY OF TERMS AND ABBREVIATIONS

AOX	Adsorbable Organic Halogens
BAT	Best Available Technique
BOD	Biochemical Oxygen Demand
BREF	Reference Document on Best Available Techniques for the Textiles Industry, published by the European Commission, July 2003
°C	Degree Celsius
CO	Carbon monoxide
CO_2	Carbon dioxide
COD	Chemical Oxygen Demand
f/m	Food to Micro-organism ratio
kg	Kilogramme
m^3	Cubic metre
mg	Milligramme
Nm^3	Normal cubic metre (101.3 kPa, 273 K)
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
O_2	Oxygen
SO_2	Sulphur dioxide
SO_x	Sulphur oxides
t	Tonne (metric)
VOC	Volatile Organic Compounds