How to comply with your environmental permit
Additional guidance for:

The Textile Sector (EPR 6.05)

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The Environment Agency. Out there, making your environment a better place.

Published by:
Environment Agency
Rio House
Waterside Drive,
Aztec West Almondsbury,
Bristol BS32 4UD
Tel: 0870 8506506
Email: enquiries@environment-agency.gov.uk
www.environment-agency.gov.uk

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Introduction

In *"Getting the basics right – how to comply with your environmental permit"* (GTBR) we described the standards and measures that we expect businesses to take in order to control the risk of pollution from the most frequent situations in the waste management and process industries.

This sector guidance note (SGN) is one of a series of additional guidance for Part A(1) activities listed in Schedule 1 of the Environmental Permitting Regulations (the Regulations). We expect you to use the standards and measures in this note **in addition** to those in GTBR to meet the objectives in your permit.

Sometimes, particularly difficult issues arise such as problems with odour or noise. You may then need to consult the "horizontal" guidance that gives in depth information on particular topics. Annex 1 of GTBR lists these.

The IPPC Directive requires that the Best Available Techniques (BAT) are used. When making an application, explain how you will comply with each of the indicative BATs in this sector guidance note. Where indicative BAT is not included, where you propose to use an alternative measure or where there is a choice of options you should explain your choice on the basis of costs and benefits. Part 2 of Horizontal Guidance Note H1 Environmental Risk Assessment (see GTBR Annex 1) gives a formal method of assessing options which you should use where major decisions are to be made.

We will consider the relevance and relative importance of the information to the installation concerned when making technical judgments about the installation and when setting conditions in the permit.

Modern permits describe the objectives (or outcomes) that we want you to achieve. They do not normally tell you how to achieve them. They give you a degree of flexibility.

Where a condition requires you to take appropriate measures to secure a particular objective, we will expect you to use, at least, the measures described which are appropriate for meeting the objective. You may have described the measures you propose in your application or in a relevant management plan but further measures will be necessary if the objectives are not met.

The measures set out in this note may not all be appropriate for a particular circumstance and you may implement equivalent measures that achieve the same objective. In cases where the measures are mandatory this is stated.

Introduction

In response to the application form question on Operating Techniques, you should address each of the measures described as indicative BAT in this note as well as the key issues identified in GTBR.

Unless otherwise specified, the measures and benchmarks described in this note reflect those of the previous Sector Guidance Note. They will be reviewed in the light of future BREF note revisions. In the meantime we will take account of advances in BAT when considering any changes to your process.

Installations covered

This note applies to activities regulated under the following section of schedule 1 of the Regulations:

Section 6.4, Textile treatment, Part A(1)

b) Pre-treating (by operations such as washing, bleaching or mercerisation) or dyeing fibres or textiles in plant with a treatment capacity of more than 10 tonnes per day.

c) Treating textiles if the activity may result in the release into water of any substance in paragraph 7 of Part 1 in a quantity which, in any period of 12 months, is greater than the background quantity by more than the amount specified in that paragraph in relation to that substance.

Directly associated activities

As well as the main activities described above, the installation will also include directly associated activities which have a direct technical connection with the main activities and which may have an effect on emissions and pollution. These may involve activities such as:

- spinning, weaving and finishing processes
- the control and abatement systems for emissions to all media
- waste handling and recycling facilities

This note covers single and integrated processes to produce textiles and carpets using animal, vegetable, synthetic and mixtures of fibres. The process stages that are described in the BAT Reference Document mainly include: fibre preparation, pre-treatment before colouring, dyeing, finishing and finally washing. This note covers all main fibre types: natural fibres, man made fibres derived from natural polymers (viscose, cellulose etc), man made fibres derived from synthetic polymers together with blends of different fibres. The backing of carpets is also included as it is an intrinsic part of carpet manufacture and has the potential to pollute the environment; but in

Introduction

many cases it is likely to be outside the boundary of the installation.

Key issues

The key issues are:

Energy efficiency

The sector is a large user of energy by way of steam raising plant and where stenters are used in finishing.

Efficient use of raw materials and water

The industry is a large user of water, for example the bleaching stage. It also uses a range of fibres and chemicals as raw materials.

There are a number of opportunities either to re-use water or to recycle water from, for example, the rinse stages.

You should avoid using fibres or chemicals containing persistent organic pollutants (POPs).

Avoidance, recovery and disposal of wastes

Waste recovery is possible in this sector, particularly for wool scouring where the wool grease should be dealt with by other routes than landfill.

Emissions to air

Fibres and chemicals, especially in the finishing operations, give rise to emissions to air that may require abatement.

Emissions to water

Contaminants, including persistent organic pollutants, present on the raw materials will pass to the wash and rinse waters. Many of these compounds are very difficult to remove in wastewater treatment systems and will be present in final effluents. The properties of many of these compounds including the ability to act as endocrine disrupters cause concern.

Wool scouring has the biggest polluting potential in this sector but other processes also have the potential to release List I and II substances and high organic loads.

You should avoid colour problems in the effluent and avoid fugitive emissions to water and groundwater. For the few installations releasing directly to controlled waters, the use of direct toxicity assessment (DTA) may be appropriate.

1

Managing your activities

Energy efficiency
Efficient use of raw materials and water

1. Managing your activities

1.1 Energy efficiency

Indicative BAT

You should where appropriate:

1. Consider energy recovery techniques such as:
    - the use of heat exchangers for preheating the liquors used in wool scouring, dyeing and scouring of woven yarn for example
    - high efficiency dewatering techniques prior to drying
    - recovery of heat from stenter exhaust gases
    - preheating boiler feed water by flue gas economiser
    - optimal maintenance of the stenter burners.

1.2 Efficient use of raw materials and water

Indicative BAT

You should where appropriate:

1. Use the techniques listed in table 1 below when selecting raw materials;
2. Use automated fill and liquor temperature control systems;
3. Reduce liquor ratio by improving washing efficiency for either continuous or batch processing; techniques that will improve washing efficiency and which should be used where possible, include the following:
    - maintaining a constant liquor ratio across variable load size
    - in-process separation of the bath from the substrate
    - internal separation of process-liquor from the washing liquor
    - mechanical liquor extraction to reduce carry-over and improve washing efficiency
    - internal countercurrent flow in the batch washing process
    - combining processes
    - continuous countercurrent flow of textiles and water (this is now also possible in batch processing)
    - use of machines with built-in facilities for waste stream segregation and capture
    - combinations and scheduling to reduce the number of chemical dumps
4. Re-use rinse water within the process and re-use the dye bath when technical considerations allow.

Efficient use of raw materials and water

Table 1 Techniques for raw material selection

Raw material	Selection techniques
Natural raw fibres (including wool, cotton flax etc	Supplies of natural raw fibres should not contain harmful substances at concentrations above background level.
Dyes, pigments and auxiliaries	Dyes and auxiliary chemicals that are not either biodegradable or inorganic should be identified and their use justified. You should also minimise and justify the use of metal or reactive dyes. Where reactive dyes are used these should be high fixation low solvent . Some azo dyes have carcinogenic breakdown products and their use is restricted by EU Directive 76/769/EEC. The Industry does not use them. Dyes with solid pigments should only be used where they can be abated by clarification. The affinity (K), liquor ratio (L) and exhaustion (E) of the dyeing process should be optimised. E =K/(K+L)
Levellers and optical brighteners	The most retentive type should be used,
Lubricants	Lubricants should be biodegradable where possible can be used for monitoring.
Detergents/ surfactants	Only chemicals with high biodegradability and known degradation products should be used. Alkylphenolethoxylates should be avoided.
Biocides	Biocide use should be minimised by other complementary techniques. Biosensors can be used for monitoring.

Efficient use of raw materials and water

Chemicals for bleaching	Hydrogen peroxide based systems have a lower environmental impact Elemental chlorine should not be used. Any use of sodium hypochlorite for decolourising should be justified. Where chlorine-containing bleaches are justifiably used; the emissions of relevant chlorinated organic materials that are formed by the reaction of chlorine with organic material (e.g. chloroform, PCP and residual chlorine) are quantified.
NaOH	Only “low mercury” NaOH should be used.
Sequestering agents	DTPA should be used in preference to EDTA or NTA because of its superior degradability.
Defoamers	Only fully biodegradable products with known, safe degradation products should be used.
Solvents	Wherever possible, coatings using organic solvents should be replaced by aqueous versions.
Flame retardants	Any use of brominated flame retardants or short/medium chain chlorinated paraffins should be justified.

2
Operations

Washing

2. Operations

In-process controls

Refer to the BREF note (reference 1) for detailed information on the unit processes. Each installation will carry out a different combination of the following activities depending upon their product:

- washing
- wool scouring
- bleaching
- mercerising
- dyeing
- finishing

2.1 Washing

A number of pollutants originate from impurities present on the raw materials or from the use of less environmentally friendly materials. Raw wool may contain residues of chemicals used as veterinary medicines, to protect sheep from ectoparasites such as lice, mites, blowfly etc. Although these are present in low concentrations, they have important implications for the discharge of raw wool scouring effluent and disposal of the sludges generated by the treatment of the effluent. Other chemicals may include insecticides, acaricides or insect growth regulators and these may be present on wool, cotton or other raw fibres.

Cotton and other natural raw materials can also contain pesticide residues. It is therefore important that you know the source of your raw materials and the harmful substances that may potentially be present.

In addition to these substances oils, glues, chemicals (such as mothproofing and crease resist agents) and other additives are used in the processes. Residual amounts of all of these substances can be released to water during the washing stages. Annexes I, and II to the BREF provide reviews of the Auxiliary Chemicals and Dyes used in the sector.

Indicative BAT

You should where appropriate:

1. Install water sub-metering to monitor efficiency of individual systems
2. Substitute overflow washing/rinsing with drain/fill methods or “ smart rinsing” techniques based on ultra-low liquor ratios
3. Reduce water & energy consumption in continuous processes by installing high-efficiency washing machinery and introducing heat recovery equipment
4. Interlock water supply with running of the process by use of automatic stop valves

Wool scouring
Bleaching

2.2 Wool scouring

Scouring of wool removes grease and lanolin.

Chemicals known to be present in certain sources of raw wool include:

- organochlorine insecticides: hexachlorocyclohexane, dieldrin and DDT
- organophosphorus insecticides: diazinon, propetamphos, chlorfenvinphos and dichlofenthion
- synthetic pyrethroid insecticides: cypermethrin, deltamethrin, fenvalerate, flumethrin and cyhalothrin
- insect growth regulators: cyromazine, dicyclanil, diflubenzuron and triflumuron.

Some countries avoid the use of these chemicals on their livestock. The UK Wool Textile Industry keeps a Pesticide Database to avoid wool from contaminated sources.

Indicative BAT

You should where appropriate:

1. Use raw wool that is free of list I substances.
2. Use water efficient techniques e.g. countercurrent rinsing.
3. Recover grease.

2.3 Bleaching

Hydrogen peroxide is preferred to sodium hypochlorite for bleaching, as chlorinated breakdown products are avoided.

Indicative BAT

You should where appropriate:

1. Use hydrogen peroxide for bleaching.
2. Limit the use of sodium hypochlorite in cases where it is necessary to be used e.g. where high whiteness is required.
3. To reduce the formation of hazardous adsorbable organic halogens (AOX) then bleaching should be carried out in a two stage process in which hydrogen peroxide is used in the first stage (which removes organic precursors).

Mercerising
Dyeing
Finishing

2.4 Mercerising

Indicative BAT

You should where appropriate:

1. Recover and reuse alkali from the mercerisation rinsing water.

2.5 Dyeing

Refer to Indicative BAT section above for efficient use of raw materials

Indicative BAT

You should where appropriate:

1. Use automated dispensing systems for dosing of dyes.

2.6 Finishing

The industry code of good practice (Reference 2) provides information on reducing emissions of brominated flame retardant chemicals from finishing processes.

Indicative BAT

You should where appropriate:

1. Minimise waste liquor by using minimal application techniques such as foam or spray application.
2. Reuse padding liquors.
3. Segregate and dispose of separately unavoidable residual liquors.
4. Use formaldehyde free or low formaldehyde preparations (<1% aldehyde content) in cross linking agents.

3

Emissions and monitoring

Point source emissions to air
Point source emissions to water

3. Emissions and monitoring

3.1 Point source emissions to air

Sources include:

- boilers and steam generators
- stenters for thermal setting, drying and finishing
- coating processes
- singeing

Indicative BAT

You should where appropriate:

1. Identify the main chemical constituents of the emissions, including VOC speciation where practicable.
2. Achieve the benchmark values for point source emissions unless we agree alternative values.
3. Where extraction is necessary, use the minimum extraction rates that enable COSHH requirements to be met.

3.2 Point source emissions to water

A wide variety of chemicals are used in textile processes and the effluent will be a complex mixture of substances.

In addition to the substances that give rise to the COD of the effluent, the raw materials contain persistent organic pollutants, some of which are poorly biodegradable, and which can be particularly toxic.

While most pesticides and other persistent substances have been detected in releases from UK installations in recent years, those most frequently recorded in significant amounts are Cypermethrin, PCP, lindane, mercury and cadmium. Although concentrations tend to be low the very significant volumes of water involved mean that loadings can be high.

Wastewater treatment changes the nature and distribution of these substances, with some ending up in a sludge form, others being emitted to atmosphere and some remaining in the wastewater discharge.

Point source emissions to water

Grease will also be present if it has not been removed efficiently.

The objective of primary treatment is the removal of grease and particulate solids. Settlement and dissolved air flotation systems are used. The preferred solution will depend on the specific location and wastewater characteristics. Settlement systems can produce well-clarified waters, but can suffer from operating difficulties (floating solids and odour), particularly when treating stronger, warmer wastewaters. High-rate settlement units such as lamella clarifiers are used for treating specific streams such as coating wastewaters. Chemical pre-treatment (e.g. polyelectrolytes, inorganic coagulants and bentonite) can enhance the removal of colloidal solids and/or to increase settlement velocities. Flue gases from other processes can be used to adjust the pH of alkaline effluents.

The objective of secondary treatment is to remove biodegradable materials (BOD) by degradation or by adherence of the pollutants to the sludge. The latter mechanism will also remove non-biodegradable materials such as heavy metals. (In this sector the BOD/COD ratio might be unusual because of the presence of resistant organic species.)

Dioxins, furans and DDT would be expected to bind to the biomass and fibre sludge almost totally. Hexachlorobutadiene, hexachlorobenzene, aldrin, dieldrin, endrin, PCBs, trichlorobenzene and heavy metals will also be partially removed by this mechanism (mercury 40- 50%, cadmium 95% and copper, chromium, lead and zinc 75-95%). Evidence suggests that biological treatment can remove 40% of chlorinated organic materials (70 -90% of chlorinated phenolics, including pentachlorophenol, in particular), by genuine biodegradation.

Aerobic plant, the most common biological plant, can use air, oxygen or a combination. The use of oxygen improves control and performance and can be retrofitted to existing plants; however, it would normally be preferable, on the grounds of minimising energy consumption, to size a plant to use air. High rate biological towers can be used to reduce the BOD giving an effluent suitable for further treatment at a sewage treatment works.

Anaerobic plant will break down more ring compounds, is more effective in the removal of the chlorate which is formed in the production of chlorine dioxide, avoids problems with bulking filamentous bacteria, produces lower quantities of sludge and produces methane which should be captured and used as an energy source. It is appropriate when the incoming organic concentrations and the temperature are high, say BOD > 2000 mg/l and 35°C. Most effluent from modern plant is of adequate temperature, and

Point source emissions to water

where it is not, the energy recovered from the anaerobic off-gases could be used to raise it.

An anaerobic system should be followed by an aerobic system as the latter achieves lower absolute release levels, will remove hydrogen sulphide and ensure that the final effluent is well aerated to assist in the breakdown of the remaining BOD. The energy gained from the anaerobic plant can be equivalent to that consumed by the aerobic plant.

After a biological plant, solids removal should be provided. This can be by secondary clarifier but, where space permits, systems with the benefit of large, post-treatment lagoons gain excellent protection against bulking or other problems. This should be designed in where space permits.

Irrespective of the type of waste treatment used recycling the treated wastewater in a partially or fully closed system should be considered. Membrane or possibly evaporative plant could obviate the need for conventional abatement plant, and by generating all the fresh water needs from the recycled water, an effluent-free system can be created with fresh water make-up required only to balance evaporative losses. Colour removal using inorganic clays allows water reuse and removal of colour in the final wastewater. The energy content of the recycled water is also reused.

Most textile processes discharge to sewage treatment works but may have some form of pre- treatment plant prior to discharge. In many parts of the country there are concentrations of installations and local sewage treatment works may treat the effluents from several installations. This can give rise to problems of highly coloured effluent and the current trend is for further treatment to remove colour at the dyehouse.

Indicative BAT

You should where appropriate:

1. Identify the main chemical constituents of the treated effluent and assess the fate of these chemicals in the environment.
2. For emissions to controlled waters, control the process inputs and consider the use of whole effluent bioassays for the assessment of the complex effluent.
3. Use automatic metering and blending systems for dyes and other chemicals.
4. If you have on site waste water treatment you should:
    - justify the choice and performance of treatment plant
    - assess the possibility of recycling treated wastewater
    - confirm whether pesticides are present and whether colour removal is practised or planned

Point source emissions to water Point source emissions to land Monitoring

- consider the effect of shutdowns and weekend breaks on the treatment process
- provide buffer storage or balancing tanks to even out the concentrations where there is a release of stronger, highly coloured or alkaline wastewaters. If no balancing is provided, show how peak loads are handled without overloading the capacity of the wastewater treatment plant
- consider use of flue gases from other processes to adjust the pH of alkaline effluents.

Where anaerobic treatment is used:

- use anaerobic treatment where the process conditions permit
- maximise methane production for collection and burning for energy production, noting the need to take account of other emissions such as SO_2 and NOx
- protect methanogenic bacteria from chlorinated and sulphur compounds, pH and temperature fluctuations and make the plant more robust by a pre-acidification stage in which other bacteria will predominate and break down many of the substances which cause poisoning.

Where activated sludge is used:

- understand the consequences of a breakdown of an activated sludge wastewater treatment plant by bulking (overproduction of filamentous bacteria) for example for the particular mill. For example the carry-over of fibre will take all the substances which are fibre substantive with it, such as cadmium and other heavy metals and many organic materials
- have specific procedures for nutrient and other chemical dosing which ensure that the optimum balance of added nutrients is maintained, minimising both releases of nutrients and the occurrence of bulking
- have procedures to deal with bulking when it occurs, including reducing load if necessary.

3.3 Point source emissions to land

In general the waste streams comprise sludges, grease and reject fibres. Grease should be recovered from wool.

3.4 Monitoring and reporting of emissions

This is addressed in GTBR.

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Annexes

Annex 1 Emission benchmarks
Annex 2 Other relevant guidance

Annex 1-Emission benchmarks

4. Annexes

Annex 1- Emission benchmarks

Where automatic sampling systems are employed, limits may be defined such that:

- not more than 5% of samples shall exceed the benchmark value

Where spot samples are taken:

- no spot sample shall exceed the benchmark value by more than 50%

The substances to be monitored should be selected according to the potential for their emission from the process and their subsequent impact.

Monitoring of process effluents released to controlled waters should include at least:

Parameter	Benchmark (mg/l)
Total hydrocarbon oil content (IR method)	ND
Biological oxygen demand (BOD) (5 day ATU @ 20°C)	5 - 20
Chemical oxygen demand (COD) (2 hour)	25
Suspended solids (dried @ 105°C)	10-30
Mercury and mercury compounds expressed as Hg	0.005
Cadmium and cadmium compounds expressed as Cd	0.01
Colour (Absorbance measurement)	Note (a) Absorbance in the range 400 to 800 nm <0.1

Note (a) Absorbance is not measured in mg/l

The benchmarks are generally applicable for emissions to freshwater rivers. For discharges to estuaries higher values need to be justified on a site specific basis at the time of the application. For very sensitive situations lower levels may be required.

Most textile processes discharge wastewater to sewage treatment works and limit values for several pollutants will be set by the sewerage undertaker. For harmful substances that are not removed effectively during sewage treatment, limits may be set in the Permit.

Annex 1-Emission benchmarks

Table 3: Benchmark limits for emissions to air

Substance	Emission limits /provisions
Particulate matter	50 mg /Nm^3 as 30 minute mean for contained sources
Formaldehyde	20 mg /Nm^3 as 30 minute mean for contained sources
Ammonia	30 mg /Nm^3 as 30 minute mean for contained sources
VOC	150 mg /Nm^3 expressed as total carbon excluding particulate matter as 30 minute mean for contained sources

Annex 2-Other relevant guidance

Annex 2- Other relevant guidance

For a full list of available Technical Guidance and other relevant guidance see Appendix A of GTBR (see http://publications.environment-agency.gov.uk/pdf/GEHO0908BOTD-e-e.pdf?lang=_e).

In addition to the guidance in GTBR the following guidance is relevant to this sector:

Reference 1 IPPC Reference Document on Best Available Techniques in the Textile Industry European Commission http://eippcb.jrc.es

Reference 2 Industry Code of Practice BSEF - PRODUCT STEWARDSHIP THROUGHOUT THE LIFE CYCLE OF BFRS http://www.bsef.com/product_stew/vecap/

Reference 3 Waste minimisation support references

• Environment Agency web site. Waste minimisation information accessible via: www.environmentagency.gov.uk/subjects/waste/131528

• Waste Minimisation – an environmental good practice guide for industry (helps industry to minimise waste and achieve national environmental goals). Available free to companies who intend to undertake a waste reduction programme (tel: 0345 33 77 00)

• Profiting from Pollution Prevention – 3Es methodology (emissions, efficiency, economics). Video and A4 guide aimed at process industries. Available from Environment Agency, North East region (tel: 0113 244 0191, ask for regional PIR)

• Waste Minimisation Interactive Tools (WIMIT). Produced in association with Envirowise and the BOC Foundation (a software tool designed for small and medium businesses.). Available free from The Environmental Helpline (tel: 0800 585794)

• ENVIROWISE. A joint DTI/DEFRA programme, with over 200 separate case studies, good practice guides, leaflets, flyers, software tools and videos covering 12 industry sectors, packaging, solvents and the generic areas of waste minimisation and cleaner technology. ENVIROWISE is accessible via a FREE and confidential helpline (tel: 0800 585794) or via the web site www.envirowise.gov.uk

• Increased Profit Through Improved Materials Additions: Management/Technical Guide, ENVIROWISE, GG194/195

Annex 2-References

• Waste Management Information Bureau. The UK's national referral centre for help on the full range of waste management issues. It produces a database called Waste Info, which is available for on-line searching and on CD-ROM. Short enquiries are free (tel: 01235 463162)

• Waste Minimisation – Institution of Chemical Engineers Training Package E07. Basic course which contains guide, video, slides, OHPs etc. (tel: 01788 578214) Water and Chemical Use in the Textile Dyeing and Finishing Industry ENVIROWISE GG062

Reference 4 Water efficiency references:

• Simple measures restrict water costs, ENVIROWISE, GC22

• Effluent costs eliminated by water treatment,ENVIROWISE, GC24

• Saving money through waste minimisation: Reducing water use, ENVIROWISE, GG26

• ENVIROWISE Helpline 0800 585794

• Optimum use of water for industry and agriculture dependent on direct abstraction: Best practice manual. R&D technical report W157, Environment Agency (1998), WRc Dissemination Centre, Swindon (tel: 01793 865012)

• Cost-effective Water Saving Devices and Practices ENVIROWISE GG067 IPPC S6.05 Textiles Sector | Issue 2.0 | Modified on 12 July, 2002 84

• Water and Cost Savings from Improved Process Control ENVIROWISE GC110

• Tracking Water Use to Cut Costs ENVIROWISE GG152 Water Use in Textile Dyeing and Finishing ENVIROWISE EG098

Reference 5 Releases to water references

• BREF on Waste Water and Waste Gas Treatment

• A4 Effluent Treatment Techniques, TGN A4, Environment Agency, ISBN 0-11-310127-9 (EA website)

• Pollution Prevention Guidance Note – Above-ground oil storage tanks, PPG 2, Environment Agency, gives information on tanks and bunding which have general relevance beyond just oil (EA website)

• Construction of bunds for oil storage tanks, Mason, P. A, Amies, H. J, Sangarapillai, G. Rose, Construction Industry Research and Information Association (CIRIA), Report 163, 1997, CIRIA, 6 Storey's Gate, Westminster, London SW1P 3AU. Abbreviated versions are also available for masonry and concrete bunds (www.ciria.org.uk on-line purchase)

• Dispersion Methodology Guide D1 (EA website - summary only)

Annex 2-References

• Pollution prevention measures for the control of spillages and fire-fighting run-off, PPG 18, Environment Agency Pollution Prevention Guidance Note, gives information on sizing firewater containment systems (EA website)

• MCERTS approved equipment link via http://www.environment-agency.gov.uk/business/mcerts

• Policy and Practice for the Protection of Groundwater (PPPG) (EA website)

• Choosing Cost-effective Pollution Control ENVIROWISE GG109

• Cost-effective Separation Technologies for Minimising Wastes and Effluents ENVIROWISE GG037

• Cost-effective Membrane Technologies for Minimising: Wastes and Effluents ENVIROWISE GG044

Would you like to find out more about us, or about your environment?

Then call us on
08708 506 506 (Mon–Fri 8–6)

email
enquiries@environment-agency.gov.uk

or visit our website
www.environment-agency.gov.uk

incident hotline 0800 80 70 60 (24hrs)
floodline 0845 988 1188