



BAT Guidance Note
on Best Available Techniques
for the
Brewing, Malting & Distilling Sector
(1st Edition)

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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 provide guidance on the determination of Best Available Techniques (BAT) in relation to:

- applicants seeking Integrated Pollution Prevention and Control (IPPC) licences 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 the 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 regulations.

1.2 BAT GUIDANCE NOTE STRUCTURE

This Guidance Note has been structured as follows:

Section	Details
1	Introduction
2	Interpretation of BAT
3	Sector Covered by this Guidance Note
4	Process Description, Risk to the Environment and Control Techniques
5	Best Available Techniques for the Brewing, Malting and Distilling Industry
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*, *The Landspreading of Organic Waste*, 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 technological 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 sector's 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 via 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 the 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 limit values designed to prevent or eliminate or, where that is not practicable, generally to reduce an emission and its impact 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, managed, 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 the available options may be needed to establish the best option. The choice may be justified on:

- the technical characteristics of the facility/installation;
- its geographical location;
- local environmental considerations;

- the economic and technical viability of upgrading the existing installation.

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 judgments 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 to the Environmental Protection Agency Acts 1992 to 2007:

- 7.3.1 Brewing (including cider and perry production) in installations where the production capacity exceeds 25 million litres per year, not included in paragraph 7.8.
- 7.3.2 Distilling in installations where the production capacity exceeds the equivalent of 1,500 tonnes per year measured as pure alcohol, not included in paragraph 7.8.
- 7.3.3 Malting in installations where the production capacity exceeds 100,000 tonnes per year, not included in paragraph 7.8.

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 in the Food, Drink and Milk Industry*, published by the European Commission, January 2006.

4.1 DESCRIPTION OF THE PROCESS

4.1.1 Primary Processes

The primary steps involved in the brewing, distilling and malting industries are:

- Materials, handling, unpacking and storage (see BREF Section 2.1.1.1).
- Sorting, screening, grading, dehulling, trimming (see BREF Section 2.1.1.2).
- Then for Brewing only:
 - Roasting (see BREF Section 2.1.5.5)
 - Grinding, milling, crushing (see BREF Section 2.1.2.3)
 - Centrifugation (see BREF Section 2.1.3.4)
 - Filtration (see BREF Section 2.1.3.5)
 - Dissolving (see BREF Section 2.1.4.2)
 - Fermentation (see BREF Section 2.1.4.4)
 - Cooking, boiling (stoving) (see BREF Section 2.1.5.3)
 - Pasteurisation, sterilization, UHT (see BREF Section 2.1.5.8)
 - Cooling, chilling (see BREF Section 2.1.7.1)
 - Packing, filling (see BREF Section 2.1.8.1)
 - Gas flushing (see BREF Section 2.1.8.2).
- Then for Malting only:
 - Soaking (see BREF Section 2.1.4.1)
 - Germination (see BREF Section 2.1.4.6)
 - Dehydration (see BREF Section 2.1.6.3)
 - Cooling, chilling (see BREF Section 2.1.7.1)
 - Gas flushing (see BREF Section 2.1.8.2).
- Then for Distilling only:
 - Grinding, milling, crushing (see BREF Section 2.1.2.3)
 - Mixing, blending, conching, homogenization (see BREF Section 2.1.2.2)
 - Filtration (see BREF Section 2.1.3.5)
 - Distillation (see BREF Section 2.1.3.12)
 - Soaking (see BREF Section 2.1.4.1)
 - Fermentation (see BREF Section 2.1.4.4)
 - Ageing (see BREF Section 2.1.4.14)
 - Cooking, boiling (stoving) (see BREF Section 2.1.5.3)
 - Cooling, chilling (see BREF Section 2.1.7.1)
 - Packing, filling (see BREF Section 2.1.8.1).

4.1.2 Cleaning

In addition to the above processing steps, cleaning of processing equipment, containers, floors, etc. is carried out, in some cases, on a daily basis (see BREF Section 2.1.9.1).

4.1.3 UTILITY PROCESSES

A number of utility processes are utilised in the brewing, malting and distilling industries including energy generation/consumption, water treatment, refrigeration and compressed air generation (see BREF Sections 2.1.9.2, 2.1.9.3, 2.1.9.5 & 2.1.9.6).

4.2 RISK TO THE ENVIRONMENT

The key environmental issues associated with the brewing, malting and distilling industries include high water and energy consumption, emissions to air (dust and VOCs) and large volumes of wastewater with a high organic load (see BREF Section 3.3.11).

4.2.1 Water Consumption

Water consumption for breweries is mainly used in the technology for mashing, heat transfer and cleaning operations (see BREF Section 3.3.11.1 and BREF Sections 3.2.21.1, 3.2.20 & 3.2.26.1).

4.2.2 Energy Use

Energy consumption in brewing is associated with heating processes such as mashing, wort boiling, pasteurising and electrical power consumption and generally ranges from 156 - 236 MJ/hl of beer produced. See BREF Section 3.3.11.5 for details and energy consumption per tonne of product for different processes. See BREF Sections 3.2.26.3 and 3.2.6.4 for details on energy consumption for the malting and distilling industry.

4.2.3 Emissions to Air

Emissions to air include SO_x, NO_x, CO₂, CO, particulates from energy generation and dust from grain intake and handling. Brewery emissions to air can also include emissions from the afterburners from the roasting process. Odour can also be an issue in brewing arising from the evaporation of wort boiling, distillation column and on site wastewater treatment (see BREF Section 3.3.11.3).

4.2.4 Emissions to Water

Emissions to water from brewing, distilling and malting consist of organic material contributing BOD and suspended solids, and inorganic material such as nitrogen and phosphorus (see BREF Sections 3.3.11.2, 4.5.7.8.3 (brewing), 3.2.20, 3.3.10.2 (distilling) and 2.1.4.1, 3.2.21.1 & 3.3.10.2 (malting) for details on emissions to water).

4.2.5 Waste

Solid waste and by-products from the brewing, malting and distilling industries include spent grains, surplus yeast, packaging waste, spent filter aids and sludges from wastewater. See BREF Sections 3.3.11.4 & 3.3.11.7 for details on wastes/by-products.

4.2.6 Noise

The main sources of noise associated with the brewing and distilling industry is transport noise (e.g. lorries and forklifts). The use of condensers and cooling towers may also be an issue. See BREF Sections 3.3.11.6 (brewing) and 3.2.6.5, 3.2.1.5 & 3.2.7.5 for general description of noise sources from the food and drink sector.

4.3 CONTROL TECHNIQUES

The existing or possible measures for eliminating, reducing and controlling emissions in the brewing, malting and distilling industry are described in this Section. References to more details and descriptions in the BREF document are given.

4.3.1 General Preventative Techniques

The following general techniques can be applied to all brewing, malting and distilling plants:

- Environmental Management (see BREF Section 4.4.1)
- Monitoring and targeting of energy, water consumption, waste and wastewater emissions (see BREF Sections 4.1.6 & 4.7.9.1).

4.3.2 Minimisation of Water Consumption

The following techniques can minimise water usage in brewing, malting and distilling plants:

- Implement a methodology for reducing water consumption (see BREF Sections 4.1.6, 4.1.7 & 4.1.8)
- Ensure the regular maintenance of utility systems to reduce water consumption and wastewater production (see BREF Section 4.1.5)
- Eliminate the use of water where possible (see BREF Section 4.2.14)
- Optimise cleaning procedures and provide training
- Employ good housekeeping measures (see BREF Section 4.4.1.7.11)
- Reduce water use in bottling and kegging (see BREF Section 4.7.9.5)
- Recycle/reuse water where possible:
 - Recycle transport water, e.g. used in conveying the fruit through the process for the manufacture of cider and perry
 - Use closed loop system for pasteurization (see BREF Section 4.2.10.3)
 - Reuse of cleaning and bottle/keg washing water after chemical precipitation and sedimentation (see BREF Section 4.7.9.5.3)
 - Use a multistage system in bottle/keg washing equipment to save caustic and freshwater usage (see BREF Section 4.7.9.5.2)
 - Reuse final rinse-water for pre-rinse stage (see BREF Section 4.7.9.5.4)
- Optimise water consumption of rinsing zone in the bottle/kegging washer (see BREF Section 4.1.6.2.1).

4.3.3 Minimisation of Energy Consumption

The following techniques can minimise energy consumption in brewing, malting and distilling plants:

- Apply a methodology for improving energy efficiency: (see BREF Sections 4.1.6, 4.1.7, 4.1.8 & 4.2.13)
 - Carry out energy consumption analysis
 - Identify energy efficiency measures
 - Implement an energy management system. Employ good housekeeping and process optimisation
- Employ energy efficiency techniques:
 - Employ heat recovery (see BREF Section 4.2.13.5) such as heat recovery from vapour from wort kettle in brewery (see BREF Section 4.7.9.6.5)
 - Use combined heat and power generation for electricity and thermal requirements (see BREF Section 4.2.13). The biogas from anaerobic digestion may also be utilised for energy recovery
 - Employ frequency converters on motors (see BREF Section 4.2.11.1)

- Minimise heat/energy losses through proper insulation of steam and water pipework (see BREF Section 4.2.13.3)
- Use an energy monitoring system (see BREF Section 4.1.6.7).

4.3.4 Minimisation of Emissions to Air

The following techniques can prevent or minimise the formation of air emissions and odour in brewing, malting and distilling plants (see BREF Section 4.4):

- Audit odour to identify and characterise sources and determine any action required (see BREF Section 4.4.1)
- Use appropriate abatement techniques for odour and gaseous substances and reuse exhaust gases where possible, e.g. surplus CO₂ recovery from beer fermentation where applicable (see BREF Sections 4.4.1, 4.4.3.4, & 4.2.4.1)
- Use appropriate abatement techniques for odour and gaseous substances from the grain roasting process in brewing
- Where necessary aerate and cover wastewater treatment plants to prevent odour or use anaerobic digestion for wastewater treatment.

4.3.5 Minimisation of Wastewater

The following techniques can minimise or prevent the volume and contamination level of emissions to water from brewing, malting and distilling plants (see BREF Section 4.7.9.6):

- Segregation of process water from uncontaminated storm or other water so that uncontaminated water may be recycled or used to dilute wastewater prior to discharge (see BREF Sections 4.7.9.1 & 4.1.7.8)
- Overfill protection and bunding or double skin tank protection for bulk storage tanks (see BREF Section 4.1.8.3)
- Selection of materials/chemicals used in cleaning (see BREF Section 4.3)
- Optimise cleaning procedures to reduce wastewater load, e.g. base CIP sequences on conductivity rather than time (see BREF Section 4.3.9)
- Use fine mesh baskets over floor drains to keep grain out of the drainage system (see BREF Section 4.3.1.1)
- Avoid disposing of yeast to drain because it has a very high COD level and its propensity to form organic acids (see BREF Section 4.7.9.6)
- Collect spillage in return containers rather than washing to drain (see BREF Section 4.3.1)
- In brewing, use a capacitance level switch for the separation of beer from dead yeast cells (see BREF Sections 4.1.8.3 & 4.7.9.3)
- In distilling, use multi effect vacuum evaporators to concentrate slops from the mash column and then process to obtain pot ale which can be sold for agricultural use (see BREF Section 4.7.9.7.2)
- Return strong liquors to the process or recover them for animal feed or other reuse where practicable (see BREF Section 4.7.9.1)
- Avoid overfilling process vessels, as contents can have very high COD levels (e.g. in brewing every 1% of wort going to drain adds about 5% to the trade effluent COD) (see BREF Section 4.1.8.3)
- Minimise leaching from spent grain during storage and transport (see BREF Section 4.5.7.8.4)
- See BREF Sections 4.7.9.6 & 4.5.7.8.4 for further measures of minimising wastewater emissions.

4.3.6 Waste Minimisation

The following techniques can minimise the volume of waste from brewing, malting and distilling plants:

- Implement a waste minimisation methodology (see BREF Section 4.1.6)

- Reduce waste emissions during storage and handling (see BREF Section 4.1.6.2.3):
 - Control dust during loading/unloading, conveying and storage
 - Contain emissions, e.g. bunding, local extract systems, evaporators, etc. (see BREF Section 4.6.4)
- Optimise packaging line efficiency (see BREF Section 4.2.12.4)
- Optimise the process through good housekeeping (see BREF Section 4.1.7.11) and operating practices (see BREF Section 4.1.7)
- Improve process control (see BREF Section 4.1.8)
- Recycle or reuse solid by products or sludge produced:
 - Recycle packaging (e.g. glass, cardboard, paper, plastic) waste (see BREF Section 4.2.12.3)
 - Reuse yeast, spent grain, trub and malt dust as animal fodder. Yeasts can also be used in the food industry. Spent Kieselguhr (filter aid) can be used in the cement industry (see BREF Section 3.3.11.4)
 - Recycle sludge through landspreeding providing it has a real agronomical value
 - Disposal of sludge using anaerobic digestion, with recovery of energy through biogas production.

4.3.7 Minimisation of Noise

General techniques for the reduction of noise from food industrial activities include (see BREF Section 4.1.3):

- Use silencers on ventilation systems
- Modify external fans to produce higher frequency noise (see BREF Section 4.1.3.3)
- Insulate pipework or use pipework with better insulating properties for the transport of materials (see BREF Section 4.1.3.4)
- Installation design considerations (see BREF Section 4.1.4).

4.3.8 Preventative Techniques of Specific Unit Operations

The following preventative techniques can be applied to the stated specific unit operations in the brewing, malting and distilling industries.

4.3.8.1 Raw Materials Reception and Preparation

- Control dust during loading/unloading, conveying and storage and contain emissions, e.g. local extract systems; bunding for storage of liquid chemicals, etc. (see BREF Sections 4.1.3.1, 4.1.4 & 4.4.3.2)
- Recycling of packaging materials (see BREF Section 4.2.12.3)
- Reuse transport water for the conveying of fruit through the process during the manufacture of cider (see BREF Section 3.3.10.2.2)
- Switch off the engine and refrigeration unit of a vehicle during loading/unloading and when parked (see BREF Section 4.2.1.1).

4.3.8.2 Size Reduction, Mixing, Forming

- Particulate matter is often generated and should be recovered in extracted air and reused in the process where practicable (see BREF Section 2.1.5.5.3)
- Noise can be an issue with size reduction techniques such as milling and grinding. Insulate and enclose noisy equipment in insulated buildings where possible (see BREF Section 4.1.3.5 & 4.2.4.2).

4.3.8.3 Separation

- Use high efficiency separation techniques to maximise recovery of beer from fermentation process.

- In brewing, use a capacitance level switch for the separation of beer from dead yeast cells (see BREF Sections 4.1.8.3 & 4.7.9.3)
- In distilling, use multi effect vacuum evaporators to concentrate slops from the mash column and then process to obtain pot ale which can be sold for agricultural use (see BREF Section 4.7.9.7.2)
- In distillation, if a recovery system exists, a proportion of the stillage may be reused. The balance may be processed to animal feed compounds resulting in a condensate for disposal (see BREF Section 4.7.9.7.1)
- Reuse filtrate, cake (e.g. animal feed) or filter aid (e.g. Spent Kieselguhr can be used in the cement industry) where practicable (see BREF Section 3.3.11.4).

4.3.8.4 Product Processing

- Avoid disposing of yeast to drain because it has a very high COD level and propensity to form organic acids (see BREF Section 4.3.1.1)
- Reuse spent yeast and spent grain as animal fodder. Yeasts can also be used in the food industry (see BREF Sections 4.1.7.7 & 4.7.9.3)
- Reduce the quantity of the waste gas, e.g. use air recirculation but maintain special regard to hygiene requirements. Recover CO₂ by cleaning, compressing, drying, purifying and liquefying it from beer fermentation gas where applicable (see BREF Sections 4.4.1 & 4.2.4.1).

4.3.8.5 Heat Processing

- Remove the organic odour components by condensing the vapour from boiling vessels combined with energy recovery.

4.3.8.6 Concentration by Heat

- Use appropriate abatement technology to reduce the emissions of dust to air from the drying process in malting and reuse particulate materials in the process or as animal feed
- Reduce energy consumption by pre-evaporation or dewatering before dehydration
- Reuse hot water from wort cooling
- Employ heat recovery (see BREF Section 4.2.13.5) such as heat recovery from vapour from wort kettle in brewery (see BREF Section 4.7.9.6.5) and recompression of vapour from the mashing process (see BREF Section 4.7.9.6.1).

4.3.8.7 Processing by Removal of Heat

- Employ heat recovery, e.g. use closed loop system for pasteurisation (see BREF Sections 4.1.4.4 & 4.7.5.6).

4.3.8.8 Post Processing Operations

- Recycle packaging (e.g. glass, cardboard, paper, plastic) waste (see BREF Section 4.2.12.13)
- Optimise packaging line efficiency (see BREF Section 4.2.12.4).

4.3.8.9 Cleaning and Sanitation

- Selection of materials/chemicals used in cleaning (see BREF Section 4.3.8)
- Reuse of cleaning and bottle/keg washing water after chemical precipitation and sedimentation (see BREF Section 4.7.9.5.3)
- Use a multistage bottle washing system to save caustic and freshwater usage (see BREF Section 4.7.9.5.2)
- Reuse final rinse-water for pre-rinse stage (see BREF Section 4.7.9.5.4)
- Reuse hot water from wort cooling
- Reduce water use in bottling/kegging (see BREF Section 4.7.9.5)

- Optimise water consumption of rinsing zone in the bottle/keg washer (see BREF Section 4.1.6.2.1)
- Optimise cleaning procedures to reduce wastewater load, e.g. base CIP sequences on conductivity rather than time (see BREF Section 4.3.9)
- Additionally see BREF Sections 4.3 & 4.7.9.5.

4.4 TREATMENT TECHNIQUES

4.4.1 Treatment of Air Emissions

The following techniques can be used for brewing, malting and distilling plants to treat air emissions and odour:

- Use dynamic, filter or electrostatic separators on exhaust air to remove particulates (see BREF Section 4.4.3.5)
- Dispersion of odours through capture of air and exhausting through an appropriately designed stack of sufficient height and configuration (see BREF Section 4.4.3.13)
- Use of biofilters or bioscrubbers on exhaust air to remove odour (see BREF Section 4.4.3.10)
- Use of an absorption system such as a packed bed or plate absorber on exhaust air to remove odour (see BREF Section 4.4.3.8)
- Use of an adsorption system such as activated carbon on exhaust air to remove odour (see BREF Section 4.4.3.9)
- Use thermal, boiler or catalytic treatment to control emissions from exhaust air (see BREF Section 4.4.3.11)
- Remove the organic odour components by condensing the vapour from boiling vessels combined with energy recovery
- Cover and vent wastewater treatment plants to abate odour where necessary
- Employ appropriate abatement technology to reduce emissions from the grain roasting process.

4.4.2 Treatment of Wastewater

The following techniques can be used to treat wastewater from brewing, malting and distilling plants:

- Select between treatment at source, centralised on site treatment or off site treatment of wastewater (see BREF Section 4.5.1)
- Segregation of process water from uncontaminated storm or other water so that uncontaminated water may be recycled or used to dilute wastewater prior to discharge (see BREF Sections 4.7.9.1 & 4.1.7.8)
- Screen solids from entering wastewater treatment system (see BREF Section 4.5.2.10)
- Equalisation and neutralisation of process water (see BREF Sections 4.5.2.3 & 4.5.2.4)
- Use biological treatment systems to biodegrade organic substances:
 - Anaerobic treatment for high strength wastewater (see BREF Section 4.5.3.2)
 - Aerobic treatment (see BREF Section 4.5.3)
 - Use combined anaerobic/aerobic system for the treatment of condensed vapours and singlings from distillation/rectification (see BREF Section 4.5.3.2.8)
- Use tertiary treatment systems for further removal of organic and inorganic substances for discharges to water courses or recycling of final effluent is required (see BREF Section 4.5.4).

4.4.3 Treatment of Waste/By-Products

The following techniques can be used to treat/dispose of waste from brewing, malting and distilling plants:

- Recycle/reuse/recover where possible:
 - Recycle packaging (e.g. glass, cardboard, paper, plastic) waste (see BREF Section 4.2.12.3)
 - Reuse pot ale, yeast, spent grain, trub, apple pumice and malt dust as animal fodder. Yeasts can also be used in food industry. Spent Kieselguhr can be used in the cement industry (see BREF Section 3.3.11.4)
 - Landspreading, biofiltration and composting of suitable wastes
- In treating wastewater sludges, the following techniques alone or in combination may be used (see BREF Section 4.5.6):
 - Thickening of the sludge
 - Dewatering of the sludge
 - Stabilization of the sludge through chemical, thermal or biological (aerobic or anaerobic digestion) means
 - Drying
- Landfilling: Applicable for material that is not suitable for reuse/recycle (see BREF Section 5.1(22))
- Use black spent grain as soil conditioning agent where suitable.

5. BEST AVAILABLE TECHNIQUES FOR THE BREWING, MALTING & DISTILLING 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 requirements 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 nature of process, plant scale, fuels used, etc.

5.2 BAT – GENERAL PREVENTATIVE MEASURES

For all brewing, malting and distilling plants, BAT is to do the following:

- Operate an environmental management system (see BREF Sections 4.1.1 & 5.1.1)
- Substitution or reduction of the use of some auxiliary materials, e.g. chemicals to minimise environmental impacts (see BREF Section 4.1.9)
- Employ good housekeeping practices (see BREF Section 5.1(16)).

5.2.1 Minimisation of Water Consumption

For all brewing, malting and distilling plants, BAT is to do the following:

- Apply a methodology for reducing water consumption (see BREF Sections 4.1.6.2.1 & 5.1(9))
- Provide water in a sufficient amount and suitable quality (see BREF Section 5.1(5))
- Optimise the use of water where possible (see BREF Sections 5.1(13), 5.1(5) & 5.1(20))
- Employ good housekeeping measures (see BREF Section 5.1(16))
- Recycling/reuse water where possible (see Section 4.2.3 of this document)
- Reduce water use in bottling/kegging (see BREF Section 4.7.9.5)
- Optimise water consumption of rinsing zone in the bottle/keg washer (see BREF Section 5.2.9).

5.2.2 Minimisation of Energy Consumption

For all brewing, malting and distilling plants BAT is to do the following:

- Apply a methodology for improving energy efficiency (see BREF Section 4.1.6.2.2)
- Implement an energy management system (see BREF Section 5.1(5))
- Employ good housekeeping and process optimisation; optimise process utilities such as compressed air, steam, refrigeration and electricity supply (see BREF Section 5.1(16))
- Employ energy efficiency techniques (see BREF Section 5.1.1); employ heat recovery (see BREF Sections 4.2.13.5 & 5.1.4.10(2)); use combined heat and power generation for electricity and thermal requirements (see BREF Section 4.2.13); the biogas from anaerobic digestion may also be utilised for energy recovery; install frequency converters on motors (see BREF Section 4.2.11.1); insulation of pipework to minimise heat/energy losses (see BREF Section 5.1.4.10(7))
- Use an energy monitoring system (see BREF Section 5.1(6))
- Additionally see BREF Section 5.1.4.10.

5.2.3 Minimisation of Emissions to Air

For all brewing, malting and distilling plants, BAT is to do the following:

- Apply a control strategy to identify, quantify and select appropriate abatement options for emissions to air (see BREF Section 5.1.5(1))
- Audit odour to identify and characterise sources and determine any action required (see BREF Section 5.1.5(5))
- Use appropriate storage and handling techniques to contain emissions, e.g. dust (see BREF Section 5.1(18))
- Collect waste gases at source wherever this is possible at reasonable cost (see BREF Section 5.1.5(2))
- Select process techniques with maximum possible product yield and minimum emissions to the environment (see BREF Section 5.1.5(4))
- Optimise start up and shut down procedures and other special operating situations (see BREF Section 5.1.5(3))
- Reduce the quantity of the waste gas, e.g. use air recirculation but still maintaining special regard to hygiene requirements. Recover CO₂ by cleaning, compressing, drying, purifying and liquefying it from beer fermentation gas where applicable (see BREF Section 5.2.9(1))
- Use substitutes for hazardous raw materials where possible
- Prevent or minimise emissions of substances that deplete the ozone layer, e.g. substituting such substances, collecting them during waste treatment (see BREF Sections 5.1.4(7) & 4.1.9.3)
- Procedures that involve switching off or bypassing the waste gas treatment systems must be designed and operated so as to ensure low emissions and must be subject to special monitoring by the recording of the relevant process parameters
- Put in place emergency plans and measures in the event of a failure of the emission reduction systems, to immediately reduce such emissions (see BREF Section 5.1.7)
- Aerate and cover wastewater treatment plants to prevent odour where necessary or use anaerobic digestion for wastewater treatment.

5.2.4 Minimisation of Emissions to Water

For all brewing, malting and distilling plants, BAT is to do the following:

- Implement a methodology for reducing water consumption (see BREF Sections 5.1(5) & 5.1(9))
- Ensure the regular maintenance of utility systems (see BREF Section 5.1(4))
- Optimise the use of water (see BREF Sections 5.1(13) & 5.1(5))
- Selection of materials/chemicals used in cleaning (see BREF Sections 5.1.3(9) & 5.1(21)). Optimise cleaning procedures and provide training, e.g. base CIP sequences on conductivity rather than time (see BREF Section 5.1.3)
- Apply appropriate storage and handling techniques to control emissions such as dust during loading/unloading, conveying and storage, e.g. provide bunding for liquids, use cold storage and transfer systems for dusty materials (see BREF Section 5.1(18)). Avoid overfilling process vessels, as contents can have very high COD levels (see BREF Section 4.1.8.3). Minimise leaching from spent grain during storage and transport (see BREF Section 4.5.7.8.4)
- Recycling/reuse water where possible to reduce emissions. See Section 5.2.1 of this document. Return strong liquors to the process or recover them for animal feed or other reuse where practicable (see BREF Section 4.7.9.1)
- Avoid disposing of yeast to drain because it has a very high COD level and its propensity to form organic acids (see BREF Section 4.7.9.6). Use fine mesh baskets over floor drains to keep grain out of the drainage system (see BREF Section 4.3.1.1)
- Apply multi stage bottle washing system which can lead to less chemical use (see BREF Section 5.2.9(4))

- In brewing, use a capacitance level switch for the separation of beer from dead yeast cells (see BREF Section 4.7.9.3)
- In distilling, use multi effect vacuum evaporators to concentrate slops from the mash column and then process to obtain pot ale which can be sold for agricultural use (see BREF Section 4.7.9.7.2)
- Meter the volume of product into containers rather than filling to capacity to avoid overfilling (see BREF Section 5.1.4.9).

5.2.5 Protection of Surface and Groundwater

For all brewing, malting and distilling plants, BAT is to do the following:

- Apply overfill protection on bulk storage tanks (see BREF Section 4.1.8.3)
- Use bunds or double skinned tanks for bulk storage tanks (see BREF Section 4.6.4 and the Agency Materials Storage Guidance Note)
- Seal the base and sides of WWTP tanks.

5.2.6 Waste Minimisation

For all brewing, malting and distilling plants, BAT is to do the following:

- Implement a waste minimisation programme (see BREF Section 5.1(5))
- Apply good housekeeping practices (see BREF Section 5.1(6))
- Improve operating practices. Optimise the process control to minimise spoilage, off specification product, water usage and other losses through measurement of parameters such as temperature, pressure and flow (see BREF Section 5.1(19))
- Recycle or reuse solid by-products or sludge produced (see Section 4.4.3 of this document)
- For storage and handling, reduce overfill levels to 0.03% - 0.1% by using in line check weighers or knowledgeable filler operator (see BREF Section 4.2.12.6)
- Apply appropriate storage and handling techniques to control emissions such as dust during loading/unloading, conveying and storage, e.g. provide bunding, use cold storage and transfer systems for dusty materials (see BREF Section 5.1(18))
- Optimise packaging line efficiency (see BREF Section 5.1.4.9).

5.2.7 Prevention of Noise Emissions

For general preventative measures for abatement of noise (see BREF Section 5.1(3) & 5.1(7)), BAT is to:

- Use silencers in ventilation systems
- Use elastic linkages in between fans and ducts
- Install pipes with better sound insulation properties
- Increase wall thickness of pipes
- Insulate pipes in jackets
- Insulate mechanical/thermal vapour compressors
- Install machines on a basement with rubber
- Keep doors and windows closed.

5.3 BAT – PREVENTATIVE MEASURES FOR SPECIFIC UNIT PROCESSES

For all brewing, malting and distilling industries, in addition to the general measures in Section 5.1, BAT is to do the following for all relevant unit operations.

5.3.1 Raw Materials Reception and Preparation

- Control dust during loading/unloading, conveying and storage and contain emissions, e.g. local extract systems; bunding for storage of liquid chemicals, etc. (see BREF Sections 5.1.5(2) & 5.1(18))

- Recycling of packaging materials (see BREF Sections 4.2.12.3 & 5.1.4.9(1))
- Reuse transport water for the conveying of fruit through the process during the manufacture of cider (see BREF Section 3.3.10.2.2).

5.2.2 Size Reduction, Mixing, Forming

- Particulate matter (dust) is often generated and should be recovered in extracted air and reused in the process where practicable (see BREF Section 2.1.5.5.3)
- Noise can be an issue with size reduction techniques such as milling and grinding. Insulate and enclose noisy equipment in insulated buildings where possible (see BREF Sections 4.1.3.5, 4.1.4.1 & 5.1(3)).

5.3.3 Separation

- Use high efficiency separation techniques to maximise recovery of beer from fermentation process
- In brewing, use a capacitance level switch for the separation of beer from dead yeast cells (see BREF Sections 4.1.8.3 & 4.7.9.3)
- In distilling, use multi effect vacuum evaporators to concentrate slops from the mash column and then process to obtain pot ale which can be sold for agricultural use (see BREF Section 4.7.9.2)
- In distillation, if a recovery system exists, a proportion of the stillage may be reused. The balance may be processed to animal feed compounds resulting in a condensate for disposal (see BREF Section 4.7.9.7.1)
- Reuse filtrate, cake (e.g. animal feed) or filter aid (e.g. Spent Kieselguhr can be used in the cement industry) where practicable (see BREF Sections 3.3.11.4 & 5.2.9(3)).

5.3.4 Product Processing

- Avoid disposing of yeast to drain because it has a very high COD level and its propensity to form organic acids (see BREF Section 4.3.1.1)
- Reuse spent yeast and spent grain as animal fodder. Yeasts can also be used in the food industry (see BREF Sections 4.1.7.7 & 4.7.9.3)
- Reduce the quantity of the waste gas, e.g. use air recirculation but still maintaining special regard to hygiene requirements. Recover CO₂ by cleaning, compressing, drying, purifying and liquefying it from beer fermentation gas where applicable (see BREF Section 5.2.9(1)).

5.3.5 Heat Processing

- Remove the organic odour components by condensing the vapour from boiling vessels combined with energy recovery.

5.3.6 Concentration by Heat

- Use appropriate abatement technology to reduce the emissions of dust to air from the drying process in malting and reuse particulate materials in the process or as animal feed
- Reduce energy consumption by pre-evaporation or dewatering before dehydration
- Reuse hot water from wort cooling (see BREF Section 5.2.9.1(1))
- Employ heat recovery (see BREF Section 5.1.4.10(2)) such as on vapour from wort kettle in brewery (see BREF Section 5.2.9.1(1)).

5.3.7 Processing by Removal of Heat

- Employ heat recovery, e.g. use closed loop system for pasteurisation (see BREF Sections 5.1.4.10(2), 4.1.6.4 & 4.7.5.6).

5.3.8 Post Processing Operations

- Recycle packaging waste (e.g. glass, cardboard, paper, plastic) (see BREF Section 5.1.4.9(1))
- Optimise packaging line efficiency (see BREF Sections 5.1.4.9(4) & 4.2.12.4).

5.3.9 Cleaning and Sanitation

- Selection of materials/chemicals used in cleaning (see BREF Section 5.1.3 (9))
- Reuse of cleaning and bottle/keg washing water after chemical precipitation and sedimentation (see BREF Section 4.7.9.5.3)
- Use a multistage bottle washing system to save caustic and freshwater usage (see BREF Sections 4.7.9.5.2 & 5.2.9(4))
- Reuse final rinse-water for pre-rinse stage (see BREF Section 4.7.9.5.4)
- Reuse hot water from wort cooling (see BREF Section 5.2.9.1(1))
- Reduce water use in bottling/kegging (see BREF Section 4.7.9.5)
- Optimise water consumption of rinsing zone in the bottle/keg washer (see BREF Section 5.2.9(5))
- Optimise cleaning procedures to reduce wastewater load, e.g. base CIP sequences on conductivity rather than time (see BREF Sections 4.3.9, 5.1(19.4) & 5.1.3(10))
- Manage and minimise the use of water, energy and detergents (see BREF Section 5.1.3(5)).

5.4 BAT – MEASURES FOR TREATMENT, ABATEMENT AND DISPOSAL

5.4.1 Treatment of Air Emissions

For all brewing, malting and distilling plants, BAT is to minimise the formation of air emissions and odours using measures outlined in Section 5.2 of this document and then if necessary, treat air emissions as follows:

- Use dynamic, bag filter or electrostatic separators on exhaust air to remove particulates (see BREF Sections 4.4.3.5 & 5.1.5(2))
- Dispersion of odours through capture of air and exhausting through an appropriately designed stack of sufficient height and configuration (see BREF Section 4.4.3.13)
- Use of biofilters or bioscrubbers on exhaust air to remove odour (see BREF Sections 4.4.3.10 & 5.1.5(5))
- Use of an absorption system such as a packed bed or plate absorber on exhaust air to remove odour (see BREF Sections 4.4.3.8 & 5.1.5(5))
- Use of an adsorption system such as activated carbon on exhaust air to remove odour (see BREF Sections 4.4.3.9 & 5.1.5(5))
- Use thermal, boiler or catalytic treatment to control emissions from exhaust air (see BREF Section 4.4.3.11)
- Employ appropriate abatement technology to reduce emissions from the grain roasting process
- Remove the organic odour components by condensing the vapour from evaporating/boiling pans combined with energy recovery
- Cover and vent wastewater treatment plants to abate odour where necessary.

5.4.2 Treatment of Wastewater

For all brewing, malting and distilling plants, BAT is to minimise the quantity and load of wastewater generated using measures outlined in Section 5.2.4 of this document, then treat wastewater as follows:

- Select between treatment at source, centralised on site treatment or off site treatment of wastewater (see BREF Section 5.1.6)
- Segregation of process water from uncontaminated storm or other water so that uncontaminated water may be recycled or used to dilute wastewater prior to discharge (see BREF Section 5.1.6)
- Screen solids from entering wastewater treatment system (see BREF Section 5.1.6(1))
- Use primary treatment – Equalisation and neutralisation of process water, etc. (see BREF Sections 5.1.6(2-5))
- Use secondary treatment by means of biological treatment systems to biodegrade organic substances:
 - anaerobic treatment for high strength wastewater (see BREF Section 5.1.6(7))
 - aerobic treatment (see BREF Section 5.1.6(7))
 - use combined anaerobic/aerobic system for the treatment of condensed vapours and singlings from distillation/rectification (see BREF Section 4.5.3.3)
- Use tertiary treatment systems for further removal of organic and inorganic substances for discharges to water courses or recycling of final effluent is required (see BREF Sections 5.1.6(9-13))
- Regularly conduct laboratory analysis of the effluent composition and maintain records (see BREF Section 5.1(6))
- Addition information, see BREF Section 5.1.6.

5.4.3 Treatment and Disposal of Waste

For all brewing, malting and distilling plants, BAT is to minimise the quantity and load of waste generated using measures outlined in Section 5.2 of this document, then treat/dispose of waste as follows:

- Composting of solid organic waste
- Landspreading and biofiltration of suitable wastes
- Recycle/reuse/recover where possible (see BREF Section 5.1(19) & 5.1(5)):
 - Recycle packaging waste (e.g. glass, cardboard, paper, plastic) (see BREF Section 4.2.12.3)
 - Reuse pot ale, yeast, spent grains, trub, apple pumice and malt dust as animal fodder. Yeasts can also be used in the food industry. Spent Kieselguhr can be used in the cement industry (see BREF Section 3.3.7.3)
- In treating wastewater sludges, the following techniques alone or in combination may be used (see BREF Sections 5.1.6(15-18)):
 - Thickening of the sludge
 - Dewatering of the sludge
 - Stabilization of the sludge through chemical, thermal or biological (aerobic or anaerobic digestion) means
 - Drying.

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 Emission to Air

Constituent Group or Parameter	Emission Level (mg/m ³)	Mass Threshold (g/hr) ^{Note 1}
Total Particulate Matter (including emissions from material handling)	5 - 50 150	>200 At mass flow up to 200
Total Organic Carbon ^{Note 2}	50	500
Other	--	Note 3

Note 1: The Mass Flow Threshold is calculated in g/hr or kg/hr and is determined to be the maximum emission, which can occur over any one-hour period of plant operation. Where the Mass Flow in the raw gas exceeds the mass flow threshold given in the Table, abatement will be required to reduce the emission to below the appropriate emission level or mass flow threshold.

Note 2: For discharge points associated with solvent emissions (gumming, labelling, etc.)

Note 3: Any relevant polluting substances as specified in Schedule to S.I. No. 394 of 2004: EPA (Licensing)(Amendment) Regulations, 2004.

6.1.1 Odour Emission

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. Reference shall be made to the Environmental Protection Agency's publication *Odour Impacts and Odour Emission Control Measures for Intensive Agriculture (2001)*.

6.2 EMISSION LEVELS FOR DISCHARGES TO WATER

The following table sets out emission level values 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*

Constituent Group or Parameter	Emission Level	Notes
pH	6 - 9	
Number of Toxicity Units (TU)	5	1
BOD ₅	>90% removal ³ , or 20 - 40mg/l	
COD	>75% removal ³ , or 125 - 250mg/l	
Suspended Solids	50mg/l	
Total Ammonia (as N)	10 - 15mg/l	
Total Nitrogen (as N)	>80% removal ³ , or 5 - 25mg/l	2,4
Total Phosphorus (as P)	>80% removal ³ , or 2 - 5mg/l	4
Oils, Fat and Grease	10 - 15mg/l	
Mineral Oil (from interceptor)	20mg/l	
Mineral Oil (from biological treatment)	1.0mg/l	
Other	--	5

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

6.3 EMISSIONS TO LAND

In the assessment of the impact of landspreading of organic waste, reference shall be made to the relevant Environmental Protection Agency's guidance and any guidance from the Department of Agriculture and Teagasc.

7. COMPLIANCE MONITORING

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

7.1 MONITORING OF EMISSIONS TO AIR

- Annual monitoring of boiler stack emissions for SO_x, NO_x, 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 instruction at a frequency determined by the Agency.
- Odour monitoring (if considered necessary) should be conducted at the nearest odour sensitive receptor locations at a frequency determined by the Agency.
- Periodic monitoring for other parameters as determined by the Agency.

7.2 MONITORING OF AQUEOUS EMISSIONS

- For uncontaminated cooling waters, continuous monitoring of temperature and flow.
- Continuous monitoring of flow discharge from wastewater treatment plant and any other parameters deemed necessary by the Agency.
- Daily monitoring of flow, volume, pH, temperature and any other relevant parameters deemed necessary by the Agency, taking account of the nature, magnitude and variability of the emissions and the reliability of the control technique.
- Establish existing conditions prior to start-up of key emission constituents and salient flora and fauna.
- Monitoring of influent and effluent for the waste water treatment plant to establish % BOD reduction and early warning of any difficulties in waste water treatment, 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 process emissions to groundwater, including during the 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 Reference Document on Best Available Techniques in the Food, Drink and Milk Industry (January 2006).
- 1.2 Council Directive 96/61/EC of 24 September 1996 concerning Integrated Pollution Prevention and Control.

2. Ireland

- 2.1 Integrated Pollution Control Licensing BATNEEC Guidance Note for the Malting, Brewing, and Distilling (Draft 3, May 1996).
- 2.2 Environmental Protection Agency Guidance Note For Noise in Relation to Scheduled Activities - 2ND Edition (2006).

Appendix 2

GLOSSARY OF TERMS AND ABBREVIATIONS

BAT	Best Available Technique
BOD	Biochemical Oxygen Demand
BREF	Reference document on Best Available Techniques in Food, Drink and Milk Industries, published by the European Commission, January 2006.
°C	Degree Celsius
CIP	Cleaning In Place
CO	Carbon monoxide
COD	Chemical Oxygen Demand
CO ₂	Carbon dioxide
ELV	Emission Limit Value
kg	Kilogramme
K	Degree Kelvin (0 °C = 273.15 K)
m ³	Cubic metre
mg	Milligramme
MJ	Megajoule (1 MJ = 1000 kJ = 10 ⁶ joule)
N ₂	Nitrogen
Nm ³	Normal cubic metre (101.3 kPa, 273 K)
NH ₃	Ammonia
NH ₄	Ammonium
NO	Nitrogen monoxide
NO ₂	Nitrogen dioxide
NO _x	Nitrogen oxides
O ₂	Oxygen
SO ₂	Sulphur dioxide
SO _x	Sulphur oxides
SRM	Specified Risk Material
t	Tonne (metric)
VOC	Volatile Organic Compounds
WWTP	Waste Water Treatment Plant