BAT Guidance Note on
Best Available Techniques for the Manufacture of Glass including Glass Fibre

(1st Edition)

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Contents

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(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. Operators should therefore continue to keep up to date with the best available techniques relevant to the activity and discuss appropriate innovations with the EPA.

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 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 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:

4.2.1 The melting of mineral substances including the production of mineral fibres with a melting capacity exceeding 20 tonnes per day.

4.2.2 The manufacture of glass fibre or mineral fibre, not included in paragraph 4.2.1 or 4.3.

4.3 The manufacture of glass including glass fibre with a melting capacity exceeding 20 tonnes per day or 5,000 tonnes per year.

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 Glass Manufacturing Industry*, published by the European Commission, December 2001.)

4.1 DESCRIPTION OF PROCESS

The Glass Manufacturing Industry is considered to be comprised of eight sectors. These sectors are based on the products manufactured, but inevitably there is some overlap between them. The eight sectors are:

1. Container Glass;
2. Flat Glass;
3. Continuous Filament Glass Fibre;
4. Domestic Glass;
5. Special Glass (including water glass);
6. Mineral Wool (With two sub-sectors, glass wool and stone wool.);
7. Ceramic Fibre;
8. Frits.

Some process steps apply to all of the manufacturing sectors such as melting and refining while others are more sectoral specific. The principal steps involved in the Glass manufacturing process are:

- Raw materials handling and storage (see BREF Section 2.1)
- Mixing and transfer (see BREF Section 2.1)
- Melting and refining (see BREF Sections 2.2 & 2.3)
  - Regenerative Furnaces (see BREF Section 2.3.1)
  - Recuperative Furnaces (see BREF Section 2.3.2)
  - Oxy-Fuel Melting (see BREF Section 2.3.3)
  - Electric Melting (see BREF Section 2.3.4)
  - Combined Fossil Fuel & Electric Meting (see BREF Section 2.3.5)
  - Discontinuous Batch Melting (see BREF Section 2.3.6)
  - Special Melter Designs (see BREF Section 2.3.7)
- Forming
  - Float bath (see BREF Section 2.5.1)
  - Rolling (see BREF Section 2.5.2)
  - Pressing (see BREF Sections 2.4, 2.7 and 2.8)
  - Blowing (see BREF Section 2.4)
  - Fiberising (see BREF Section 2.9)
  - Frit quenching (see BREF Section 2.11)
- Conditioning (see BREF Section 2.2.2)
- Coating, including binder and lubricant application (see BREF Section 2)
- Surface treatments (e.g. acid polishing) (see BREF Section 2.7)
- Curing and drying activities (see BREF Sections 2.6, 2.9 & 2.10)

- Milling (see BREF Sections 2.6, 2.9 & 2.11)
- Machining and cutting (see BREF Sections 2.5.1 & 2.7).

4.2 RISK TO THE ENVIRONMENT

The main environmental concerns for the Glass Industry as a whole are emissions to atmosphere and energy consumption. Glass making is a high temperature, energy intensive process, and the energy is provided either directly by the combustion of fossil fuels, by electrical heating or by a combination of both techniques. In general the most significant emissions include oxides of nitrogen, particulate matter, sulphur dioxide, VOCs, halides and in some cases metals.

Water pollution is not a major issue for most installations within the glass industry, although there are exceptions. Water is used mainly for cleaning and cooling and is generally readily treated or reused. Process waste levels are relatively low with many solid waste streams being recycled within the process (see BREF Section 3.2).

4.2.1 Energy Use

Glass making is energy intensive and the choices of energy source, heating technique and heat recovery method are central to the design of the furnace. The same choices are also some of the most important factors affecting the environmental performance and energy efficiency of the melting operation. Thus, one of the most important inputs to the glass making process is energy. The three main energy sources are fuel oil, natural gas and electricity.

The actual energy requirements experienced in the various sectors vary widely from about 3.5 to over 40 GJ/tonne of finished product. This figure depends very heavily on the furnace design, scale and method of operation. However, the majority of glass is produced in large furnaces and the energy requirement for melting is generally below 8 GJ/tonne.

See BREF Sections 3.3.5 (Container Glass), 3.4.5 (Flat Glass), 3.5.5 (Continuous Filament Glass Fibre), 3.6.5 (Domestic Glass), 3.7.5 (Special Glass), 3.8.5 (Mineral Wool), 3.9.5 (Ceramic Fibre) and 3.10.5 (Frits) for details of energy usage arising from sector specific processes.

4.2.2 Emissions to Air

All of the sectors within the Glass Industry involve the use of powdered, granular or dusty raw materials. The storage and handling of these materials represents a significant potential for dust emissions. The movement of materials through systems incorporating silos and blending vessels results in the displacement of air, which if uncontrolled could contain very high dust concentrations. This is particularly true if pneumatic transfer systems are used. The transfer of materials using conveyor systems and manual handling can also result in significant dust emissions (see BREF Section 3.2.2.1).

Many processes in the Glass Industry involve the use of cullet (either internal or external – cullet is broken glass which is recycled as a raw material), which may require sorting and crushing prior to use in the furnace. This also has the potential for dust emissions. The level of emissions will depend on factors such as the design of the installation, if extraction is filtered before discharge, how well buildings are sealed, etc. Some processes also involve the use of volatile liquids (solvents), which can result in releases to air from tank breathing losses and from the displacement of vapour during liquid transfers (see BREF Section 3.2.2.1).

For many of the processes falling within the scope of this document the greatest potential for environmental pollution arises from the melting activities (see BREF Section 3.2.2.1). In general, the main environmental pollutants arising from melting are:

- the products of fossil fuel combustion and the high temperature oxidation of nitrogen in the combustion atmosphere (i.e. sulphur dioxide, carbon dioxide, and oxides of nitrogen),
- particulate matter arising mainly from the volatilisation and subsequent condensation of volatile batch materials, and
- gases emitted from the raw materials and melt during the melting processes.

For downstream activities (i.e. activities undertaken following melting) for example, forming, annealing, coating, processing, etc. The emissions can vary greatly between the different sectors and are discussed in the sector specific sections. Although many of the sectors share some similar melting techniques the downstream activities tend to be exclusive to each sector (see BREF Section 3.2.2.1). In general, emissions to air can arise from:

- coating application and/or drying (e.g. mineral wool, continuous filament glass fibre, container glass, and some flat glass),
- any activities performed on the materials produced such as cutting, polishing, or secondary processing (e.g. mineral wool, domestic glass, special glass, ceramic fibre), and
- some product forming operations (e.g. mineral wool, and ceramic fibre).

See BREF Sections 3.3.2 (Container Glass), 3.4.2 (Flat Glass), 3.5.2 (Continuous Filament Glass Fibre), 3.6.2 (Domestic Glass), 3.7.2 (Special Glass), 3.8.2 (Mineral Wool), 3.9.2 (Ceramic Fibre) and 3.10.2 (Frits) for details on emission to air arising from sector specific processes.

4.2.3 Emissions to Water

In general, emissions to the water environment are low compared to other industrial sectors and there are few major issues that are specific to the Glass Industry. However, there are activities undertaken in some sectors which require further consideration and are discussed in the sector specific sections, particularly domestic glass (see BREF Section 3.6.3), special glass (see BREF Section 3.7.3) and continuous filament glass fibre (see BREF Section 3.5.3). Specific issues of organic contamination can arise from mineral wool and continuous filament glass fibre processes. Issues of heavy metals (particularly lead) and high trade effluent volumes can arise from special glass, frits and domestic glass processes.

In general water is used mainly for cleaning and cooling and can be readily recycled or treated using standard techniques.

Most activities will use some potentially polluting substances, e.g. water treatment chemicals, lubricants or fuel oil. All liquid raw materials pose a potential threat to the environment through spillage or containment failure. Good practice and design is sufficient to control most potential emissions.

Specific issues relating to aqueous emissions are discussed in the sector specific sections in BREF Sections 3.3.3 (Container Glass), 3.4.3 (Flat Glass), 3.5.3

(Continuous Filament Glass Fibre), 3.6.3 (Domestic Glass), 3.7.3 (Special Glass), 3.8.3 (Mineral Wool), 3.9.3 (Ceramic Fibre) and 3.10.3 (Frits).

4.2.4 Emissions of Other Waste

A characteristic of most of the Glass Industry sectors is that the great majority of internally generated glass waste is recycled back to the furnace. The main exceptions to this are the Continuous Filament Sector, the Ceramic Fibre Sector and producers of very quality sensitive products in the Special Glass and Domestic Glass Sectors. The Mineral Wool and Frits Sectors show a wide variation in the amount of waste recycled to the furnace ranging from nothing to almost 100 % for some stone wool plants.

Other waste production includes waste from raw material preparation and handling, waste deposits (generally sulphates) in waste gas flues, and waste refractory materials at the end of the life of the furnace.

See BREF Sections 3.3.4 (Container Glass), 3.4.4 (Flat Glass), 3.5.4 (Continuous Filament Glass Fibre), 3.6.4 (Domestic Glass), 3.7.4 (Special Glass), 3.8.4 (Mineral Wool), 3.9.4 (Ceramic Fibre) and 3.10.4 (Frits) for detailed description of other wastes arising from sector specific processes.

4.2.5 Noise and Odour

Other outputs from the Glass Manufacturing processes can include noise and odours. Noise arises from a range of activities including: fans, motors, material handling; vehicle movements, engineering activities, and compressed air systems. Noise is not considered to be a particular problem in the Glass Industry. However, noise sources clearly exist and could lead to problems with any close residential developments. In general, any problems are readily dealt with by good design and where necessary, noise abatement techniques. Certain pollution control techniques can also require noise control, which can add to the overall cost of the technique.

Odours are not generally a problem within the Glass Industry, but they can arise from certain activities and measures may be required to avoid problems off-site. The main activities that can be associated with odour problems are cullet preheating, mineral wool curing, and sometimes oil storage (see BREF Section 3.2.2).

4.3 Control Techniques

The existing or possible measures for eliminating, reducing and controlling emissions in the Glass Manufacturing Industry are described in this Section. References to more details and descriptions in the BREF document are given.

4.3.1 Environmental Management

An Environmental Management System (EMS) is a tool that operators can use to address design, construction, maintenance, operation and decommissioning issues in a systematic, demonstrable way. An EMS includes the organisational structure, responsibilities, practices, procedures, processes and resources for developing, implementing, maintaining, reviewing and monitoring the environmental policy. Environmental Management Systems are most effective and efficient where they form an inherent part of the overall management and operation of an installation.

An environmental management system (EMS) for an IPPC installation contains the following components:

- (i) Defining of an environmental policy,
- (ii) Planning and establishing objectives and targets,
- (iii) Implementing and operating procedures,
- (iv) Checking and corrective action,
- (v) Management review,
- (vi) Preparing a regular environmental statement,
- (vii) Validating by certification body or external EMS verifier,
- (viii) Considering design for end-of-life plant decommissioning,
- (ix) Development of cleaner technologies,
- (x) Benchmarking.

4.3.2 Minimisation of Energy Consumption

Glass making is a very energy intensive process and the choices of energy source, heating technique and heat recovery method are central to the design of the furnace and to the economic performance of the process. The same choices are also some of the most important factors affecting the environmental performance and energy efficiency of the melting operation. In general, the energy necessary for melting glass accounts for over 75 % of the total energy requirements of glass manufacture, however there may be differences across the sector specific sections. This section concentrates on techniques to reduce the energy requirements for melting activities.

The correct application of the following can minimise energy consumption in the melting process.

- Melting Technique and Furnace Design (see BREF Section 4.8.1)
- Combustion Control and Fuel Choice (see BREF Section 4.8.2)
- Use of Cullet in the Glass Furnace (see BREF Section 4.8.3)
- Use of a Waste Heat Boiler (see BREF Section 4.8.4)
- Batch and Cullet Preheating (see BREF Section 4.8.5).

4.3.3 Techniques for Material Handling and Storage

The diversity of the Glass Industry results in the use of a wide range of raw materials. The majority of these materials are solid inorganic compounds, either naturally occurring minerals or man-made products. They vary from very coarse materials to finely divided powders. Liquids and, to a lesser extent, gases are also used within most sectors.

There are few issues regarding emissions from materials handling that are specific to the Glass Industry. Therefore, this section only summarises those techniques, which are generally considered to constitute good practice when handling these types of materials (see BREF Section 4.3).

Bulk powder materials are usually stored in silos, and emissions can be minimised by using enclosed silos, which are vented to suitable dust abatement equipment such as fabric filters. Where practicable collected material can be returned to the silo or recycled to the furnace.

Where the amount of material used does not require the use of silos, fine materials can be stored in enclosed containers or sealed bags. Stockpiles of coarse dusty materials can be stored under cover to prevent wind born emissions. Where dust is a particular problem, some installations may require the use of road cleaning vehicles and water damping techniques.

Where materials are transported by above ground conveyors some type of enclosure to provide wind protection is necessary to prevent substantial material loss.

An area where dust emissions are common is the furnace feed area. The main techniques for controlling emissions in this area are listed below:

- batch moisture
- slight negative pressure within the furnace (only applicable as an inherent aspect of operation)
- provision of extraction, which vents to a filter system, (common in cold top melters)
- enclosed screw feeders
- enclosure of feed pockets (cooling may be necessary).

Volatile raw materials can be stored so as to minimise emissions to air. In general, bulk storage temperatures should be kept as low as practicable and temperature changes due to solar heating, etc. should be taken into account. For materials with a significant vapour pressure, or for odorous substances, specific techniques may be necessary for reducing releases arising from tank breathing or from the displacement of vapour during liquid transfers. Techniques for reducing losses from storage tanks at atmospheric pressure include the following:

- tank paint with low solar absorbency
- temperature control
- tank insulation
- inventory management
- floating roof tanks
- vapour return transfer systems
- bladder roof tanks
- pressure/vacuum valves, where tanks are designed to withstand pressure fluctuations
- specific release treatment, e.g. adsorption, absorption, condensation
- subsurface filling.

Standard good practice can be used to control emissions from storage of liquid raw materials and intermediates (see BREF Section 4.6):

- Provision of adequately sized containment (bunding)
- Inspection/testing of tanks and bunding to ensure integrity
- Overfill protection (cut off valves, alarms, etc.)
- Positioning of vents and filling points within the bund or other containment.

4.3.4 Minimisation of Emissions to Air

The following are the main techniques for controlling each substance emitted to atmosphere from melting activities and from some of the downstream operations.

BREF Section 4 gives detailed descriptions of each technique and explains the emission levels achieved, the applicability of the technique, financial issues and other associated considerations. Sections 4.3.4.1 to 4.3.4.4 below deal with emissions from melting processes and Section 4.3.4.5 deal with reducing emissions from non-melting processes.

4.3.4.1 Particulate Matter

Techniques for controlling particulate emissions include secondary measures, generally electrostatic precipitators (EP's) and bag filters, and primary measures.

Primary control techniques are based mainly on raw material changes and furnace/firing modifications. In most applications primary techniques cannot achieve emission levels comparable with bag filters and EP's (see BREF Section 4.4.1.1).

The electrostatic precipitator (EP) consists of a series of high voltage discharge electrodes and corresponding collector electrodes. Particles are charged and subsequently separated from the gas stream under the influence of the electric field. EPs are very effective in collecting dust in the range 0.1 µm to 10 µm, and overall collection efficiency can be 95 - 99 %. Actual performance varies depending mainly on waste gas characteristics and EP design. In principle, this technique is applicable to all new and existing installations in all sectors (except stone wool cupolas due to the risk of explosion). Costs are likely to be higher for existing plants, particularly where there are space restrictions. (see BREF Section 4.4.1.2).

Bag filter systems use a fabric membrane which is permeable to gas but which will retain the dust. Dust is deposited on and within the fabric, and as the surface layer builds up it becomes the dominating filter medium. The direction of gas flow can be either from the inside of the bag to the outside, or from the outside to the inside. Fabric filters are highly efficient and a collection efficiency of 95 - 99 % would be expected. Particulate emissions between 0.1 mg/m^3 and 5 mg/m^3 can be achieved and levels consistently below 10 mg/m^3, could be expected in most applications (see BREF Section 4.4.1.3).

Other secondary measures, which can be used to reduce particulate emission, are:

- Mechanical Collectors (see BREF Section 4.4.1.4)
- High Temperature Filter Media (see BREF Section 4.4.1.5)
- Wet Scrubbers (see BREF Section 4.4.1.6).

4.3.4.2 Oxides of Nitrogen

The most appropriate techniques for controlling emissions of NOx are generally:

- Primary measures,
  - Combustion Process Modification (see BREF Section 4.4.2.1)
  - Changes to Batch Formulations (see BREF Section 4.4.2.2)
  - Furnace Design (see BREF Section 4.4.2.3)
  - The FENIX Process (combination of above primary measures) (see BREF Section 4.4.2.4)
- Oxy-fuel melting (see BREF Section 4.4.2.5)
- Chemical reduction by fuel (SRF) (see BREF Section 4.4.2.6)
- Electric Melting (see BREF Section 5.6.2)

- Selective catalytic reduction (SCR) (see BREF Section 4.4.2.7) and
- Selective non-catalytic reduction (SNCR) (see BREF Section 4.4.2.8).

4.3.4.3 Oxides Of Sulphur

The main techniques for controlling SOx emissions are fuel selection, batch formulation and acid gas scrubbing (see BREF Section 4.4.3).

Fuel Selection: The most obvious way to reduce SOx emissions is to reduce the sulphur content of the fuel. Fuel oil is available in various sulphur grades (<1 %, <2 %, <3 % and >3 %), and natural gas is essentially sulphur free. The conversion to a lower sulphur content fuel does not generally result in any increased costs except the higher fuel price. The conversion to gas firing requires different burners and a range of other modifications.

Batch Formulation: In conventional glass making, sulphates are the main source of SOx emissions from batch materials. Sulphates are the most widely used fining (i.e. fining is a process for removing oxygen bubbles from molten glass) agents and are also important oxidizing agents. In most modern glass furnaces the levels of batch sulphates have been reduced to the minimum practicable levels, which vary depending on the glass type. The issues surrounding the reduction of batch sulphates are discussed in BREF Section 4.4.1.1 and the issues relating to the recycling of filter/EP dust are discussed in BREF Section 4.4.3.3.

In stone wool production important sources of SO_2 emission (in addition to coke) are the use of blast furnace slag and cement bound briquettes in the batch. The availability of low sulphur coke and slag are restricted by very limited supply within economical transport distances. Slag can generally be eliminated from most batches, with the exception of the production of limited amounts of white fibre for specific applications.

Acid Gas Scrubbing: The operating principles of dry and semi-dry scrubbing are the same. The reactive material (the absorbent) is introduced to, and dispersed in the waste gas stream. This material reacts with the SOx species to form a solid, which must be removed from the waste gas stream by an electrostatic precipitator or bag filter system. The absorbents chosen to remove SOx are also effective in removing other acidic gases. In the dry process the absorbent is a dry powder (usually $Ca(OH)_2$, $NaHCO_3$, or $Na_2(CO)_3$). In the semi-dry process the absorbent (usually Na_2CO_3, CaO or $Ca(OH)_2$) is added as a suspension or solution and water evaporation cools the gas stream. The reductions achieved with the techniques depend on a number of factors including waste gas temperature, the amount and type of absorbent added (or more precisely the molar ratio between reactant and pollutants) and the dispersion of the absorbent. BREF Section 4.4.3.3 outlines the efficiencies obtained with various absorbents and processes.

4.3.4.4 Fluorides (HF) and Chlorides (HCl)

Emissions of HF and HCl arise from impurities in the batch materials or from batch materials that are selected because they contain these species in sufficient quantities to impart desired product qualities. The main techniques for controlling emissions of HF and HCl are:

- Reduction at Source (see BREF Section 4.4.4.1)
- Scrubbing Techniques (see BREF Section 4.4.4.2).

Where the halides are present as impurities emissions can generally be controlled by raw material selection, although scrubbing is often used either where raw material selection is not sufficient or where scrubbing is used to control other substances. Where halides are used to impart specific characteristics there are two main approaches scrubbing or batch reformulation to achieve the same characteristics by other means. Particular successes with reformulation have been achieved in continuous filament glass fibre.

4.3.4.5 Emissions from Downstream Processes

Emissions from downstream processing are sector specific and are described in some detail in BREF Section 4.5. With the exception of the mineral wool sector emissions are generally much lower than from the melting activities. Abatement techniques are generally based on conventional dust collection and wet scrubbing techniques with some thermal oxidation.

In mineral wool processes there is the potential for substantial emissions from the application and curing of organic resin based binder systems. The techniques for controlling these emissions are discussed in detail in BREF Section 4.5.6.

4.3.5 Minimising of Wastewater

In general, emissions to the water environment are low compared to other industrial sectors and there are few major issues that are specific to the Glass Industry. However, there are activities undertaken in some sectors which require further consideration and are discussed in the sector specific sections, particularly domestic glass which has the potential to discharge significant quantities of wastewater (see BREF Section 3.6.3), special glass (see BREF Section 3.8.3) and continuous filament glass fibre (see BREF Section 3.6.3). Specific issues of organic contamination can arise from mineral wool and continuous filament glass fibre processes. Issues of heavy metals (particularly lead) and high trade effluent volumes can arise from special glass, frits and domestic glass processes.

The issues considered specific to the Glass Industry are:

- Mineral wool process water systems
- Continuous filament glass fibre effluent
- Special glass (TV glass)
- Domestic glass (lead crystal, crystal glass).

Some general BAT techniques for consideration in the glass manufacturing industry are (see BREF Section 4.6):

- Water is used mainly for cleaning and cooling and can be readily recycled or treated using standard techniques

- Where any potentially harmful materials are used (e.g., lubricating oils, water treatment chemicals) measures can be taken to prevent them entering the water circuit
- Wherever practicable closed cooling systems can be used and blow down minimised
- Standard pollution control techniques (listed in Table 4.3) can be used to reduce emissions further if necessary. For example: settlement, screening, oil separators, neutralisation, and discharge to municipal wastewater schemes. Specific technical details for these treatment techniques may be found in reference [Reference Document on Best Available Techniques in Common Waste Water and Waste Gas Treatment / Management Systems in the Chemical Sector, February 2003].

Table 4.3 - Possible wastewater treatment processes – glass industry.

Physical Treatment		
▪ Screening	▪ Skimming	▪ Settlement
▪ Centrifuge	▪ Filtration	▪ Neutralisation
▪ Aeration	▪ Precipitation	▪ Coagulation and Flocculation
Biological Treatment		
▪ Activated Sludge		
▪ Biofiltration		

4.3.6 Specific Sub-Sector BAT Techniques

4.3.6.1 Mineral Wool Process

Mineral wool processes are, under normal circumstances, net consumers of water, with substantial amounts of water vapour emitted to air from the forming and to a lesser extent the curing operations. There are no inherent wastewater discharges except the general issues mentioned above. BAT techniques include (see BREF Section 4.6):

- Operation of a closed loop process water system
- Where practicable cooling water blow down and cleaning waters are fed into the closed loop process water system
- Process cleaning waters and binder spillages recycled to the process water circuit
- The process water system has a limited volume but can be designed to include a holding tank to accommodate volume overloads, which can then be bled back into the system
- Where process materials are not compatible with the process water system they can be routed to a holding tank. Due to the very low volumes of these materials they are usually disposed of to municipal wastewater sewer or sent for off-site disposal
- The large volume of the process water system represents a potential for contamination of clean water circuits such as surface water and cullet quench water. Systems can be designed and operated to minimise this risk. For

example, clean water systems should be sealed where they pass through areas where contamination may occur.

4.3.6.2 Continuous Filament Glass Fibre

Emissions arise from the forming area, binder preparation, cleaning, cooling, tissue/mat binder application, and from water based scrubbing systems. The main source of emission is the forming area. The main pollutants in the untreated wastewater are the binder materials themselves. BAT techniques include (see BREF Section 4.6):

- Careful handling procedures, particularly in the binder preparation area, can significantly reduce emission levels from other areas
- Effluent treatment either by discharge to municipal sewers or by treatment on-site using an appropriate combination of the techniques listed in Table 4.3
- If the effluent is to be disposed of directly to a watercourse the most effective on-site treatment is likely to be biological treatment with careful design of such a system.

4.3.6.3 Special Glass

The Special Glass Sector is very diverse and it is not possible to identify all potential emissions to water and the abatement techniques that are appropriate. Most of the activities in this sector only involve the general wastewater issues described above. However, the manufacture of certain products, particularly TV glass, involves wet grinding or polishing operations. This gives rise to an aqueous stream containing the grinding and polishing aids, and fine glass that may contain lead. This waste stream can be treated by a combination of the standard solids removal techniques listed in Table 4.3. The lead in the glass is essentially insoluble and the total lead content will depend on the solids content.

4.3.6.4 Domestic Glass

In general, the Domestic Glass Sector has low emissions to water. In common with other sectors of the industry, the major water uses include cooling and cleaning, and aqueous emissions will contain the cooling water system purges, cleaning waters and surface water run off.

However, certain activities carried out in the domestic glass sector in particular the production of lead crystal and crystal glass have more specific emissions and can result in significant quantities of wastewater emissions. Emissions to water related to such activities, and BAT techniques are:

- Water used in cutting operations contains any cutting aids and quantities of fine glass particles. Treatment of emissions using standard solids separation techniques (refer to physical/chemical treatment techniques in Table 4.3)
- Cutting water can be reused for cutting to minimise emissions levels following considerable treatment for solids removal to ensure quality of the final glass product. A small volume would have to be bled off from the circuit in order to maintain the quality of the glass
- After dipping in acid the glass has a layer of lead sulphate on the surface which is then washed off. Treatment of resulting wastewater is possible using neutralisation, coagulation and flocculation followed by a physical separation
- The acidic waste from the wet scrubbers will require neutralisation before discharge alternatively hexafluorosilicic acid can be recovered and sold as a chemical feedstock.

4.3.7 Waste Minimisation

A characteristic of the Glass Industry is that most of the activities produce relatively low levels of solid waste. Most of the processes do not have significant inherent by-product streams. The process residues consist of unused raw materials and waste glass that has not been converted into the product. The techniques used to control the main process residues encountered in the glass industry are listed below.

- Reduce Waste Batch Material (see BREF Section 4.3)
- Dust Collection in Waste Gas Stream (see BREF Sections 4.4.1 and 4.7)
- Recycling melt not converted into product (see BREF Section 4.7)
- Recycling Waste Product (see BREF Section 4.7).

5. BEST AVAILABLE TECHNIQUES FOR THE MANUFACTURING OF GLASS INCLUDING GLASS FIBRE

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.

An important characteristic of many installations in the Glass Industry is the periodic rebuild of the furnaces. There are two major categories of rebuild, the normal rebuild and the complete rebuild (see BREF Section 4.1). For a number of the techniques discussed in BREF Section 4 it may be both technically beneficial and more cost-effective to delay implementation until a rebuild. For some techniques implementation may only be possible at a rebuild (either normal or complete), but for other techniques such a delay may offer little benefit. These issues are discussed further in BREF Section 4.1 and in the specific considerations of the techniques described in Section 4.

Another important factor in the decision of what is appropriate at a particular installation is the age of the furnace. The appropriate course of action for a furnace that is expected to run for a further 8 to 12 years may be very different than for a furnace which requires rebuilding in 1 or 2 years time. This can particularly affect the balance between, for example, a technique requiring a major change of technology (e.g. oxy-fuel firing) that can only be implemented at a rebuild, and a secondary technique that can be retrofitted to an existing plant.

In many cases in the Glass Industry the implementation of the full range of techniques discussed in this chapter represents a very substantial investment; and the associated costs could be untenable unless implemented over a reasonable time period.

5.2 BAT - GENERAL PREVENTIVE MEASURES

5.2.1 Management Systems

Effective management is important in achieving good environmental performance. It is an important component of BAT and forms part of the definition of techniques given in Article 2 of the Directive. For BAT a management system includes the following elements (see Section 4.3.1 of this document for details):

- A management policy and commitment
- Incorporates design and maintenance elements which include for the assessment of the effects of existing plant and any new or substantially changed processes on the degree of protection of air, water and land as follows
- A training element.

5.2.2 Energy Consumption

The techniques described in Section 4.3.2 for the minimisation of energy consumption within the glass industry can be used in a combination appropriate to a particular installation to ensure energy consumption is reduced as much as practicable. If problems exist at a particular installation the proper application of these techniques can usually provide a solution.

5.2.3 Material Handling and Storage

The techniques described in Section 4.3.3 for the storage and handling of materials can be used in a combination appropriate to a particular installation to ensure that any emissions from these activities are insignificant. If problems exist at a particular installation the proper application of these techniques can usually provide a solution (see BREF Section 5.2.1).

5.3 BAT - Preventive Measures for Specific Unit Operations

5.3.1 Sector Specific BAT For Emissions to Air

This section discusses BAT for the main emissions for each sector of the Glass Industry separately in Sections 5.4.1 to 5.4.9 of this document. In most of the sectors these are restricted to emissions to air, because these are seen as the priority for the Glass Industry. Within each of these sector specific sections emissions are discussed separately for each substance from melting and then more generally for downstream activities.

5.3.1.1 Container Glass

Dust

In general in this sector, BAT for dust is considered to be the use of an electrostatic precipitator or bag filter operating, where appropriate, in conjunction with a dry or semi-dry acid gas scrubbing system (see BREF Section 5.3.1).

Oxides of Nitrogen (see BREF Section 5.3.2)

The Container Glass Sector utilises a wide range of furnace types and sizes, and there are many primary and secondary techniques available that can achieve good NOx reduction efficiencies. There are also a number of techniques, which can achieve very low NOx levels, but which may only be applicable in certain circumstances. These are discussed in BREF Section 4, for example, the LoNOx melter, the Flex melter, or electric melting. There are also techniques that are more widely applicable but which may not represent the most appropriate option in all circumstances, for example oxy-fuel firing and batch/cullet preheating.

The selection of techniques that represents BAT will depend very much on the site-specific issues. The main techniques (or combinations thereof) likely to represent BAT in this sector are primary measures (combustion modifications), 3R/Reburning (for regenerative furnaces), oxyfuel firing, SNCR or SCR. However, where other techniques can achieve emission limit values presented in Section 6 of this document and are both technically and economically viable, they may also represent BAT.

Where the most appropriate techniques for a given situation require a delay until the next rebuild (e.g. oxy-fuel or revised furnace geometry) emission limit levels may not be achievable until after the rebuild. With only the use of primary measures higher emission limit levels could be expected for many air-fuel fired furnaces.

Wherever practicable the first step should be to minimise the use of nitrates in the batch before considering secondary abatement.

Oxides of Sulphur (see BREF Section 5.3.3)

In most glass formulations the sulphate levels in the batch are already minimised commensurate with the glass formulation and product quality requirements. It is envisaged that in most instances BAT for dust emissions will involve the use of a dust abatement system, which will often include acid gas scrubbing. The sulphated waste produced can generally be recycled with the furnace raw materials to avoid the generation of a solid waste stream. Where appropriate this is taken into account in the proposed emission levels associated with BAT. The principle factors affecting emissions of SOx are therefore, the choice of fuel, the glass type and the abated dust recycling considerations. The scrubbing system also can be optimised to reduce other acid gases, and the figures discussed in the following sections are generally based on the use of such a system.

Where batch sulphate levels are very low (or even zero) and natural gas is used as the fuel an acid gas scrubbing system may not be necessary. However, in these circumstances SOx emissions will generally be lower than the figures for sulphate containing batches with acid gas scrubbing.

The choice between gas and fuel oil is very dependent on the prevailing economic conditions and it is considered outside the scope of this document to specify which of these fuels represents BAT. Where a natural gas supply is accessible and where economic conditions permit, the use of natural gas will generally result in lower SOx emissions. Where fuel oil is used then a sulphur content of 1 % or less is considered to represent BAT. However, a higher sulphur content fuel may also be acceptable if this is combined with a scrubbing system to achieve an equivalent emission level, and if an appropriate disposal route is identified for the collected material.

Other Emissions from Meltings (see BREF Section 5.3.4)

In general in this sector, BAT is considered to be raw material selection to minimise emissions, combined with acid gas scrubbing, where appropriate. Acid gas scrubbing may not always be necessary either to protect the abatement equipment or to achieve the emission limit values for SOx.

Downstream Processes (see BREF Section 5.3.5)

The main potential source of emissions from downstream processes is hot end coating treatment. A number of techniques described in BREF Section 4.5.1 can be used to treat emissions and the techniques chosen will depend on installation specific issues. BAT is considered to be techniques, which minimise emissions.

5.3.1.2 Flat Glass

Dust

In general in this sector, BAT for dust is considered to be the use of an electrostatic precipitator or bag filter operating, where appropriate, in conjunction with a dry or semi-dry acid gas scrubbing system (see BREF Section 5.4.1).

Oxides of Nitrogen (see BREF Section 5.4.2)

BAT is considered primarily the use of primary techniques or 3R/Reburning combined with primary techniques. However, where appropriate other techniques (e.g. SCR and SNCR) can also be used to minimise emissions and may be considered as BAT.

Where 3R/Reburning or SCR are used emission levels towards the lower end of the range in Table 6.1 would be expected. Where the most appropriate techniques for a given situation require a delay until the next rebuild (e.g. oxy-fuel or revised furnace geometry) such levels may not be achievable until after the rebuild.

For those processes that require substantial use of nitrate compounds in the batch, the emission levels identified in Table 6.1 may be difficult to achieve without secondary abatement. If the use of nitrates is very frequent, or if very high emissions arise, then secondary techniques may be necessary. If the use of nitrates is infrequent then the costs of secondary measures (where they would not otherwise be required) may not be justified. Wherever practicable the first step should be to minimise the use of nitrates in the batch before considering secondary abatement.

Oxides of Sulphur

See Section 5.4.2.3 above (See also BREF Section 5.4.3).

Other Emissions from Melting

In general in this sector, BAT is considered to be raw material selection to minimise emissions, combined with acid gas scrubbing in association with dust abatement (see BREF Section 5.4.4).

Downstream Processes

A number of techniques described in BREF Section 4.5.2 can be used to treat downstream emissions and the techniques chosen will depend on installation specific issues. BAT is considered to be techniques, which minimise emissions (see BREF Section 5.4.5).

5.3.1.3 Continuous Filament Glass Fibre

Dust (see BREF Section 5.5.1)

In general in this sector, BAT for dust is considered to be the use of an electrostatic precipitator or bag filter operating, where appropriate, in conjunction with a dry or semi-dry acid gas scrubbing system.

In this sector the nature of the dust means that the cooling of the waste gas and the positioning of the abatement system are very important in optimising abatement efficiency. In some cases abatement equipment may have already been installed which meets the requirements of BAT in its general design but which may have been installed to meet a less demanding target and so not positioned ideally.

Oxides of Nitrogen (see BREF Section 5.5.2)

There are no known examples of SNCR or SCR in this sector. It is considered that SCR is unlikely to be applicable in the near future due to concerns over borate condensation in the catalyst. There do not appear to be any substantial technical obstacles to the use of SNCR in this sector, and if installed the technique could be expected to result in reductions of 40 - 70 %, depending on the precise application. It is understood that there are currently 6 oxy-fuel melters in Europe (out of 26) and several further examples elsewhere in the world. The number of oxy-fuel melters is increasing and there are no overriding technical obstacles to its implementation. However, there is still some uncertainty over the economic implications of the technique and also concerns over the effect on refractory life. The technique is used more widely in other sectors and is gradually gaining more general acceptance.

In general in this sector, BAT for oxides of nitrogen (expressed as NO_2) is considered likely to be oxy-fuel melting. It is acknowledged that the technique still carries an element of financial risk, but it is expected that the technique will become more widely accepted as BAT in the medium term.

Oxides of Sulphur

See Section 5.4.2.3 above (see also BREF Section 5.5.3).

Other Emissions from Melting

In general in this sector, the BAT is considered to be either primary measures or acid gas scrubbing combined with dust abatement (see BREF Section 5.5.4).

Downstream Processes

A number of techniques described in BREF Section 4.5.3 can be used to treat downstream emissions and the techniques chosen will depend on installation specific issues. BAT is considered to be techniques, which minimise emissions (see BREF Section 5.5.5).

5.3.1.4 Domestic Glass

In general and where it is economically viable, predominantly electrical melting is considered BAT for lead crystal, crystal glass and opal glass production, since this technique allows efficient control of potential emissions of volatile elements. Where crystal glass is produced with a less volatile formulation, other techniques may be considered when determining BAT for a particular installation.

Dust

In general in this sector, BAT for dust is considered to be the use of an electrostatic precipitator or bag filter system operating, where appropriate, in conjunction with a dry or semi-dry acid gas scrubbing system (see BREF Section 5.6.1).

Oxides of Nitrogen (see BREF Section 5.6.2)

As stated above it is difficult to form firm conclusions on what constitutes BAT for NOx emissions in the Domestic Glass Sector. In general where electrical melting (either 100 % or predominantly electrical) is economically viable, and particularly for lead crystal, crystal glass and opal glass production the technique is considered BAT. Where electrical melting is not economically viable a number of other techniques could be used (see BREF Sections 4.2 and 4.4.2). The sector utilises a wide range of furnace types and selection of the most appropriate technique will depend on the features of the particular installation. The main techniques (or combinations thereof) likely to represent BAT in this sector are primary measures (combustion modifications – see BREF Section 4.4.2.1), 3R/Reburning (for regenerative furnaces (see BREF Section 4.4.2.6), oxy-fuel firing (see BREF Section 4.4.2.5), SNCR or SCR (see BREF Sections 4.4.2.7 & 4.4.2.8). It is claimed that, in a small number of cases, the use of 3R/Reburning could necessitate an upgrade of the refractory material that would add to the overall cost, and potentially affect the choice of BAT. For smaller melters consideration could also be given to innovative designs.

For those processes that require substantial use of nitrate compounds in the batch, the emission levels identified above may be difficult to achieve without secondary abatement. If the use of nitrates is very frequent or permanent, or if very high emissions arise, then secondary techniques may be necessary. Wherever practicable nitrate use should be minimised as far as possible.

Oxides of Sulphur

See Section 5.4.2.3 above (see also BREF Section 5.6.3).

Other Emissions from Melting

In general in this sector, BAT is considered to be raw material selection to minimise emissions, combined with acid gas scrubbing. Acid gas scrubbing may not be necessary either to protect the abatement equipment or to achieve the figures given in Table 6.1 for SOx. Where this is the case, acid gas scrubbing is considered to constitute BAT if the levels identified in Table 6.1 cannot be achieved by primary measures (see BREF Section 5.6.4).

Downstream Processes

Potential emissions from downstream processes consist mainly of dust and acid gas fumes from lead crystal and crystal glass production. For potentially dusty activities BAT is considered to be cutting under liquid where practicable, and if dry cutting or grinding is carried out then extraction to a bag filter system. Where acid gases or fumes are generated BAT is considered to be wet scrubbing (see BREF Section 5.6.5).

5.3.1.5 Special Glass

Dust

In general in this sector, BAT for dust is considered to be the use of an electrostatic precipitator or bag filter operating, where appropriate, in conjunction with a dry or semi-dry acid gas scrubbing system (see BREF Section 5.7.1).

Oxides of Nitrogen (see BREF Section 5.7.2)

The Special Glass Sector utilises a wide range of furnace types and sizes. Oxy-fuel melting and SNCR or SCR may be used (see BREF Section 4.4.2.7 & 4.4.2.8). There are other techniques for reducing NOx emissions to comparable levels and the most appropriate technique will depend very much on site-specific issues. There are also a number of techniques, which can achieve levels below those given; however, these techniques may not be applicable to all installations. Where high levels of nitrates are used consideration should also be given to minimising their use as far as practicable within the constraints of the process and product requirements.

Oxides of Sulphur

See section 5.4.2.3 above (see also BREF Section 5.7.3).

Other Emissions from Melting

In general in this sector, BAT is considered to be raw material selection to minimise emissions, combined with acid gas scrubbing. Acid gas scrubbing may not always be necessary to protect the abatement equipment or to achieve the figures given in Table 6.1 for SOx. Where this is the case, acid gas scrubbing is considered to constitute BAT if the levels identified in Table 6.1 cannot be achieved by primary measures (see BREF Section 5.7.4).

Downstream Processes

The emissions associated with downstream processing can be very variable and a wide range of primary and secondary techniques can be used. For potentially dusty activities BAT is considered to be dust minimisation by cutting, grinding or polishing under liquid, or where dry operations are carried out extraction to a bag filter system. Where acid gases or fumes are generated BAT is considered to be wet scrubbing (see BREF Section 5.7.5).

5.3.1.6 Mineral Wool

Dust (see BREF Section 5.8.1)

In general in this sector, BAT for dust is considered to be the use of an electrostatic precipitator or bag filter. In glass wool production the use of a dry or semi-dry acid gas scrubbing system is not generally considered necessary to protect the equipment, because almost all furnaces are gas fired or electrically heated. In some cases, the application of BAT for metals emissions may result in lower emission levels for dust. Hot blast cupolas will generally be fitted with bag filters rather than electrostatic precipitators due to the risk of explosion.

In glass wool production the nature of the dust means that the cooling of the waste gas and the positioning of the abatement system are very important in optimising abatement efficiency. In some cases abatement equipment may have already been installed which meets the requirements of BAT in its general design but which may have been installed to meet a less demanding target and so not positioned ideally.

Oxides of Nitrogen (see BREF Section 5.8.2)

In general for glass wool production, BAT for oxides of nitrogen (expressed as NO_2) is considered to be the use of oxy-fuel firing or predominantly electrical melting. However, conventional air-gas systems may be able to achieve emissions within the ranges indicated in Table 6.1 with primary or secondary measures. Where this is the case such systems may also be judged to represent BAT.

Where significant quantities of nitrates are required in the batch (e.g. for recycling material with a high organic component) the emission levels identified Table 6.1 may be difficult to achieve without secondary abatement or conversion to oxy-fuel or electric melting. If the use of nitrates is very frequent or permanent, or if very high emissions arise, then such techniques are likely to constitute BAT.

Stone wool cupolas do not generally give rise to substantial NOx emissions. Where tank furnaces are used the emission level associated with BAT is considered to be equivalent to glass wool production.

Oxides of Sulphur (see BREF Section 5.8.3)

For glass wool production, emissions of oxides of sulphur (expressed as SO_2) tend to be low. Almost all furnaces are gas fired/electrically heated and only very low levels of sulphate are used. In these circumstances SOx emissions would be expected to be below 50 mg/Nm^3, which generally equates to less than 0.1 kg/tonne of glass melted, without any specific abatement measures. If furnaces are oil fired then acid gas scrubbing will usually be necessary to protect the dust abatement equipment.

For stone wool production, BAT for oxides of sulphur is considered prioritising the recycling of process wastes and the prevention of further solid waste streams for disposal. However, when from an integrated environmental approach the priority is for the reduction of SOx emissions, and the associated mass balance evaluation does not enable emission level values to be obtained the use of acid gas scrubbing may represent BAT. These systems entail significant costs and in general the collected material cannot be effectively recycled giving rise to a solid waste stream for disposal. Where acid gas scrubbing is considered to represent BAT then dry scrubbing is likely to be the most cost effective technique.

The levels given above relate principally to melting with stone charges, but where the charge contains cement bound briquettes there is a contribution from the sulphur in the cement binder. The effect on the SO_2 emissions will clearly depend on the amount of material recycled as briquettes. Where SO_2 reduction is the priority, acid gas scrubbing is generally considered to represent BAT.

If the briquettes also contain recycled dust collected from abatement equipment this will add a further sulphur contribution. The sulphur concentration in the collected dust will vary significantly from installation to installation, generally 0.05 - 0.28 %.

The use of blast furnace slag is not generally considered to form part of BAT, and where its use is required for product or process reasons BAT is considered to include dry scrubbing.

Other Emissions from Melting (see BREF Section 5.8.4)

Emissions of halides and metals tend to be very low from these processes and the emission levels indicated in Table 6.1 can usually be achieved by raw material selection. Stone wool cupolas can give rise to high emissions of hydrogen sulphide and carbon monoxide. BAT for hydrogen sulphide emissions is considered to be raw material selection or thermal oxidation. BAT for carbon monoxide emissions is considered to be thermal oxidation.

Downstream Processes (see BREF Section 5.8.5)

Forming area and combined forming and curing emissions

Following optimisation of primary measures BAT is considered to be the use of either a wet electrostatic precipitator, a packed bed scrubber, or a stone wool filter (generally stone wool processes only). The performance of these different techniques varies. The wet electrostatic precipitator and the stone wool filter are more effective at removing solid particles and droplets, and the packed bed scrubber is more effective in removing gaseous substances. These issues and the relevant performance of each technique are described in BREF Section 4. It is not considered practicable to use both techniques.

Curing oven emissions

In glass wool production, BAT and the associated emission levels are generally considered to be as given in Table 6.1.

In general, for stone wool processes BAT is considered to be the use of a thermal incineration unit.

The emission levels associated with BAT given in Table 6.1 for forming area and curing oven emissions may not be achievable with these techniques under all circumstances. If high density products or products with high binder contents are produced, the levels achieved with the techniques generally considered as BAT for the sector could be significantly higher. If these types of products represent the majority of the production from a given installation then consideration should be given to other techniques.

For both forming area and curing oven emissions the figure given for amines in Table 6.1 is based on the use of amine free binders and non-amine catalysed resins.

Emissions from product cooling can be treated separately or combined with forming or curing emissions. Where they are treated separately the emission levels associated with BAT are considered to be the same or lower than those for the forming area. BAT for particulate matter from other downstream activities such as machining and packaging is considered to be the use of a bag filter system.

5.3.1.7 Ceramic Fibre

Melting

BAT for melting in this sector is considered to be electric melting in conjunction with a bag filter system. BAT is to minimise associated pollutants (see BREF Section 5.9.1).

Downstream Processing

BAT for all areas where dust may arise in this sector is considered to be collection and extraction to a bag filter system (see BREF Section 5.9.2).

5.3.1.8 Frits

Dust

In general in this sector, BAT for dust is considered to be the use of an electrostatic precipitator or bag filter operating, where appropriate, in conjunction with a dry or semi-dry acid gas scrubbing system. In some cases, the application of BAT for metals emissions may result in lower emission levels for dust (see BREF Section 5.10.1).

Oxides of Nitrogen

In general in this sector, the BAT for oxides of nitrogen (expressed as NO_2) is considered to be the use of oxy-fuel melting.

Oxides of Sulphur

In general for frit production, the BAT for oxides of sulphur (expressed as SO_2) is considered to be fuel selection (where practicable) and control of batch composition (see BREF Section 5.10.3).

Other Emissions from Melting

Fluorides are predominantly used in the production of enamel frits and are not usually present to any significant extent in the raw materials used for ceramic frit manufacture. Some ceramic frit producers may, periodically, manufacture small quantities of enamel frits in the ceramic frit kilns, giving rise to fluoride emissions, but this constitutes a very small proportion of the overall production. The emission of fluorides is probably the most significant environmental impact of enamel frit production. BAT is considered to be wet scrubbing, using a packed bed scrubber circulating water or more effectively an alkali solution (see BREF Section 5.10.4).

Downstream Processes

Frits production does not present any significant specific emissions to air from downstream activities. Product grinding and milling is usually carried out wet, but dust control measures may be necessary if dry milling is carried out and potentially in dry product packaging areas. The most effective technique is likely to be extraction followed by a bag filter system (see BREF Section 5.10.5).

5.4 BAT - Measures for Treatment, Abatement and Disposal

5.4.1 Emissions to Water

The techniques described in BREF Section 4.6 for the minimisation of water emissions within the glass industry can be used in a combination appropriate to a particular installation to ensure emissions are reduced as much as practicable. If problems exist at a particular installation the proper application of these techniques can usually provide a solution and are considered BAT (see BREF Section 5.11).

For wastewater emission discharging from a installation directly into a receiving waterbody, on-site treatment techniques that minimise emissions for wastewater discharges is considered BAT.

5.4.2 Other Wastes

Wherever practicable, the prevention or where that is not practicable, the minimisation of waste by primary means is considered to constitute BAT (see BREF Section 5.12).

Wherever practicable, the recycling of cullet or other process waste back to the process is considered BAT. Fine material to be recycled to a hot blast cupola generally requires treatment such as briquetting. In the Continuous Filament Glass Fibre Sector the recycling of process wastes has proven difficult and further development work is recommended (see BREF Section 5.12).

The recycling of particulate matter collected from waste gas streams to the process wherever practicable is considered to constitute BAT (this does not include regenerator waste). In most melting operations, where dry collection systems are used, this will involve a simple adjustment of the batch formulation to allow for the composition of the collected material. The difficulties associated with recycling collected material from dry scrubbing systems are discussed in BREF Section 4.

In some circumstances, a compromise may have to be made between achieving the levels discussed for emissions to air and minimising the generation of a solid waste stream. Where this situation arises it must be considered on an installation specific basis, and on the relative priorities for the minimisation of pollution to the environment as a whole (see BREF Section 5.12).

Where conditions allow, the maximised use of cullet and recycled waste (both internal and external) is considered as complementary to BAT, this is based on (see BREF Section 5.12):

- Reduced waste (on site only)
- Generally improved energy efficiency
- Contribution to minimising certain other emissions
- Reduced consumption of natural resources.

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 given below in Table 6.1 (a), (b) and (c).

All parameters will not be relevant to every installation and will depend on the type of substances and processes in use at the installation, and other site-specific factors.

Table 6.1(a) Emission Limit Values for the Manufacture of Glass including Glass Fibre (Melting Processes)

Substance	Concentration Limit Note 1 (mg/m³)		Mass Emission Threshold (kg/tonne of glass melted)	
Total Particulate Matter	5 - 30 5 - 50 Note 2C 5 - 50 Note 2F 10 Note 2G		0.1 0.14 0.1 ---	
Sulphur Oxides (expressed as SO_2)	Gas Fired	**Oil Fired**	Gas Fired	**Oil Fired**
- Container Glass	200 - 800	500 - 1500	0.3 - 1.2	0.75 - 2.25
- Flat Glass	200 - 800	500 - 1500	0.5 - 2.0	1.25 - 3.75
- Continuous Filament Glass Fibre	200	500 - 1000	0.9	2.25 - 4.5
- Domestic Glass	200 - 500	500 - 1300	0.5 - 1.25	1.25 -3.25
- Special Glass	200 - 500	500 - 1200	---	---
- Mineral Wool	200 - 500 Note 3	300 - 1000 Note 3	0.5 - 1.0 Note 3	0.6-2.0 Note 3
- Ceramic Fibre - Frits	200	500 - 1000	0.1 - 0.5	---
Nitrogen Oxides (expressed as NO_2)	500 - 700		0.1 - 0.5 Note 2G 0.4 - 1.4 Note 2F 0.5 - 1.1 Notes 2A,C&E 0.5 - 1.5 Note 2H 0.5 - 1.75 Note 2D 1.25 - 1.75 Note 2B	
- where the raw materials contain significant quantities of nitrate	700 Note 2F 850 Note 2B&E 1000 Note 2A 1,500 Note 2D		1.4 2.2 3.0 3.0	
Fluorides (expressed as HF)	5 5 - 15 Note 2C		--- ---	
Chlorides (expressed as HCl)	30 10 Notes 2 G&H		--- ---	
Total Arsenic, Cobalt, Nickel, Selenium and Chromium VI	1		---	
Total Arsenic, Cobalt, Nickel, Selenium, Chromium VI, Antimony, Lead, Chromium III, Copper, Manganese, Vanadium and Tin	5		---	
Hydrogen Sulphide	5 Note 2F		---	
Carbon Monoxide	200 Note 2F		---	

Note 1: Achievement of ELV concentration by the introduction of dilution air is not permitted.

Note 2: ELV applies in the case of the following sectors:

- A: Container Glass
- B: Flat Glass
- C: Continuous Filament Glass Fibre
- D: Domestic Glass
- E: Special Glass
- F: Mineral Wool
- G: Ceramic Fibre
- H: Frits

Note 3: BAT assumes heating by electricity.

Table 6.1(b): Emission Limit Values for the Manufacture of Glass including Glass Fibre (Downstream Processes – coating, annealing, surface treatments, curing and drying)

Substance	**Concentration Limit** Note 1 **(mg/m^3)**
Total Particulate Matter	5 Notes 2E,G&H 10 Note 2D 5 - 20 Note 2C 20 Notes 2A&B
Fluorides (expressed as HF)	5 Notes 2B,D&E
Chlorides (expressed as HCl)	30 Notes 2A&B
Volatile Organic Compounds	5 - 50 Note 2C 10 - 20 Note 2G
Ceramic Fibre	1 Note 2G
Total Arsenic, Cobalt, Nickel, Selenium and Chromium VI	1 Notes 2B,E&H
Total Arsenic, Cobalt, Nickel, Selenium, Chromium VI, Antimony, Lead, Chromium III, Copper, Manganese, Vanadium and Tin	5 Notes 2B,D,E & H
Tin	5 Note 2A
Organotin	1 Note 2A

Note 1: Achievement of ELV concentration by the introduction of dilution air is not permitted.

Note 2: ELV applies in the case of the following sectors:

- A: Container Glass
- B: Flat Glass
- C: Continuous Filament Glass Fibre
- D: Domestic Glass
- E: Special Glass
- G: Ceramic Fibre
- H: Frits

Table 6.1(c): Emission Limit Values for Mineral Wool Sector (excluding melting processes)

Substance	**Concentration Limit** Note 1 **(mg/m^3)**
Total Particulate Matter	20 - 50
Total Volatile Organic Compounds	10 - 50
Phenol	5 - 10
Ammonia	30
Amines	5
Formaldehyde	5

Note 1: Achievement of ELV concentration by the introduction of dilution air is not permitted.

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*

Constituent Group or Parameter	Emission Level	Percentage Reduction[3]	Notes
pH	6 - 9	-	
Toxicity	1 TU		1
BOD_5	25mg/l	>91 - 99%	
COD	100 - 500mg/l	>75%	
Suspended Solids	10 - 35mg/l		
Total Ammonia (as N)	5 - 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		
Phenols			5
Metals			5
Organohalogens			5
Priority Substances (as per Water Framework Directive)			5
Cyanides			5
Other			5, 6

* 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.
- Continuous monitoring on main emissions where technically feasible (e.g. Particulates, SO_2, NOx).
- Monitor solvent / VOC usage by annual mass balance reports and use to determine fugitive emissions.
- 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.
- Olfactory (sniff) assessment for odours should be carried out daily or as directed by the Agency at a minimum at four boundary locations and at the nearest odour sensitive locations to be agreed with 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.
- 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. Council Directive 96/61/EC of 24 September 1996 concerning Integrated Pollution Prevention and Control.
2. Reference Document on Best Available Techniques for the in the Glass Manufacturing Industry, published by the European Commission, December 2001.
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.
4. Reference Document on Best Available Techniques on Emissions from Storage (January 2005).
5. Reference Document on Best Available Techniques in common wastewater and waste gas treatment/management systems in the chemical sector (February 2003).

2. IRELAND

1. BATNECC Guidance Note for Asbestos and Glass and Mineral Fibre.
2. BATNECC Guidance Note for the Manufacturing of Glass Fibre or Mineral Fibre.
3. BATNECC Guidance Note for Glass Manufacture.
4. Integrated Pollution Control Licensing BATNEEC Guidance Note For Noise in Relation to Scheduled Activities (EPA No. LC 8 (1995)).
5. Guidance Note For Noise in Relation to Scheduled Activities - 2ND Edition (EPA (2006)).

Appendix 2

GLOSSARY OF TERMS AND ABBREVIATIONS

BAT	Best Available Technique
BOD	Biochemical Oxygen Demand
BREF	Reference document on Best Available Techniques for the surface treatment of metals and plastics, published by the European Commission, December 2001
°C	Degree Celsius
CO	Carbon monoxide
CO_2	Carbon dioxide
COD	Chemical Oxygen Demand
kg	Kilogramme
m^3	Cubic metre
mg	Milligramme
Nm^3	Normal cubic metre (101.3 kPa, 273 K)
NOx	Nitrogen oxides
O_2	Oxygen
SOx	Sulphur oxides
t	Tonne (metric)
VOC	Volatile Organic Compounds