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Sector Guidance Note IPPC SG 2 Integrated Pollution Prevention and Control (IPPC)

Secretary of State's Guidance for A2 Activities in the Glassmaking Sector

October 2006

Department for Environment Food and Rural Affairs

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Environment
Agency
Defra would like to acknowledge the work of the Environment Agency's Local Authority Unit in the drafting of this guidance note.

Contents

List of Figures

List of Tables

1 Introduction

Background

1.1 This sector guidance note is issued by the Secretary of State and the Welsh Assembly Government (WAG), following consultation with relevant trade bodies, representatives of regulators including members of the Industrial Pollution Liaison Committee, and other interested organisations.

1.2 The note constitutes statutory guidance under regulation 37 of the Pollution Prevention and Control (England and Wales) Regulations 2000, SI 1973 (**Ref 1**) on the integrated pollution control standards appropriate for the generality of new and existing A2 installations in the glass manufacturing sector.

These installations require a permit to operate in accordance with the 2000 Regulations under what is known as the Local Authority-Integrated Pollution Prevention and Control (LA-IPPC) regime. Local authority regulators are required by regulation 37 to have regard to this guidance. The Secretary of State / WAG will also treat this guidance as one of the material considerations when determining any appeals made under the Regulations against a local enforcing authority decision.

1.3 The guidance also (where appropriate) gives details of any mandatory requirements affecting emissions and impacts from these installations, which are in force at the time of publication. These include requirements contained in directions from the Secretary of State / WAG.

1.4 This is one of a series of such guidance notes aimed at providing a strong framework for consistent and transparent regulation of LA-IPPC installations.

1.5 General guidance explaining LA-IPPC and setting out the policy and procedures, is contained in the “General Guidance Manual on Policy and Procedures for A2 and B Installations” (**Ref 2**) available from **www.defra.gov.uk/environment/ppc/index.htm**, to be referred to in this document as the "General Guidance Manual.” This is designed for operators and members of the public, as well as for local authority regulators.

Best Available Techniques (BAT)

1.6 BAT is the main basis for determining standards in LA-IPPC. This sector guidance note addresses what is considered by the Secretary of State/WAG to constitute BAT for glass manufacturing activities with melting capacity of more than 20 tonnes/day.

This sector guidance note takes into account information contained in the BREF guidance, (**Ref. 3**)

As made clear in chapter 12 of the General Guidance Manual, BAT for each installation should be assessed by reference to the appropriate sector guidance note, and these notes should be regarded by local authorities as their primary reference document for determining BAT in drawing up permits. In general terms what is BAT for one installation is likely to be BAT for a comparable installation. However, determination of what is BAT is ultimately a matter for case-by-case decision taking into account that individual circumstances may affect BAT judgements and what are the appropriate permit conditions.

Thus, for each glass manufacturing installation, local authorities (subject to appeal to the Secretary of State / WAG) should regard this guidance note as a baseline, but ensure they take into account any relevant case-specific factors such as the individual process configuration and other characteristics, its size, location, and any other relevant features of the particular installation. Further guidance on this, including the issue of taking account of operators' individual financial position, is contained in chapter 12 of the General Guidance Manual.

1.7 If there are any applicable mandatory EU emission limits, these must be met, although BAT may go further. The same applies to UK regulations, except that, in reconciling BAT with the Control of Pollution (Oil Storage) (England) Regulations 2001, SI 2954, it may be acceptable to achieve an equivalent level of control to that specified in the 2001 regulations (although the oil storage regulations do not apply in Wales, they should be regarded as an indication of BAT in Wales)[1].

Who is this guidance for?

1.8 This guidance is for:

- local authority regulators: who must have regard to the guidance when determining applications and when regulating installations which have a permit
- operators: who are best advised also to have regard to it when making applications and in the subsequent operation of their activities
- members of the public: who may be interested to know what standards are envisaged for the generality of installations in this sector.

1.9 The guidance is based on the state of knowledge and understanding of installations in this sector, their potential impact on the environment, and the available control techniques at the time of writing. The guidance may be amended from time to time in order to keep abreast with developments, including improvements or changes in techniques and new understanding of environmental impacts and risks. Any such amendments may be issued in a complete revision of this note, or in separate additional guidance notes which address specific issues. (N.B. It may not always be possible to issue amending guidance quickly enough to keep in absolute step with rapid changes, which might be another justification in particular cases for diverging from this note.) Steps will be taken to ensure that those who need to know about changes are informed of any amendments. Operators (and their advisers) are, however, strongly advised to check with the relevant local authority whether there have been any amendments before relying on this note for the purposes of applying for a permit or making any other decisions where BAT and related matters may be a consideration.

Terminology

1.10 In addition to the General Guidance Manual referred to above, explanation or clarification of certain terms used in this sector guidance note may be found in a general guidance note issued under Part I of the Environmental Protection Act 1990: 'Interpretation of terms used in process guidance notes', known as General Guidance Note 4 - GG4 - published by HMSO in 1991. Where there is any conflict between GG4 and the guidance issued in this note or in the General Guidance Manual, the latter two documents should prevail, as should any subsequent guidance issued in relation to LA-IPPC.

Installations covered

1.11 This note covers installations described in Section 3.3 Part A(2) (a) of Schedule 1 to the PPC Regulations (**Ref 1**) as follows:

- Manufacturing glass, unless falling within Part A(1) of this Section*, where the melting capacity of the plant is more than 20 tonnes per day.

* Part A(1) covers (a) Manufacturing glass fibre and (b) Manufacturing glass frit or enamel frit and its use in any activity where that activity is related to its manufacture and the aggregate quantity of such substances manufactured in any period of 12 months is likely to be 100 tonnes or more.

1.12 The following sub sectors in the glass manufacturing industry are included:

- flat glass
- container glass
- domestic glass
- special glass (including water glass)

[1] Further guidance on the Oil Storage Regulations, if needed, is available from www.environment-agency.gov.uk/osr

1.13 The installation includes the main activities as stated above and associated activities which have a technical connection with the main activities and which may have an effect on emissions and pollution. These include as appropriate:

- raw materials handling (offloading, storage, mixing and transfer)
- furnace operations (melting, refining and homogenisation)
- forming (e.g. float bath, rolling, pressing, blowing)
- conditioning
- coating, including lubricant application
- surface treatments
- grinding and cutting
- machine polishing
- packaging and storing
- waste storage, handling and processing

1.14 This guidance note does not address A(1) activities that are covered by the IPPC Guidance note S3.03 – Guidance for the Glass Manufacturing Sector.

Review and Upgrading Periods

Existing installations or activities

1.15 Earlier guidance, Secretary of State's Guidance Note PG 3/3 (95), relating to emissions to air, advised that upgrading should usually have been completed by 1st October 2001. Requirements still outstanding from any existing upgrading programme should be completed.

1.16 The previous version of this guidance, SG2 (03) contained improvements that were required to be completed over a range of dates up to 2009. These were listed in Table 1 of the Note. Where a date or time period in the Note has been passed then installations should have been upgraded to these standards by the date of publication of this note.

1.17 The new provisions of this note and outstanding provisions of previous relevant notes, and the dates by which compliance with these provisions is expected, are listed in **Table 1** below, together with the paragraph number where the relevant guidance is to be found. Compliance with the new provisions should normally be achieved by the dates shown. Permits should be drafted having regard to this compliance timetable.

(1) Where this guidance note specifies provisions which are additional to, higher than or different to those in PG note 3/3(95) and SG2 (03) only in exceptional circumstances should upgrading of existing installations and activities having regard to these additional/higher/different provisions be completed later than the compliance date specified in **Table 1** below.

(2) Where standards or provisions in PG note 3/3 (95) and SG3 (03) have been deleted in this guidance note or where this guidance note specifies less stringent provisions than those in PG note 3/3 (95) and SG3 (03), the new LA-IPPC permit should reflect this straightaway.

1.18 A programme for upgrading within the specified timescales, to those new / additional provisions in this guidance which involve significant improvement work, should be submitted to the relevant local authority regulator within 6 months of the date of issue of the permit.

Table 1: Compliance requirements

Guidance		Reference	Compliance Date			
			Flat Glass	Container Glass	Domestic Glass	Special Glass
Emissions to air	Audit of furnace configuration, and other primary measures	3.15 - 3.21	With permit application by 31 July 2003 (see Note 4)			
	Particulates - Note 1	Table 3a, Row 1	1 April 2005, (subject to paragraph 1.20 below)		1 April 2005	
	Particulates - Note 2	Table 3a, Row 1	1 April 2006, (subject to paragraph 1.20 below)		1 April 2006	
	SO_2 - Note 3	Table 3a, Row 3	1 April 2007			
	Chloride/Fluoride	Table 3a, Rows 4 & 5				
	Metals	Table 3a, Rows 6 & 7				
	NOx Abatement - Primary Techniques - Note 4	Table 3a, Row 2	As soon as reasonably practicable, which in most cases should have been by 1 January 2006			
	NOx Abatement - Secondary Techniques - Note 4	Table 3a, Row 2	1 April 2006	1 April 2009		
Groundwater Contamination Risk Audit - Note 4		3.100, BAT 42	1 April 2006			
Raw Materials / Waste Minimisation Audit		3.120, 3.131, Bat 58, BAT 60	Within 18 months of issue of the permit			
Energy Audit		BAT 72	Within 12 months of issue of the permit			
Environmental Management Systems		BAT 48	1 April 2007			
Competent Person for Regulator and Public Liaison		BAT 53	1 April 2007			
Formal Structure for Environmental Control & Training		BAT 54	1 April 2007			
Water Efficiency Audit		BAT 62	Within 18 months of issue of the permit			
Raw Material Usage		BAT 59 & 64	1 April 2007			
Recycling Markets		BAT 71	1 April 2007			
Additional Energy Efficiency Measures		BAT 77 & 78	1 April 2007			
Hazard identification/risk analysis - Note 4		3.149, 3.150	1 April 2005			
Accident Prevention Measures		BAT 79	1 April 2007			
Noise Mitigation Measures			(As specified in Secretary of State's Guidance Note SG2 June 2003) -1 January 2004 - Note 4			
		BAT 83	1 April 2007			
QA/QC of Monitoring Systems		BAT 93	1 April 2007			
All Other Requirements (As specified in SoS Sector Guidance Note, SG2 June 2003)			To have been complied with as soon as practicable, which in most cases should have been by June 2004.			
All Other Requirements		For requirements added by this Note - September 2006	to be complied with as soon as practicable which in most cases should be within 12 months of publication of this revised Note			

Note 1 - for existing plant that did **not** meet the emission limit described in Secretary of State's Process Guidance Note PG 3/3 (95).
Note 2 - for existing plant that did meet the emission limit described in Secretary of State's Process Guidance Note PG 3/3 (95).
Note 3 - PG 3/3 (95) already delivers the emission limit for gas fired furnaces where EP / bag filter dust is being recycled.
Note 4 - existing plant should already be meeting the emission limit described in Secretary of State's Sector Guidance Note IPPC SG2, Issue 1, June 2003.

1.19 Where abatement technology is in place to meet an emission limit value, it should be commissioned as soon as practicable. Having been commissioned, it should be maintained and operated so as to comply with the emission limit value during all normal operating conditions.

1.20 Where an energy saving method of abatement is under trial which, once fully commissioned, will control particulate emissions to meet the emission limit value, then the following requirements replace the compliance date above:

- as part of their permit application, the operator should demonstrate their intention to adopt an energy saving method of abatement, subject to successful research and development
- the benchmarks and timetable for progressing this option should also be presented at the time of the permit application
- in the light of these proposals, the regulator should allow upgrading to be completed after the April 2005 / 2006 deadline, provided that the operator informs the regulator at least once every year on progress in writing
- in the event that the method under trial is rejected, then the operator should comply with the particulate emission limit value within 24 months, and contingency plans for this event should be made in writing to the regulator at the time of the permit application
- in any event, the emission limit value should be complied with no later than 2009

1.21 Replacement plant should normally be designed to meet the appropriate standards specified for new installations or activities.

New installations or activities

1.22 For new installations or activities - from the first day of operation the permit should have regard to the full standards of this guidance.

Substantially changed installations or activities

1.23 For substantially changed installations or activities - from the first day of operation the permit should normally have regard to the full standards of this guidance with respect to the parts of the installation that have been substantially changed and any part of the installation affected by the change.

Permit Reviews

1.24 Permits should be reviewed in accordance with the guidance in chapter 26 of the General Guidance Manual. The review frequencies given in that chapter are considered appropriate for activities and installations covered by this sector guidance note.

Summary of Releases

Table 2: Summary of direct releases

Source → / **Release** ↓	Raw Materials handing, Storage and Mixing	Melting, Fining and Homogenisation	Forming	Annealing and Tempering	Online Flat Glass Coating	Container Glass Hot Coating	Container Glass Cold Coating	Cutting / Decorating	Acid Polishing	Cullet Handling / Recycle
NO_x		A		a						
SO_x		A		a						
Particulates	A	AL			A			a		
Chlorides		A			A	A				
Oxychlorides						A				
Fluorides		A			A				AW	
BREF Group 2 Metals – Arsenic, Cobalt, Nickel, Selenium and Chromium VI		A								
BREF Group 3 Metals – Antimony, Lead, Chromium III, Copper, Manganese and Vanadium		A			A				W	
Organotin						A				
Suspended solids	w							w	W	
Chemical Oxygen Demand (COD)						W	W			
Acidic pH									W	
Ammoniacal nitrogen		A								
Odour					A	A				a
Noise - *** - High, ** - Medium, * - Low	*									**
KEY- Lower case indicates minor release	A – Release to Air, W – Release to Water, L – Release to Land,									

Substances include their compounds, except where separate reference to the compound is made.

Releases to air may also be released to land or water, depending upon the abatement technology employed.

NB. It should be noted that this is not necessarily an exhaustive list. Equally, not all installations will necessarily have all these releases.

2 Emission limits and other provisions

2.1 This section contains emission limits, mass release rates and other requirements that are judged for the generality of the activities within the sector to represent BAT.

Contained emissions to air associated with the use of BAT

2.2 Concentration limits are only applicable to contained emissions exhausted to external atmosphere.

Table 3a: Contained emissions to air associated with the use of BAT - furnace operations

Row	Source/determinand	Emission limit (mg/m^3)		Type of monitoring	Frequency of monitoring (subject to 3.166 to 3.170)
Furnace Operations					
1	Particulate matter	30		Continuously recorded indicative monitoring Plus once a year extractive monitoring	Continuous plus annual
2	NO_x	Annual Average	500	Continuously recorded indicative monitoring Plus once a year extractive monitoring	Continuous plus annual
		Daily Average	700		
3	SO_2	Gas Fired	Oil Fired	Continuously recorded indicative monitoring Plus once a year extractive monitoring	Continuous plus annual
	With no recycle of EP/bag filter dust	500	1200		
	With recycle of EP/bag filter dust	800	1500		
4	Chlorides, (expressed as HCl)	30		Where the mass flow exceeds 20 kg/hr of chloride, continuously recorded indicative monitoring, otherwise once a year extractive monitoring	Continuous or annual
5	Fluorides, (expressed as HF)	5		Where the mass flow exceeds 0.5 kg/hr of fluoride, continuously recorded indicative monitoring, otherwise once a year extractive monitoring	Continuous or annual
6	Arsenic, Cobalt, Nickel, Selenium, (see note)	5 (total metals)		Isokinetic extractive	Annual
7	Antimony, Lead, Chromium, Vanadium.	5 (total metals)			
8	Ammonia – only where SCR or SCNR is applied for NO_x abatement	10		Continuous indicative monitoring	Continuous
Selenium use and emissions for the bronze glass process are currently being reviewed via the BREF process. Should this conclude a change is needed then Defra will aim to issue guidance to cover these changes.					

Table 3b: Contained emissions to air associated with the use of BAT, downstream processes

Row	Source/determinand	Emission limit (mg/m^3)	Type of monitoring	Frequency of monitoring (subject to 3.166 - 3.170)
Downstream processes for flat glass sector				
9	Particulate matter	30	Continuous indicative monitoring	Continuous
10	Chlorides (expressed as HCl)	30	Extractive Monitoring	Annual
11	Fluorides (expressed as HF)	5		
12	Total Arsenic, Cobalt, Nickel, Selenium,	1		
13	Total metals	5		
Downstream processes for container glass sector				
14	Particulate matter	30	Extractive Monitoring	Annual
15	Tin	5		
16	Organotin	1		
17	Chlorides (expressed as HCl)	30		
18	VOC measured as carbon (see note)	If annual solvent consumption is >5 tonnes then limit is 100. If annual solvent consumption is >15 tonnes then limit is 50	In stack or extractive monitoring	Annual
Downstream processes for domestic glass sector				
19	Particulate matter	30	Continuous indicative monitoring	Continuous
20	Fluorides (expressed as HF)	5	Extractive monitoring	Annual
21	Total metals	5		
Downstream processes for special glass sector				
22	Particulate matter	30	Continuous indicative monitoring	Continuous
23	Fluorides (expressed as HF)	5	Extractive monitoring	Annual
24	Total Arsenic, Cobalt, Nickel, Selenium	1		
25	Total metals	5		
Where cold-end coating is carried out using oleic acid/polyethelenes, (or any similar compound that is not classed as a VOC) then this monitoring requirement shall not apply.				

2.3 The emissions from the downstream processes should not be monitored if the discharge from these processes is combined with the emissions from the furnace prior to stack abatement and monitoring. Monitoring will be required if the downstream processes discharge to atmosphere via an alternative route.

Benchmark emissions to controlled water associated with the use of BAT

2.5.1 Limit values for discharges to controlled waters (which includes surface water discharges not to sewer), will be specified in individual cases taking account of the receiving environment. On site wastewater treatment systems can maximise the removal of metals using precipitation, sedimentation and possibly filtration. The reagents used for precipitation may be hydroxide, sulphate, flocculent or a combination of both, depending on the mix of metals present. It is also practicable in many cases to re-use treated water. **Table 4** provides information regarding achievable levels associated with the use of such wastewater treatment systems for discharge to surface water.[2]

2.6 Where the discharge of liquid effluent is to an external treatment works then the trade effluent consent will specify the discharge conditions.

Table 4: Emissions to controlled water associated with the use of BAT

Determinand	Benchmark release concentration, mg/litre
COD	130 (trade effluent consent) 30 (surface water)
Total hydrocarbon oil	5
Total suspended solids	30
Ammoniacal nitrogen expressed as N	10
Sulphate	3000
Fluoride	30
Antimony	0.3
Total Chromium, Copper, Lead, Nickel	0.5
The appropriateness of the above release concentrations will vary dependent upon the sensitivity of the receiving water and should be proportionate to the scale of the operations.	

3 Techniques for pollution control

[2] Further information on the permitting aspects of discharges to controlled waters can be found in paragraph 3.95.

3.1 This section summarises, in the outlined BAT boxes, what BAT should be in most circumstances. The boxes should not be taken as the only source of permit conditions; compliance with emission limits and other provisions contained in this guidance note together with any relevant case-specific considerations will also need to be taken into account.

3.2 The standards cover the techniques and measures which, in combination with those in the relevant previous (LAPC/IPC/Waste) guidance, have been identified as representing BAT in a general sense. They also cover the other requirements of the Pollution Prevention and Control (England and Wales) Regulations 2000 and requirements of other regulations, such as the Waste Management Licensing Regulations 1994 and the Groundwater Regulations 1998 insofar as they are relevant to an IPPC Permit. For the sake of brevity these boxes simply use the term "BAT".

3.3 Where techniques or operating conditions are referred to in the BAT boxes below, provided that it is demonstrated to the satisfaction of the regulator that an equivalent or better level of control of environmental impacts will be achieved, then other techniques or operating conditions may be used.

Installation description and in-process controls

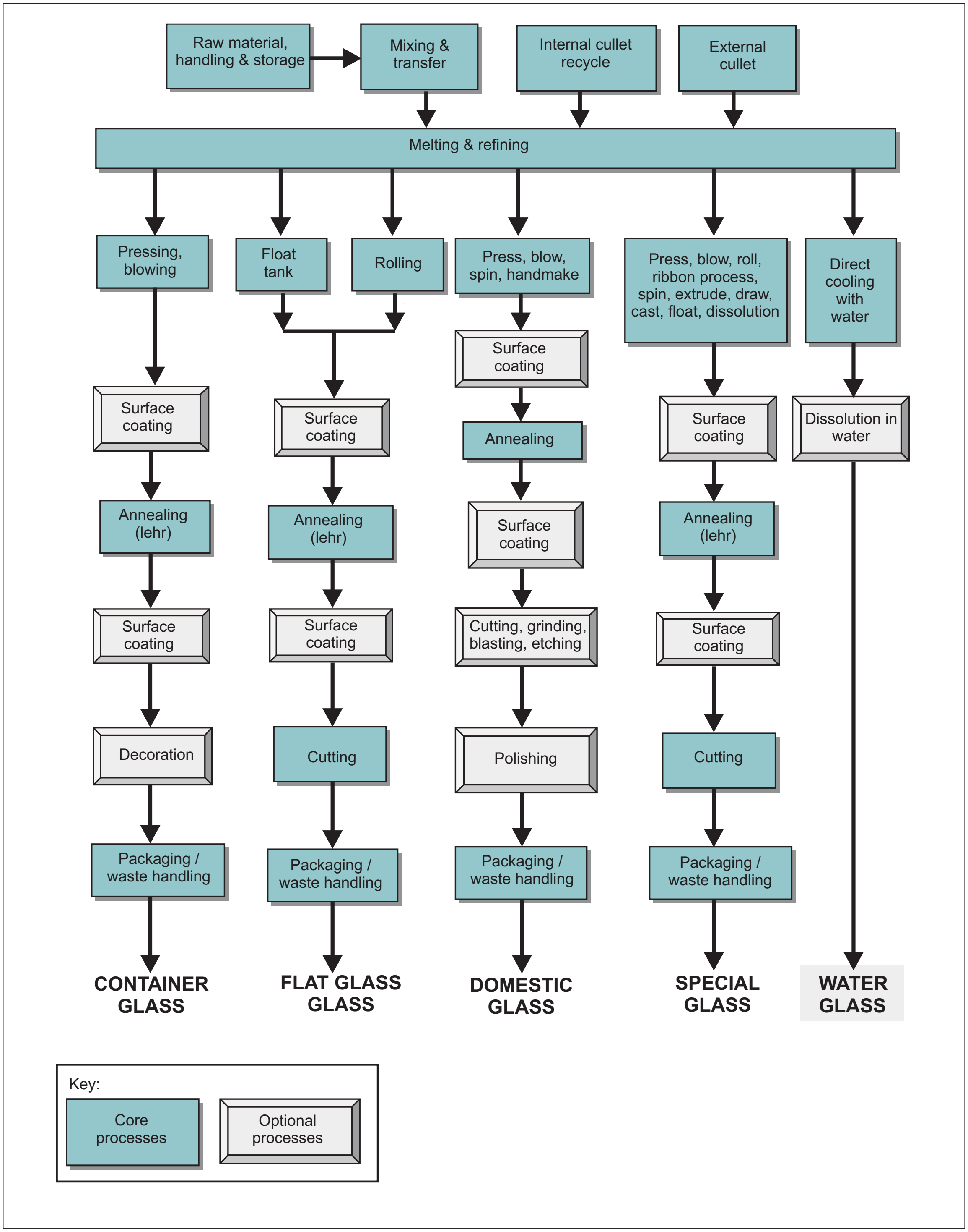
3.4 The meaning of “installation” and “directly associated activity” is addressed in chapter 2 of the General Guidance Manual.

Overview of the activities in this sector

3.5 As depicted in **Figure 3.1** below, the raw materials handling, cullet recycle and furnace operations are, in principle, the same across all the sub-sectors, with the choice of techniques largely dependant on the nature of materials handled and the scale of the operation.

3.6 In the remainder of downstream activities the characteristics of the processes used and hence abatement techniques employed, vary from sub-sector to sub-sector and product to product.

Figure 3.1 Glassmaking Activities



Delivery, storage and handling of raw materials

Summary of activities

3.7 The diversity of the glass industry results in the use of a wide range of raw materials. The majority of these are solid inorganic compounds delivered by road or rail haulage:

- very coarse materials >50mm diameter such as process and external (post consumer) cullet are conveyed and stockpiled in storage bays or silos
- granular and powdered raw materials are transferred pneumatically or mechanically to bulk storage silos. Lower volume materials can be delivered in bags or kegs and are usually gravity fed to the mixing vessels

3.8 The raw materials are combined by weight to give a precisely formulated batch that is conveyed to the furnace for melting. Transfer of the solid materials into the mixing stage of the process is usually by pneumatic or mechanical conveyor; subsequent transfer to the furnace being by enclosed screw conveyor or open flat conveyors. Water is normally added to reduce dust formation.
Liquids and gases are also used, the former for coating and other ancillary processes.

3.9 The use of internal and external cullet, has the following benefits for fuel use and emissions in relation to glass works, (**Ref. 4**):

- cullet requires less energy to melt than virgin raw materials, thus increasing its proportion in the feed has the positive environmental effect of reduced emissions from combustion
- with virgin raw materials, up to 20% of the batch weight may be emitted as gases. When high levels of cullet are used, this figure can be reduced to as low as 3%
- Cullet use, however, has to be commensurate with quality issues and availability.

Further discussion relating to the selection of raw materials can be found at 3.121 to 3.125.

Environmental impact from raw materials handling, etc

Water:	*Run off from contaminated or dirty cullet and external bulk stores.*
Land:	*Spillage, overfilling of silos and other containers.*
Air:	*Dust.*
Waste:	*Refer to accidents*
Energy:	*Not significant.*
Accidents:	*Potentially from delivery and transfer of liquids, solids and powders.*
Noise:	*Vehicles and delivery operations, including blowing into hoppers from road tankers, may cause noise disturbance, especially if close to the site boundary. Recycling of cullet may cause a problem.*

BAT

1 The operator should select the type and purity of raw materials (including fuels and fining agents) that are technically and economically viable for use in the installation, so as to minimise the environmental impact that arises through chemical decompositions in the furnace.

2 The operator should use the following techniques to minimise emissions of particulate matter :

- for coarse materials:- partial or full enclosure of storage bays or silos, enclosed conveyor systems, dust control sprays or wash-down systems to control fugitive dust
- for granular / powdered materials:- pneumatic conveying systems should include filtering of displaced air from silos; mechanical conveyors should be enclosed. Displaced air from gravity feeding and the extracted air from local extract systems used to control dust in areas where kegs and bags are handled or bags are split should also be filtered

• buildings should be designed such that entrances and vents will as far as possible not be the source of fugitive emissions

Melting and refining processes

Summary of the Activities

3.10 The temperature needed to melt and refine glass depends on the precise formulation but is typically between 1300°C and 1650°C heated by flames of up to 2000°C. The burning of fossil fuels releases combustion products, namely carbon dioxide, water vapour, and sulphur dioxide. Nitrogen oxides (NO_x), however, are created more from the high temperature oxidation of the nitrogen contained in the combustion air.

3.11 As materials heat up, moisture evaporates and some of the raw materials decompose and gases trapped in the raw materials escape. As the temperature rises further, the silica from the sand combines with sodium oxide from soda ash and other batch raw materials to form silicates releasing further carbon dioxide. In addition hydrates, carbonates, nitrates and sulphates in the feed material decompose giving off water, carbon dioxide, oxides of nitrogen and oxides of sulphur.

3.12 Bubbles in the glass melt could lead to defects. Further it is necessary to obtain a homogenous melt to optimise the physical properties. The addition of chemical fining agents eliminates gaseous bubbles from the melt and aids homogenisation. The most frequent fining agent is sodium sulphate which decomposes to sodium oxide releasing gaseous oxides of sulphur (SO_X) and oxygen. Other fining agents include carbon materials and oxides of arsenic and antimony used for special glass production. Sodium nitrate and calcium sulphate are also used.

3.13 In the conditioning stage, lower temperature causes all remaining soluble bubbles to be reabsorbed into the melt. At the same time the melt cools slowly to a working temperature of between 900°C and 1300°C.

Furnace types

3.14 There are many furnace designs in use and they are usually distinguished from each other in terms of the method of heating, the combustion air preheating system employed and burner positioning. The main types of furnace are described in **Table 5** below, including some of the main advantages and disadvantages. Typically the residence time of material within the furnace is 24 hours for container furnaces and 72 hours for float glass furnaces.

Table 5: Outline of furnace descriptions

Furnace	Principle of operation	Advantages	Disadvantages
Cross fired regenerative	Waste gases preheat "regeneration" chambers through which combustion air is passed and thus preheated	Combustion air preheated to 1400^{o}C High thermal efficiency Can control furnace temperatures closely Larger furnaces possible giving economies of scale	Tendency for higher NOx levels than in end fired Less fuel efficient than end fired
End fired regenerative	Similar principle to the above	Cheaper than cross fired regenerative	Less control of furnace temperature profile than cross fired regenerative. Maximum size of the order of 450tpd
Recuperative (unit melter)	Waste gases continually pass over heat exchanger across which combustion air is passed		Combustion air typically only preheated to 800^{o}C Small furnaces
LoNox melter	Proprietary technique. Shallow furnace. Preheated combustion gas and preheated raw materials used	Can operate furnace at a lower temperature. Low NOx emissions (<1kg NOx per tonne of glass melted)	>70% cullet required in raw material
Electric melter	Resistive heating by electrodes.	Low waste gas volume. Reduced size of abatement plant required. High thermal efficiency due to lower heat losses of a smaller furnace. Also lower rebuild costs.	Small furnaces only due to cost of electricity compared to fossil fuels Overall CO_2 balance may not be favourable
Pot furnaces, day tanks	Not continuous. Used to melt specific batches.		Small (<20t/d)
Flex melter	Not continuous. Used to melt specific batches. Combination of electric and gas used for heating.		Small (<20t/d)
Oxy-fuel fired	High percentage of oxygen used instead of 21% oxygen in combustion air	Reduces volume of waste gases by up to 85%. Potential for reduction of on site fossil fuel use.	Waste gases require cooling Requires on site oxygen supply infrastructure

Control of point source emissions from furnaces

3.15 The environmental performance of the furnace is a result of a combination of the choice of melting technique, fuel used, end product and load, the internal design of the furnace, the method of operation, and the provision of secondary abatement measures.

3.16 From an environmental perspective, techniques that are inherently less polluting or that can be controlled by primary means (e.g. method of operation) are generally preferred to those that rely on secondary abatement to control emissions. The economic and technical limit of primary measures which prevent or minimise pollution at source should be fully considered and a balance between these and secondary abatement made, to achieve the most viable means to attain the emission limit values.

Selection of furnace configuration

3.17 The choice of furnace configuration and melting technique should be that which is suitable for the combination of production capacity, glass formulation, fuel prices and existing infrastructure, and will deliver the best environmental performance.

Selection of fuel / combustion / heating techniques

3.18 There is a generally held opinion within the industry that oil flames, being more radiant than gas flames, give better heat transfer to the melt. There are many grades of fuel oil with varying purity and operators should aim to use the fuel of the lowest sulphur content as this will directly reduce SO_x emissions.

3.19 The use of liquid petroleum gas (LPG) or natural gas, although burning with lower radiance, has many advantages including lower sulphur content, its ease of control which can lead to higher efficiencies and the fact that for natural gas storage facilities are not required. However, an alternative fuel source may be required in case of interruption to, or national shortage of, the primary fuel.

3.20 Some furnaces are fitted with burners that can fire on either gas or oil. The fuel the operator wishes to use may be driven by economic, rather than environmental, considerations. In such cases the operator will need to demonstrate, either in the original application, or via a subsequent variation request, that whichever fuel is used the environmental impact is acceptable. Permit conditions may have to reflect the possibility of such a fuel switch.

3.20 Electricity can be used either as the main heat source, or as a boost to increase the throughput of a furnace. In practice a combination of fuels is often used:

• many large furnaces are equipped to run on both natural gas and fuel oil such that they can change over during interruption in gas supply or major change in the relative price of the fuels
• to enhance control of the heat input, it is not uncommon for predominantly gas fired furnaces to burn oil on one or two ports
• electric boosting is a method of adding extra heat to a fossil fuel fired glass furnace by passing an electric current through electrodes in the bottom of the tank, to increase throughput.

3.21 This technique can be installed while a furnace is running if suitable access is available. As well as increasing heat input, electric boost can also improve convection currents in the glass melt, enhancing heat transfer and refining processes. It is commonly used as an operational tool to:

- meet periodic fluctuations in demand
- support the pull rate of a furnace as it nears the end of its operating life
- assist in the melting of green and amber glass which have poor radiant heat transfer characteristics

• over-firing with gas or oil can be used with a principally electrically heated furnace to assist in start-up and to overcome some of the operational difficulties encountered with 100% electric melting. This simply involves firing flames over the surface of the batch material to add heat to the materials and aid melting

• oxy-fuel melting has a number of advantages including furnace energy savings, reduction of waste gas volume, and significantly reduced NO_x emissions.[3]

[3] Either oxy-fuel firing, or use of LPG, could lead to the installation being classified as a COMAH site, with a need to comply with the COMAH Regulations. The regulator should note this when considering furnace options.

Enhancing energy efficiency

3.22 Achieving the best furnace efficiency means less fuel is used per tonne of glass produced which therefore yields less CO_2, NO_x and SO_x. Less air is required to burn less fuel, so there is less turbulence on the surface of the molten glass. Thus the mass emission of particles is also reduced.

Environmental impact from melting and refining

Water: *Not significant*

Land: *materials to landfill*

Air: *Major emissions of combustion gases, particulates and heavy metals from melting furnaces such that abatement may be required.*

Waste: *not significant*

Energy: *design of furnace has major impact on energy consumption*

Accidents: *not significant*

Noise: *not significant*

Downstream processes

3.23 This section covers the processes carried out downstream of the furnace operations for the four main sub-sectors: flat glass, container glass, domestic glass and special glass.

Flat glass

3.24 The two main processes for forming flat glass are the "float glass" process and the "rolled glass" process.

3.25 Where coating process are used, these often involve tin tetrachloride ($SnCl_4$), hydrofluoric acid (HF), methanol (CH_3OH), and silane (SiH_4).

The float glass process

3.26 The basic principle of the float process is to pour the molten glass onto a bath of molten tin, and to form a ribbon with the upper and lower surfaces becoming parallel under the influence of gravity and surface tension.

3.27 The float tank (or bath) consists of steel casing supported by a steel framework, and lined with refractory blocks which contain the molten tin. Float tanks are typically about 55m to 60m long, 4m to 10m wide and divided into 15 to 20 bays. The tank is airtight and a slightly reducing atmosphere is maintained by the injection of a mixture of nitrogen and hydrogen. This is essential to prevent the oxidation of the tin surface, which would damage the crucial contact surface between the glass and the tin.

3.28 Inside the float tank are several pairs of water-cooled top rollers, adjustable in direction, height, penetration and angle. These rollers catch the glass sheet on both edges by cog-wheels and draw it in length and width. The rate of glass flow and the rotation speeds of the rollers help to govern the thickness of the glass, typically from 1.5 mm to 19 mm. The glass has a maximum natural thickness on the tin surface and graphite barriers can be introduced in order to produce the thicker glasses.

3.29 At the exit of the float bath the glass ribbon is taken out by lift-out rollers, and is passed through a temperature controlled tunnel, the lehr, to be annealed. At the beginning of the lehr, SO_2 is sprayed on both sides of the ribbon, providing a surface treatment to protect the glass against the contact of the rollers. The lehr is divided in sections in which there is heating and indirect or direct cooling by forced and natural convection. Glass is thus gradually cooled from 600^{o}C to 60^{o}C in order to reduce residual stresses, caused during the forming process, to an acceptable level.

3.30 The cooled glass ribbon is cut on-line to the required sizes by a travelling cutter. The edges of the glass ribbon that bear roller marks are cut off. These edges and any glass rejected by the process / breakages become the 'process cullet' which is generally recycled to the furnace. Finished glass sheets are then inspected, packed and stored, either for sale or for secondary processing.

3.31 On-line coatings can be applied to improve the performance of the product (e.g. low emissivity glazing). This is done by spraying the moving ribbon of hot glass with silica or tin compounds which react to form the required film. The process generally consists of two separate coating stages, a silicon based undercoat and a separate topcoat, e.g. fluorine doped tin oxide. Due to the nature of the chemicals used, emissions of acid gases and fine particulates can arise, which need to be treated in an abatement system.

3.32 In general, the emissions to air from non-melting activities in flat glass production (being combustion products from natural gas heaters and SO_2 used for lubricating the lift-off rollers) are very low and do not require abatement measures. If the float bath is correctly operated there are no appreciable emissions of tin vapours. However where on-line coating processes are carried out abatement of emissions may be required to meet the emission limit values.

The rolled process (patterned and wired glass)

3.33 Rolled glass is formed by a continuous double-roll process. Molten glass at about 1000^{o}C is fed from the furnace and squeezed between water-cooled steel rollers to produce a ribbon with controlled thickness and surface pattern. It is then further cooled and carried forward into the annealing lehr at about 600^{o}C

.

3.34 Wire-reinforced glass is made by a wire mesh being fed down from a roll suspended above the machine and guided into the so-called bolster of glass that is formed by the glass flow entering the space between two rollers.

Container glass

3.35 There are five essential stages involved in the forming of glass containers:

• the feeder mechanism, creates a number of equal parallel flowing streams and cuts these into accurate lengths by use of a shear mechanism to obtain sausage shaped 'gobs' of molten glass at the correct weight and temperature

• the primary shape (parison) or blank is formed in a first mould by pressure from compressed air or a mechanical plunger

• the primary shape is transferred to the final (or finish) mould

• the shaping process is then completed by blowing the container with compressed air to the shape of the final mould

• removing the finished product for post forming processes. Emissions from mould coating should normally be considered trivial for regulatory purposes.

3.36 Depending on whether mechanical plungers or compressed air are used in the primary and final forming stages, these processes may be termed "press and blow" or "blow and blow".

3.37 These processes are generally carried out by automated machines, the operating speeds of which depend on the complexity of the shape being produced. The extraction of heat is achieved by blowing high volumes of air onto and through the moulds, and various high temperature (graphite based) release agents are used to prevent glass sticking to the mould. Any rejects from this process are recycled as process cullet to the melting furnace.

3.38 To eliminate the stresses (and hence fragility) caused by rapid cooling, the formed containers are passed through a continuous annealing oven (lehr), where they are reheated to 550^{o}C then cooled under controlled conditions. Lehrs need to be initially heated up but once brought to operating temperature the heat from the incoming containers provides the majority of the heating energy.

3.39 To improve the performance of the products, surface coatings can be applied either immediately after forming while the articles are still above 500^{o}C ("hot end coating") or after annealing ("cold end coating") or, more commonly, a combination of the two.

3.40 The main source of emissions to air from non-melting activities in container glass production is the hot end coating operation. The coating, a very thin layer of metal oxide, is applied by passing the hot containers from the forming machine through a hood containing vapours of tin or, rarely, titanium compounds. The most common material used is monobutyl tin trichloride ($C_4H_9SnCl_3$). The emissions consist of hydrogen chloride, tin and any unreacted coating materials, as well as minimal fine particulate.

Domestic glass

3.41 Due to the wide range of products made in this sector, forming processes can be automatic, semi-automatic or hand made. Forming is carried using similar “press and blow” or “blow and blow” techniques described for the container glass sector above and also by pressing a “gob” of molten glass into moulds for open top vessels or by spinning into moulds for shallow articles.

3.42 The formed articles are generally fire-finished and polished to obtain the required surface quality. Very high temperatures are often necessary and are provided by means of oxy-gas or in some cases oxygen-hydrogen firing. These processes have the advantage of a lower specific energy consumption, easy use and reduction of exhaust gases volumes. Following firing, the articles pass through a tempering furnace or through an annealing lehr / cold coating station. Other parts e.g. stems and feet for glasses and handles for cups, are added after local remelting.

3.43 In some installations patterns are cut on the blank glass articles using diamond impregnated wheels. This process can be carried out either by hand or automatically, depending on the product. Water (sometimes dosed with lubricants etc.) is used as a coolant for cutting and also removes the fine glass particles produced. The water is treated and either discharged or recycled. The edges of the articles are sometimes ground and polished using similar techniques.

3.44 Alternative techniques to acid polishing are being developed e.g. mechanical polishing and high temperature polishing, either with flames or lasers.

3.45 Other techniques such as decorating with enamels, frosting (by sand blasting or acid etching) and engraving can be used. The volumes of emissions from these post forming operations are small in comparison with the main processing stages.

Special glass

3.46 The main forming techniques used within this sector are:

(a) Press and blow production (borosilicate glass, tableware and kitchen products)

(b) Rotary-mould (past-mould) process (borosilicate glass, lamp units)

(c) Blow down (or settle blow) process (borosilicate glass, domestic glass)

(d) Rolling (ceramic flat glass)

(e) Pressing (Cathode Ray Tube glass and lamp units)

(f) Ribbon process (light bulbs)

(g) Spinning process (borosilicate glass)

(h) Tube extrusion, (glass tubing including lighting)

(i) Casting (optical glass blocks and some special products)

(j) Drawing process (down draw for thin film glass like display glass, up draw for borosilicate glass), & the Danner and Vello processes

(k) Floating (borosilicate glass)

(l) Dissolution (water glass solutions)

3.47 Environmental impact issues are similar to those for the flat, container and domestic glass sectors described above, but generally on a smaller scale.

BAT

Flat Glass - coating operations

3 Where a SiCO undercoat is applied, emissions should be passed through a thermal incinerator to destroy any organics. Waste gas can then be cooled and the solids (amorphous silica) removed by a bag filter. The collected material can in general be recycled to the furnace.

4 Where a top coat of fluorine doped tin oxide is applied, waste gases, containing halides and tin compounds, should be passed through a high temperature reactor to oxidise the tin compounds. The solid tin oxide can then be removed by an electrostatic precipitator and halides removed in a packed bed chemical scrubber.
In general, the emissions from these types of activities can be controlled using a combination of the techniques listed below, in some cases other equally effective techniques may be appropriate.

Container Glass – coating operations

5 The first step in reducing emissions is to minimise the usage of the coating commensurate with the product requirements. The use of the material can be further optimised by ensuring good sealing of the application areas to minimise losses.

6 Waste gases from such operations should only be emitted directly to atmosphere via a stack that ensures good dispersion if concentrations in the stream without dilution are already below the emission limit values.

7 Where secondary abatement is already applied to furnace waste gas; it may be appropriate to combine the extract from hot end coating with this stream. The scrubber removes acid gases and the electrostatic precipitator or bag filter removes particulates. This may however constrain the recycling of the collected dust.

8 Combining the extract from hot end coating with furnace combustion air might be appropriate in certain cases but may disturb primary controls of NO_x and dust or affect the glass chemistry.

9 A better environmental solution might be for the gases extracted from coating processes to be treated by secondary techniques. A wet scrubber or spinning mop scrubber alone may be sufficient to deliver emissions below the emission limits. Alternatively a bag filter followed by one or two stages of packed bed scrubber or venturi scrubber may be required.

Domestic Glass

10 Fumes of HF and SiF_4 released from the surface of the polishing bath should be treated in scrubbing towers.

11 During acid polishing, hexafluorosilicic acid (H_2SiF_6) is formed with concentrations building up to 35%. This H_2SiF_6 can be recovered and, where feasible, used as a feedstock in the chemical industry.

12 Acidic water created by rinsing the glass after acid polishing also requires periodic neutralisation.

Special Glass

13 The same techniques as described above should be applied albeit at smaller scale.

Environmental impact from downstream processes

Water:	*Not significant.*
Land:	*Not significant.*
Air:	*Hot end coating **-** release of coating and breakdown products such as HCl.*
Waste:	*Acidic residues from hot end coating*
Energy:	*Not significant.*
Accidents:	*When used, fugitive releases of HF and other acidic gases.*

Noise: *Not significant.*

Emissions control

Point source emissions to air

Sources

3.48 The nature and source of the emissions to air expected from each activity are given in previous sections. In general they comprise:

- Oxides of Nitrogen
- Particulate matter
- Oxides of Sulphur
- Chlorides/Fluorides
- Heavy Metals

3.49 There should not normally be persistent visible emission from glass manufacturing contained sources which are complying with the 30 mg/m^3 particulate limit, although it will not necessarily be essential to take action to prevent such emissions if the particulate limit is being respected on a continuous basis. Continuous indicative monitoring and recording in accordance with **Table 3** would be expected to demonstrate that this is the case.

Controlling emissions of oxides of nitrogen (NO_x)

3.50 NO_x in furnace emissions can arise as a result of breakdown of nitrates in the feed material or oxidation of nitrogen contained in fuel (which is typically very small). The vast majority however is thermal NO_x, generated by the oxidation of nitrogen in the high temperature combustion atmosphere present in the glass furnaces (typically 1650 - 2000^{o}C).

3.51 Reduction of NO_x can be achieved to a large extent at source by special furnace designs or by primary means of combustion control applied on conventional furnaces. In general however a combination of these with secondary techniques is required to achieve the emission limit.

BAT

14. Normally a combination of the following techniques, both primary and/or secondary, in agreement with the regulator, should be used for the control of NO_x emissions:

Primary techniques

- loNOx melter - capable of achieving emissions of <1kg of NO_x per tonne of glass melted
- oxy-fuel melter - to be considered at major rebuild or for a new installation
- FENIX process - to be considered for a new installation, (if available in BAT terms)
- prevent ingress of air into the furnace - 10% reduction of NO_x possible
- reduced air/fuel ratio - 40% reduction of NO_x possible
- staged combustion - 35% reduction of NO_x possible
- loNOx burners - 30% reduction of NO_x possible

Secondary techniques

- 3R process - 85% reduction of NO_x possible
- reburning - 60% reduction of NO_x possible
- SNCR - up to 70% reduction of NO_x possible
- SCR - up to 70% reduction of NO_x possible

Controlling emissions of particulates

3.52 The three main sources of dust from melting are:

- batch material carryover
- volatilisation and reaction of substances from batch materials and the glass melt
- metals impurities in the fuels

For fossil-fuelled furnaces the volatilisation and subsequent reaction/condensation of volatile materials released from the hot glass surface, represents by far the largest proportion of the overall dust emission. In general, 80 to 95% of the dust emission will be produced in this way.

Secondary abatement techniques as well as primary measures are required in order to meet the particulate emission limit for furnaces.

Primary measures

3.53 Primary measures described below include raw material modifications, temperature reduction at the melt surface, optimising burner position and improved furnace charging techniques.

3.54 Raw material modifications:

- sodium chloride can be a significant factor in emissions of dust and chlorides. It is often a low level impurity in man-made soda ash. Levels might be reduced by negotiation with soda ash producers or use of more expensive natural soda ash, which is virtually sodium chloride free
- sulphate levels should be reduced to the minimum commensurate with good fining and maintaining the correct oxidation state of the glass

3.55 Temperature reduction at melt surface by:

- improving furnace design and geometry, to improve convective currents and heat transfer. This can only be implemented at the furnace rebuild or with a new furnace.
- electric boost, putting energy directly into the melt to improving convective currents in the glass. It should be noted that there are costs and indirect emissions associated with this method.
- the increased use of cullet will reduce the melting energy requirement allowing operation at a lower temperature and lower fuel usage

3.56 Burner position can be optimised to reduce gas velocity and level of turbulence at the surface of the melt, thus decreasing the rate of volatilisation.

3.57 Dust from batch material charging can be minimised by reducing air flows and turbulence during charging, and by raw material grain size and moisture optimisation.

Secondary measures

3.58 Secondary abatement techniques include electrostatic precipitators and bag filters (described below).

Electrostatic precipitators

3.59 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 generated between the electrodes.

3.60 This technique is applicable to all new and existing installations in all sectors and can normally be retrofitted without furnace shutdown. It is recognised that there may be some existing furnaces where furnace shut-down would be required in order to fit an EP due to the configuration. Such instances should be discussed with the regulator. (Having given due regard to the full range of BAT considerations it is possible that the furnace rebuild may have to be brought forward to accommodate installation of an EP). It is possible for one EP to serve several furnaces. An EP will be capable of achieving emissions of <0.1kg particulate per tonne of glass melted. Once operating, regular servicing is required to maintain performance. It is necessary to take the equipment off-line for essential maintenance.

3.61 In dry conditions, the discharge electrodes must be rapped or vibrated to prevent material build-up.

3.62 In wet precipitators, the collected material is removed from the collector plates by flushing with a suitable liquid, usually water, either intermittently or by continuous spray irrigation.

3.63 In applications where the gas stream may contain significant concentrations of acid gases (particularly SO_x, HCl and HF) it is generally considered necessary to use some form of acid gas scrubbing to protect the EP.

3.64 Indicative costs for EPs and the major factors affecting them are included in the BREF (**Ref. 3**).

Bag filters

3.65 Conventional filter fabrics have maximum operating temperature of between 130 and 220^oC. This means that waste gas from furnaces (typically between 450 to 800^oC) will require cooling by air dilution, quenching or heat exchanger before entry to a bag filter. A bag filter will be capable of achieving emissions of <0.1kg particulate per tonne of glass melted.

3.66 If flue gases contain acidic species (particularly from oil fired furnaces) it may be necessary, depending on the materials of construction and the type of filter fabric used, to install a scrubbing stage upstream of the filter to prevent acid condensation which would damage bags and filter housing. If the gas being treated contains boron, a scrubbing stage will also help precipitate the volatile boron species and make the dust easier to collect.

3.67 Bag filters should feature reliable electronic control systems to continuously monitor temperature and pressure drop to avoid damage to the filter fabric. If bag filters become damaged, emission levels can be quite high. For this reason a system of bag failure detection by continuous monitoring of plant operation must also be incorporated. However, it should be noted that with multi-bag filters failure of a single bag is unlikely to have a significant environmental impact.

3.68 Despite the relatively high maintenance requirements and the potential for the fabric to blind, resulting in the need for costly replacement, bag filters have been installed in container and special glass manufacturing sites. As with electrostatic precipitators equipment will need to be taken off-line for essential maintenance or repair, but this should be possible without a major impact on particulate emissions.

3.69 There is further concern in that most fossil fuel fired furnaces require sensitive pressure control and the presence of a fabric filter with high pressure drop can make this more difficult.

Bag filters are however widely used for ("cold top") electric melters and, in conjunction with scrubbing, on smaller fossil fuelled furnaces where capital costs are lower and, because of low gas flows, operating costs are also proportionally reduced.

For those installations using either type of abatement equipment described above, allowance should be made to emission limit values to accommodate the impact of routine maintenance. This could be in the form of a condition setting different limits during the maintenance period, or by allowing emissions to be averaged a period that includes both normal operation and the maintenance work.

BAT

15 Normally a combination of the following techniques, in agreement with the regulator, should be used for the control of particulate emissions:

Primary measures:
• raw material modifications, reduction of temperature at melt surface, burner position and gas firing

Secondary abatement techniques:
• electrostatic precipitator
• bag filter.

Controlling emissions of oxides of sulphur (SO_x)

3.70 Primary techniques for reduction of SO_x emissions include selecting a low sulphur content fuel and reducing levels of sulphates added to the batch for refining and oxidation control purposes.

3.71 The secondary techniques of dry and semi-dry scrubbing can both be applied in the glass industry. In both, the reactive material (the absorbent) is introduced into the waste gas stream. This material reacts with the SO_x species to form a solid, which must be removed from the waste gas stream by an electrostatic precipitator or bag filter system.

3.72 In the dry process the absorbent is a dry powder (usually lime $Ca(OH)_2$, sodium carbonate $Na_2(CO)_3$ or sodium bicarbonate $NaHCO_3$). In the semi-dry process the absorbent is added as a suspension or solution and water evaporation cools the gas stream.

3.73 The majority of installed SO_x scrubbing systems operate with dry lime scrubbing at a temperature of around 400^{o}C, which is the waste gas temperature obtained from an efficient regenerative type furnace. At these temperatures, a SO_x reduction of around 50% can be achieved.

3.74 In practice however there is often a case for recycling of the filter dust from EP or bag filter located downstream of the scrubber for reasons of waste minimisation and reduction in consumption of sulphate based fining and oxidising agents. In such cases it is necessary to accept lower overall SO_x removal. This may also be the case where there are high cullet levels.

3.75 As greater amounts of this dust (containing the wastes created in the acid gas scrubbing) is recycled, the amount of sulphur in the process loop increases. The emissions of SO_x to air will purely reflect the sulphur input, via fuel and raw material, minus the quantity used in the glass manufacture.

3.76 For this reason a balance must be struck between the reduction of raw material consumption / production of solid waste and emission of SO_x to air when setting the most appropriate level of external disposal for the filter dust. Where this is the case a process sulphur balance is essential in determining emission levels commensurate with BAT.

3.77 With closed loop filter dust recycling, the SO_x emission levels observed are generally in the range of 200 - 800 mg/Nm^3 for natural gas firing and 800 - 1500 mg/ Nm^3 with 1% sulphur fuel oil.

3.78 Further detail on SO_x scrubbing is presented in the BREF, (**Ref. 3**).

BAT

16 Normally a combination of the following techniques, in agreement with the regulator, should be used for the control of SOx emissions:

• selection of a low sulphur fuel - natural gas is essentially sulphur free
• reduction of sulphates used for refining and oxidation control purposes to the minimum practicable level
• recycling of particulates collected in abatement plant - the operator should provide a process sulphur balance if recycling particulates
• acid gas scrubbing

Controlling emissions of chloride and fluorides

3.79 Emissions of chloride and fluoride as Hydrogen Chloride (HCl) and hydrogen Fluoride (HF) are of concern because of their potential environmental impact. They generally arise from the volatilisation of fluorides and chlorides in the batch materials, either present as impurities or added intentionally to provide specific product (e.g. opaque glass or fluorine crown glass) or processing characteristics to the glass. The main techniques for the reduction of these emissions are reduction at source by batch modification or reformulation, to achieve the same characteristics by other means, or by secondary acid gas scrubbing of furnace emissions.

Reduction at source

3.80 Many raw materials contain very low levels of fluoride and chloride that have little impact on final emission levels but there are some that contain significant levels including:

- man-made soda ash, which has a residual NaCl content of approximately 0.05 - 0.15%
- dolomite, which can contain significant fluoride impurities
- post consumer glass cullet, which can contain a range of impurities at significant levels, particularly chlorides, fluorides and metals. The amount of these substances varies depending on the purity of the cullet supply, but in regions with high recycling levels the species can gradually build up in the glass
- recycled dusts from abatement equipment contain fluoride and chloride salts, which can build up in the system

The emission levels can be minimised by the careful selection of raw materials and by a number of the primary techniques that reduce volatilisation by lowering temperatures, by reducing airflow and by minimising turbulence. These techniques include:

- increased cullet usage, which lowers temperature and energy usage and substitutes for soda ash with its associated chloride impurity. Note however that some cullet can have high chloride or fluoride content
- electric boost
- improved furnace design and geometry
- bumer positioning
- reduced air fuel ratio
- low NO_x burner systems
- oxy-fuel melting
- electric melting

Scrubbing techniques

3.81 As with SO_x above, the main scrubbing techniques applicable to these emissions are dry scrubbing and semi-dry scrubbing.

3.82 Another technique that could be technically and economically viable for very small scale processes is wet scrubbing, using a packed bed scrubber circulating water or more effectively an alkali solution. The main drawback with this approach is that an aqueous waste stream is generated.

BAT	
17	Normally the following techniques, in agreement with the regulator, should be used for the control of chloride and fluoride emissions: • dry scrubbing or semi-dry scrubbing in conjunction with downstream electrostatic precipitator or bag filter (with dust recycled to the furnace unless technically undesirable) that may already be installed for abatement of particulates

Dispersion and dilution of stack emissions

3.83 The basis upon which stack heights are calculated using HMIP Technical Guidance Note D1 (D1) (**Ref 5**) is that pollutants are dispersed and diluted in the atmosphere to ensure that they ground at concentrations that are harmless under the theoretical conditions of the D1 model. The emission limits in this sector note should be used as the basis for stack height calculation. The stack height so obtained is adjusted to take into account local meteorological data, local topography, nearby emissions and the influence of plant structure. It is necessary that the assessment also takes into account the relevant air quality standards that apply for the emitted pollutants.

The calculation procedure of D1 is usually used to calculate the required stack height but alternative dispersion models may be used in agreement with the regulator. D1 relies upon the unimpeded vertical emission of the pollutant. A cap or other restriction over the stack impedes the vertical emission and hinders dispersion. For this reason where dispersion is required such flow impeders should not be used. A cone may sometimes be useful to increase the efflux velocity and achieve greater dispersion. An operator may choose to meet a tighter emission limit in order to reduce the required stack height.

Revised stack height calculations should not be required unless it is considered necessary because of a breach, or serious risk of breach, of any relevant EC Air Quality standard and it is clear from the detailed review and assessment work that the Part A2 activity itself is a significant contributor to the problem.

3.84 Where an emission consists purely of air and particulate matter, the above provisions relating to stack height calculation for the purpose of dispersion and dilution should not normally be applied. However, if the emission point is within a designated air quality management area with respect to PM_{10}, then this may have to be reviewed. Dispersion models for vent and stack height calculations should take into account any emissions of the same pollutants from any other permitted activity on the installation, in order to avoid exceeding local ground-level pollution thresholds and limit national and transboundary pollution impacts. Such models should be based on the most sensitive receptor, be it human health, soil or terrestrial ecosystems.

3.85 Vent and stack heights should be sufficient to ensure adequate dispersion under circumstances of foreseeable process upsets or equipment failure that may give rise to abnormally high emission levels over short periods.

3.86 Where offensive odour is likely outside the installation boundary, the assessment of stack or vent height should take into account the need to render harmless residual offensive odour.

3.87 Exhaust gases from a wet scrubber should be heated by the use of all available waste heat to raise the temperature of the exhaust gases and prevent immediate condensation on the exit from the vent. This procedure also aids the thermal buoyancy of the plume. Where there is no available waste heat and the vent contains no significant environmentally harmful substances, the operator may be able to demonstrate that the BAT criteria have nonetheless been met.

Arrestment plant should be used where practicable to ensure particulates are recovered and reused within the process.

3.88 Liquid condensation on internal surfaces of flues and exhaust ducts might lead to corrosion and ductwork failure or to droplet emission.

- adequate insulation should be provided to minimise the cooling of waste gases and prevent liquid condensation by keeping the temperature of the exhaust gases above the dewpoint

3.89 Unacceptable emissions of droplets could possibly occur as a result of entrainment from wet abatement plant where the linear velocity within the associated ductwork exceeds 9 m/s. The use of mist eliminators reduces the potential for droplet emissions.

- where a linear velocity of 9 m/s is exceeded in the ductwork of existing wet abatement plant, the linear velocity should be reduced, subject to health and safety considerations, to ensure that droplet fallout does not occur

3.90 The dispersion from all emission points to air can be impaired by low exit velocity at the point of discharge, or deflection of the discharge.

- flues and ductwork should be cleaned to prevent accumulation of materials, as part of the routine maintenance programme
- a minimum discharge velocity should be required in order to prevent the discharged plume being affected by aerodynamic down wash

BAT

All releases to air

The operator should:

18 Ensure that all operations which generate emissions to air are contained and adequately extracted to suitable abatement plant, where this is necessary to meet specified emission limit values.

19 Ensure that emissions from combustion processes in normal operation are free from visible smoke and in any case do not exceed the equivalent of Ringelmann Shade 1 as described in British Standard BS 2742:1969.

20 Ensure that hot emissions take place from the minimum practicable number of stacks, in order to obtain maximum advantage from thermal buoyancy. This is particularly important when new plants are being designed or when changes are being made to existing processes. Where practicable a multi-flue stack should be used.

21 Ensure that stack heights are sufficient to ensure adequate dispersion under normal conditions.

22 Ensure that the minimum stack height is 3 metres above roof ridge height of any building within a distance of 5 times the uncorrected stack height and in no circumstances should it be less than 8 metres above ground level.

23 Be able to demonstrate to the regulator that all reasonably practicable steps are taken during start-up and shut down, and changes of fuel or combustion load in order to minimise emissions.

24 Investigate the cause and nature of any persistent visible emissions and provide a report, indicating the cause and how reoccurrence will be prevented, to the regulator.

25 Ensure that emissions of water vapour are free from droplet fallout.

26 Ensure that liquid entrainment in the duct of wet abatement, leading to droplet fallout, does not occur as a result of the linear flow rate within the duct exceeding 9 m/s.

27 Ensure that flues and ductwork are cleaned to prevent accumulation of materials, as part of the routine maintenance programme.

28 Ensure that exhaust gases discharged through a stack achieve an exit velocity greater than 15 m / sec during normal operating conditions to achieve adequate dispersion.

29 Ensure that stacks are not fitted with any restriction at the final opening such as a plate, cap or cowl, with the exception of a cone which may be necessary to increase the exit velocity of the emissions

Dispersion modelling

30 Dispersion models for stack height calculations should take into account any emissions of the same pollutants from any other permitted activity on the installation, in order to avoid exceeding local ground-level pollution thresholds and limit national and transboundary pollution impacts. Such models should be based on the most sensitive receptor, be it human health, soil or terrestrial ecosystems.

31 The requirement to use D1 or another dispersion model for calculation of stack height should not normally be applied where an emission consists purely of air and particulate matter.

32 An operator may choose to meet tighter emission limits in order to reduce the required stack height. For existing stacks, the heights do not need to be recalculated, except where EU air quality standards are breached.

33	Where offensive odour is likely outside the installation boundary, the assessment of stack height should take into account the need to render harmless residual offensive odour.

Point source emissions to surface water and sewer

3.91 The nature and source of the emissions expected from each activity is given in previous sections. In general, wastewater can arise from storm water, from cooling water, from accidental emissions of raw materials, products or waste materials, foul water to sewer, and from fire-fighting.

Control of point source emissions to water

3.92 In general, direct emissions to the water environment are relatively low and there are few major issues that are specific to the glass industry. Water is used mainly for cleaning and cooling and can be readily recycled or treated using standard techniques. Issues of heavy metals (particularly lead) can arise from special glass and domestic glass processes.

3.93 The following general principles should be applied in sequence to control emissions to water:

- water use should be optimised and wastewater re-used or recycled
- contamination risk of process or surface water should be minimised
- wastewater treatment systems can maximise the removal of pollutants, for example metals, using precipitation, sedimentation and filtration. The mix of pollutants will define the methods and reagents used.
- ultimately, surplus water is likely to need treatment to meet the requirements of BAT (and statutory and non-statutory objectives). Generally, effluent streams should be kept separate as treatment will be more efficient. However, the properties of dissimilar waste streams should be used where possible to avoid adding further chemicals, e.g. neutralising waste acid and alkaline streams. Also, biological treatment can occasionally be inhibited by concentrated streams, while dilution, by mixing streams, can assist treatment
- systems should be engineered to avoid effluent by-passing any treatment plant.

3.94 The nature of the receiving water should be taken into account, with regard to any pollutant released to this media. However, irrespective of the receiving water, the adequacy of the plant to minimise emissions must be considered. Guidance on treatment of persistent substances can be found in **Ref. 5.**

Local Authority Regulation

3.95 Regulation 13 of The Pollution Prevention and Control (England and Wales) Regulations 2000 states that:

- “(1) In the case of a Part A installation or Part A mobile plant in relation to which a local authority regulator exercises functions under these Regulations, the Environment Agency may, at any time, give notice to the local authority regulator specifying the emission limit values or conditions which it considers are appropriate in relation to preventing or reducing emissions into water."
- "(3) Where a notice under paragraph (1) specifies conditions in relation to emissions into water from an installation or mobile plant, the permit authorising the operation of that installation or mobile plant, shall include those conditions or more onerous conditions dealing with the same matters as the local authority regulator considers to be appropriate."

Off site effluent treatment

3.96 Where an operator discharges to a Sewage Treatment Works via sewer, the sewerage undertaker is a statutory consultee and must be sent a copy of the application. The STW operator is likely to confirm to the Agency and the local authority the levels of pollutants (considering levels specified in the trade effluent consent) that the sewer is able to take.

In all cases the effluent discharged from the installation must not give rise to a potential breach of an EQS or EAL for the final receiving water, when taken with compliance with any water company permit. In a significant number of cases the Agency find that the STW operator's discharge consent and the Agency's concerns to protect watercourses are closely aligned. Where they are aligned and there is a simple discharge, it is common Agency practice just to rely on the consent and not to replicate limits in permit conditions.

For glass making activities it is unlikely that BAT equates with tighter limits than those specified by the Environment Agency. Therefore, the consent can be relied upon (as for simple discharges above) without replicating limits in permit conditions.

Further guidance on regulating water discharges from A2 Installations can be found in AQ11(05) (**Ref 14**).

BAT
The operator should ensure that: 33 All emissions are controlled, as a minimum, to avoid a breach of water quality standards. (Calculations and/or modelling to demonstrate this may be required to be submitted to the regulator). 34 Run-off from the installation should be controlled and managed and where necessary (given the nature of the run-off) treated before discharge in a suitable effluent treatment plant. 35 All interceptors: ▪ are impermeable ▪ are subject to at least weekly visual inspection and, where necessary to ensure the continuous function, contamination removed ▪ have an annual maintenance inspection; prior to inspection all contents should be removed ▪ records kept of the above inspections 36 For new plant, any cooling water and/or water used for wet abatement should be recycled in a closed circuit in order to minimise or avoid effluent discharge. 37 Where necessary to protect the environment, process effluent is channelled / transported to suitable effluent treatment plant. 38 Process effluent is kept separate from surface drainage unless agreed with the regulator.

Point source emissions to groundwater

3.97 There should be no intentional point source emissions of List I and List II substances to groundwater from the glass manufacturing sector (**Ref 13**).[4]

BAT
39 There should be no intentional point source emissions of List I and List II substances to groundwater.

Fugitive emissions to air

3.98 Common sources of fugitive emissions are:

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[4] The Groundwater Regulations 1998 require that List I substances are prevented from entering groundwater, and that List II substances are controlled so that pollution of groundwater does not occur. Any discharge of listed substances onto or into land must be subject to a prior investigation under the terms of the Groundwater Regulations, and this investigation should be carried out by the applicant and submitted in support of the permit application.

• storage areas (e.g. cullet bays, stockpiles etc.)
• the loading and unloading of transport containers
• conveyor systems
• pipework and ductwork systems (e.g. pumps, valves, flanges, catchpots, drains, inspection hatches etc.)
• bypass of abatement equipment (to air or water)
• accidental loss of containment from failed plant and equipment

BAT

Operations should be controlled to minimise fugitive emissions.

40 A high standard of housekeeping should be maintained. The operator should, in particular:

• ensure that all skips and vessels containing dusty or volatile materials are adequately covered to minimise emissions
• avoid outdoor or uncovered stockpiles of dusty materials
• ensure that dusty materials, such as collected material from abatement plant, are transferred by methods which do not give rise to particulate emissions (such material should be contained and kept enclosed to ensure that fugitive emissions are prevented)
• ensure that conveyors are fully enclosed and maintained, in order to prevent emissions of dust

Fugitive emissions to surface water, sewer and groundwater

3.99 The operator should have a clear diagrammatic record of the routing of all installation drainage for surface water and process effluent, to include subsurface pipework, the position of any sumps and storage vessels including the type and broad location of the receiving environment.

3.100 An inspection and maintenance programme should be established for all subsurface structures. Inspection frequencies and test methods should be chosen to prevent pollution by minimising leaks from subsurface pipework, sumps and storage vessels, having regard to the risk factors in paragraph 3.102 below.

The minimum inspection frequency should normally be no less than once every five years for yard drainage (ie rainwater from roofs, hardstanding etc) and no less than once every three years for process effluent. The precise choice of inspection frequency and the sophistication of the method should be guided by the level of risk presented but a likely maximum frequency may be once per annum.

3.101 Examples of inspection and test methods are pressure tests, leak tests, material thickness checks, and CCTV survey. Using secondary containment and/or leakage detection can serve to reduce the inspection frequency to the minimum quoted in paragraph **3.100**

3.102 The likely risk to the environment from drainage systems is dependant on the following factors:

- nature and concentration of contaminants in the water transferred in the drainage systems
- volume of water transferred
- vulnerability of the groundwater in the locality
- proximity to surface waters.

For yard drainage, it is likely that the minimum inspection frequency and least complex inspection methods will suffice irrespective of volume of water, vulnerability of local groundwater and proximity to surface waters.

The vulnerability is defined by the nature of the subsurface, and is mapped for England and Wales in a series of Groundwater Vulnerability maps. An additional measure of risk is whether the installation sits within a Groundwater Source Protection Zone (GPZs) as defined by the Environment Agency's Groundwater Protection Policy. GPZs help to identify areas, which are particularly sensitive to groundwater pollution because of their proximity to an important water supply.

The location of GPZs can be searched on the Environment Agency website http://www.environment-agency.gov.uk/maps/info/groundwater/

3.103 Operational areas should be equipped with an impervious surface, spill containment kerbs, sealed construction joints, and connection to a sealed drainage system unless the operator fully justifies that this is not necessary. Management controls such as recording the design and condition of the surfacing (capacities, thicknesses, falls, material, permeability, strength/reinforcement, and resistance to chemical attack), and regular inspections and maintenance should be used.

3.104 The operator should ensure that all tanks containing liquids whose spillage could be harmful to the environment are contained. Bunds should be impermeable and resistant to the stored materials, have no outlet (drains, soakaways etc) and drain to a blind collection point. Pipework should be routed within bunded areas with no penetration of contained surfaces. Bunds should be designed to have a holding capacity of at least 110% of the largest tank and be located more than 10m from watercourses and 50m from drinking water boreholes

It is good practice for bunds to be fitted with a high-level probe and an alarm as appropriate and to be inspected regularly by the operator. Rainwater entry to bunds should be minimised as far as is practicable, with spills and rainwater accumulations being removed as soon as possible.

3.105 All storage tanks should be fitted with high-level alarms or volume indicators to warn of overfilling. Where practicable the filling system should be interlocked to the alarm system to prevent overfilling. Tanks should have delivery connections located within a bunded area, fixed and locked when not in use and have their integrity inspected, recorded and documented, particularly where corrosive substances are involved. These inspections should be included in the maintenance schedule.

BAT

41 The operator should have a clear diagrammatic record of the routing of all installation drains, subsurface pipework, sumps and storage vessels including the type and broad location of the receiving environment.

42 The operator should identify the potential risk to the environment from drainage systems recorded by **BAT 41** and should devise an inspection and maintenance programme having regard to the nature and volume of waste waters, groundwater vulnerability and proximity of drainage systems to surface waters

3 All sumps should be impermeable and resistant to stored materials. The operator should ensure that all operational and storage areas are equipped with an impervious surface, spill containment kerbs, sealed construction joints, and connected to a sealed drainage system or such alternative requirements as approved by the regulator.

43 All liquid storage tanks should be located within bunds that are designed, constructed and located to appropriate standards and ensuring that the receiving volume is more than 110% of the largest tank.

44 Storage tanks should be fitted with high-level alarms or volume indicators to warn of overfilling and where practicable the filling system should be interlocked to the alarm system to prevent overfilling. delivery connections should located within a bunded area, fixed and locked when not in use.

45 All tanks bunds and sumps should be subject to regular visual inspection as agreed with the regulator, placed on a preventative maintenance programme. The contents of bunds and sumps should be pumped out or otherwise removed as soon as is practicable after checking for contamination.

Odour

3.105 Odour can arise from activities such as cullet pre-heating, oil storage, use of SO_2 for surface treatment and use of VOCs e.g. from silvering of flat glass.

3.106 Chapter 17 of the General Guidance Manual provides guidance on controlling odour from installations and the information required in an application.

Assessment

3.107 Operators should assess the likely sources of odour and carry out olfactory assessments at the site boundary. Odour control should be carried out in the following order of priority:

- Prevention - substitution
- Minimisation
- Containment and extraction
- Abatement

3.109 The overall aim should be that all emissions are free from offensive odour outside the installation boundary, as perceived by the regulator. The locality will influence the assessment of the potential for odour impact for example local meteorological conditions (all predicted wind directions and weather conditions) which may lead to poor dispersion conditions. Where the site has a low odour impact, the escape of offensive odour beyond the installation would be unlikely to cause harm.

Prevention

3.110 Where applicable, operators should seek to prevent and minimise odours from the installation by prevention i.e. by reducing the production of odorous chemicals.

Minimisation

3.111 Where odour generation is not preventable, odours should be minimised at source and/or contained with effective treatment prior to discharge.

BAT

46 Operators should conduct odour assessments to determine whether emissions result in offensive odours at or beyond the installation boundary.
47 If operations are identified as resulting in offensive odour, operators should devise an odour control programme of improvements and maintain an odour management plan.

Management

3.112 Within IPPC, an effective system of management is a key technique for ensuring that all appropriate pollution prevention and control techniques are delivered reliably and on an integrated basis.

3.113 An effective Environmental Management System (EMS) will help the operator to maintain compliance with regulatory requirements and to manage other significant environmental impacts. An EMS includes an environmental policy and programme which: includes a commitment to continual improvement and prevention of pollution;

- includes a commitment to comply with relevant legislation and other requirements to which the organisation subscribes; and
- identifies, sets, monitors and reviews environmental objectives and key performance indicators independently of the Permit.

3.114 The operator should have demonstrable procedures (e.g. written instructions) which incorporate environmental considerations into process control, design, construction and review of new facilities and other capital projects (including provision for their decommissioning), capital approval and purchasing policy.

Audits should be carried out, at least annually, to check that all activities are being carried out in conformity with the above requirements. Reporting should be carried out annually on environmental performance, objectives and targets, and future planned improvements. Ideally, these should be published environmental statements.

Guidance on how to develop Environmental Management Systems in the glass manufacturing sector can be found in Envirowise publications (**Ref 7**)

Operations and maintenance

3.115 **Maintenance** - It is good practice to ensure:

- effective preventative maintenance on all aspects of the process the failure of which could impact on the environment
- clear written maintenance instructions for all relevant items are developed and maintained
- a method of reviewing maintenance needs, with demonstrable evidence that this process takes place

3.116 **Training** – it is good practice to train all relevant (including operational) staff in the regulatory implications of the permit, all potential environmental impacts (under normal and abnormal circumstances). Training should also include the procedures for dealing with a breach of the permit conditions, prevention of accidental emissions and action to be taken when accidental emissions occur and also in all operating procedures.

3.117 **Responding to problems** - The regulator needs to be notified about certain events and expects the operator to respond to problems, which may have an effect on emissions to the environment. Such problems may arise within the process itself or, for example, with the abatement plant.

3.118 **Contractors on site** - It is important to be aware that in complying with their permit, operators will be responsible for work undertaken by contractors. Operators are advised to provide instructions to contractors regarding protecting the environment whilst working on site.

BAT

Environmental Management System

48 Operators should use an effective Environmental Management System with policies and procedures for environmental compliance and improvements. Audits should be carried out against those procedures at regular intervals.

Operations and maintenance

49 Effective operational and maintenance systems should be employed on all aspects of the installation whose failure could impact on the environment. As a minimum this should include abatement plant, extraction fans and also major 'non productive' items such as tanks, pipework, retaining walls, bunds, ducts and filters. Such systems should be reviewed and updated annually.

50 Environmentally critical process and abatement equipment (whose failure could impact on the environment) should be identified and listed. The regulator should be provided with a list of such equipment.

51 For equipment referred to in 50 above:

- Alarms or other warning systems should be provided, which indicate equipment malfunction or breakdown.
- Such warning systems should be maintained and checked to ensure continued correct operation, in accordance with the manufacturer's recommendations

- Essential spares and consumables for such equipment should be held on site or be available at short notice from suppliers, so that plant breakdown can be rectified rapidly.

52 Records of breakdowns should be kept and analysed by the operator in order to eliminate common failure modes.

Competence and training

53 A competent person, (or persons), should be appointed to liaise with the regulator and the public with regard to complaints. The regulator should be informed of the designated individual(s).

54 A formal structure shall be provided to clarify the extent of each level of employee's responsibility with regard to the control of the process and its environmental impacts. This structure shall be prominently displayed within the process building at all times. Alternatively, there must be a prominent notice referring all relevant employees to where the information can be found.

55 Personnel at all levels shall be given training and instruction sufficient to fulfil their designated duties under the above structure. Details of such training and instruction shall be entered into the employees record and be made available for inspection by the regulator.

56 The potential environmental risks posed by the work of contractors should be assessed and instructions provided to contractors about protecting the environment while working on site.

Accidents/incidents/non conformance

57 There should be written procedures for investigating incidents, (and near misses) which may affect the environment. This should include identifying suitable corrective action and ensuring it is implemented.

Raw Materials

3.119 This section covers the use of raw materials and water and the techniques for optimising their use and minimising their impact by selection (**Ref. 4**),(Energy and fuels are covered under **Energy**).

3.120 As a general principal, the operator will need to demonstrate the measures taken to:

- **reduce** the use of chemicals and other materials (**Waste minimisation (optimising the use of raw materials)**)
- **substitute** with materials presenting lower risks to the environment
- **understand** the fate of by-products and contaminants and their environmental impact

Raw materials selection

3.121 The majority of raw materials are solid inorganic compounds delivered by road or rail haulage:
• very coarse materials >50mm diameter such as process and external (post consumer) cullet are conveyed and stockpiled in storage bays or silos
• granular and powdered raw materials are transferred pneumatically or mechanically to bulk storage silos. Lower volume materials can be delivered in bags or kegs and are usually gravity fed to the mixing vessels
• to minimise spillages from vehicle tippers, if used, for transporting cullet/sand from storage points to feed points the transfer area should be pot hole free with an even impermeable surface.

3.122 The operator should select the type and purity of raw materials (including fuels, fining agents and materials used in any abatement process) that are technically and economically viable for use in the installation, so as to minimise environmental impact that arises through chemical decompositions in the furnace.

3.123 The use of internal and external cullet, has the following benefits for fuel use and emissions in relation to glass works:
• cullet requires less energy to melt than virgin raw materials, thus increasing its proportion in the feed has the positive environmental effect of reduced emissions from combustion

• with virgin raw materials, up to 20% of the batch weight may be emitted as gases. When high levels of cullet are used, this figure can be reduced to as low as 3%

3.124 Virtually all installations recycle their in-house cullet, but operators will be concerned to control the use of external cullet where it could have impacts on product quality.

3.125 Subject to quality and economic feasibility the criteria in Table 6 should be considered when selecting raw materials

Table 6: Selection of raw materials.

Raw material	Selection criteria
Silica Sand	Sand to be of a size distribution such as to minimise dust .
Cullet	Maximise use to reduce energy consumption, commensurate with achievement of adequate product quality.
Soda Ash	Quality to be such as to minimise emissions of pollutants
Other intermediate and refining agents	
De-colouring Agents	Choice of least harmful alternative where possible.
Fuel *	Subject to abatement equipment, the choice of fuel may affect emissions of carbon dioxide, sulphur dioxide and oxides of nitrogen.
Granulated blast furnace slag	Used in conjunction with the solid raw materials above.
Water	Identify most sustainable source. Consider possibility for recycling.

* Regulators should note that liquid fuels will be subject to the Sulphur in liquid fuels regulations. Regulation 3 (3) of these states that combustion plant (other than new large combustion plant covered by the LCPD for which there is a separate provision) can burn heavy fuel oil with a sulphur content greater than 1% so long as the sulphur dioxide emission from the plant is less than or equal to 1700mg/m3 at 3% oxygen dry. Defra is the enforcing authority for these regulations.

3.126 When selecting alternative raw materials, operators should ensure that decisions are taken on the basis of their environmental impact, whilst not compromising glass quality and product integrity.

3.127 Operators should maximise the amount of cullet reclaimed and reused in the installation whilst maintaining quality specifications.

BAT

58 The operator should adopt procedures to control the specification of those types of raw materials with the main potential for environmental impact, such as cullet quality, fuel types and mixes, and coating materials in order to minimise any potential environmental impact. An annual review of alternative raw materials should be carried out with regard to environmental impact from the installation.

Waste minimisation (optimising the use of raw materials)

3.128 Waste minimisation can be defined simply as: *"a systematic approach to the reduction of waste at source, by understanding and changing processes and activities to prevent and reduce waste".*

3.129 A variety of techniques can be classified under the term waste minimisation and they range from basic housekeeping techniques through statistical measurement techniques, to the application of clean technologies

3.130 Key operational features of waste minimisation should be:

- the ongoing identification and implementation of waste prevention opportunities
- the active participation and commitment of staff at all levels including, for example, staff suggestion schemes

- monitoring of materials' usage and reporting against key performance measures or benchmarks

3.131 Using this information, opportunities for waste reduction, changes in process and improved efficiency should be generated and assessed, and an action plan prepared for the implementation of improvements.

3.132 The use and fate of all materials should be mapped onto a process flow diagram using data from the raw materials inventory and other company data as appropriate. Data should be incorporated for each principal stage of the operation in order to construct a mass balance for the installation. The mass balance can then be used to identify opportunities for improvements.

3.133 Monitoring and mapping material usage in this way can be carried out to determine benchmarks in terms of the amount of any given raw material used per tonne of product manufactured. Assessment against benchmarks can reveal whether the process is being maintained "in control" or to trigger investigations in to why raw material usage is increasing.

3.134 There should be continuous movement towards more Sustainable Consumption and Production (i.e. doing more for less) as laid out in Government Guidance "Changing Patterns - UK Government Framework for Sustainable Consumption and Production" (**Ref 7**). Section 3.3 of the guidance identifies advice and funding programmes available to achieve more sustainable production practices. The National Industrial Symbiosis Programme shares information across all industrial sectors to produce guidance and case studies for resource efficiency (**Ref 7**).

BAT
59 The operator should record materials usage and waste generation in order to establish internal benchmarks. Assessments should be made against internal benchmarks to maintain and improve resource efficiency
60 The operator should carry out a waste minimisation audit at least as frequently as the permit review period. If an audit has not been carried out in the 2 years prior to submission of the application it should be completed within 18 months of the issue of the first PPC permit. The methodology used and an action plan for optimising the use of raw materials should be submitted to the regulator within 2 months of completion of the audit.
61 Specific improvements resulting from the recommendations of audits should be carried out within a timescale approved by the regulator.

Water use

3.135 The amount of water used in glassmaking processes is small. Its main uses are as a coolant and as a scrubber medium in abatement plant.

3.136 Water use should be minimised within the BAT criteria for the prevention or reduction of emissions and be commensurate with the prudent use of water as a natural resource.

3.137 Reducing water use may be a valid environmental and/or economic aim in itself, perhaps because of local supply constraints. Also, from the point of view of reducing polluting emissions, any water passing through an industrial process is probably degraded by the addition of pollutants, and there are distinct benefits to be gained from reducing the water used. These include: reducing the size of (a new) treatment plant, thereby supporting the cost benefit BAT justification of better treatment.

The use of a simple mass balance for water use may help to reveal where reductions can be made.

Advice on cost-effective measures for minimising water use can be found in **Ref 6**.

3.138 The following general principles should be applied in sequence to reduce emissions to water:

- water-efficient techniques should be used where possible
- water should be recycled within the process from which it issues, treating it first if necessary. Where this is not practicable, it should be recycled to another part of the process which has a lower water quality requirement

3.139 Furnace cooling water (and wet abatement systems) can be maintained within a closed circuit recycling system. Operators should monitor the quality of the return water to ensure that levels of contamination are kept to a minimum. Treatment may be required. The quality specification may be constrained by the need to discharge a recycle purge. The need to purge may be removed by dilution from make-up water required to compensate for evaporative losses.

3.140 The volumes of water used by an installation should normally be metered so that water efficiency audits can be carried out and benchmarks can be set for optimal efficiency.

BAT

62 The operator should carry out a regular review of water use (water efficiency audit) at least as frequently as the permit review period. If an audit has not been carried out in the 2 years prior to submission of the application it should be completed within 18 months of the issue of the first PPC permit.

63 Using information from the water efficiency audit opportunities for reduction in water use should be assessed and, where appropriate, should be carried out in accordance with a timescale approved by the regulator.

64 Information from audits should be used to establish benchmarks. Operators should keep records of such benchmarks and make measurement against them to reveal whether the process is being maintained “in control” or to track improvements.

65 The volume of mains and abstracted water used in the activities should be directly measured, when the installation is first operating, once a day for at least a fortnight. There after the measurement should be weekly, but with an annual exercise of taking daily measurements for at least a fortnight. All measurements should be recorded and the records held on site.

Waste handling

3.141 Good segregation of materials is essential to facilitate opportunities for recovery, recycling and re-use and to maximise scope for good waste management.

3.142 The major wastes produced are:

- Off-specification cullet that cannot be recycled
- Dust collected in EP's/bag filters
- Waste resulting from furnace maintenance and rebuild, including refractory material
- Used filter bags
- packaging waste including wood and paper

Environmental impact - Raw materials, water and waste.

Water: *Not significant*

Land: *Fugitive releases, particularly leaks from liquid wastes or “empty” containers.*

Air: *Fugitive dust from handling and transfer.*

Waste: *Most wastes are disposed of to landfill.*

Energy: *Not significant*

***Accidents**:* *Not significant*

Noise: *Transport and handling of raw/recycled materials*

BAT	
66	The operator should produce an inventory of the quantity, nature, origin and where relevant, the destination, frequency of collection, mode of transport and treatment method of any waste which is disposed of or recovered.
67	Operators should segregate the main waste types described in paragraph 3.142.
68	Operators should ensure that waste is stored in containers that are durable for the substances stored and that incompatible waste types are kept separate.
69	Operators should ensure that waste storage areas are clearly marked and signed, and that containers are clearly labelled.

Waste re-use, recovery, recycling or disposal[5]

3.143 Waste should be re-used, recovered or recycled unless the regulator has accepted a satisfactory BAT justification.

3.144 **Table 7** summarises the routes currently taken by the various waste streams from a typical glass making site. Whether re-use, recovery or recycling is possible at a particular site will depend on the particular fuels and raw materials being used, the products being made and the methods of operation employed. The table reflects where recycling can be achieved when the appropriate combination of these factors is in place.

- the majority of cullet produced in the process as a result of breakage and wastage whose composition complies with the product specification is recycled to the furnace
- off specification waste cullet is recycled as far as practicable outside the process
- dust collected in electrostatic precipitators or bag filters is recycled to the furnace and used to substitute for raw materials as far as possible without breaching emission limits for SO_x
- hexafluorosilicic acid (H_2SiF_6) formed during acid polishing of domestic glass products is recovered and, where feasible, used as a feedstock in the chemical industry
- all avenues for the recycling of wastes from plant maintenance and furnace rebuild e.g. filter bags and redundant refractory, are explored

3.145 Operators should seek to establish markets for the recovery or recycling of wastes generated within the installation. Envirowise guides provide information on the recycling of glass industry wastes (**Ref. 4** and **Ref 8**). In addition, the Waste & Resources Action Programme (WRAP) researches and can provide guidance into recycling of other wastes such as wood, paper, cardboard and plastics (**Ref. 9**).

Table 7: Solid waste streams: routes currently taken

Process waste stream	Fate
Internal Cullet	Recycled
Lime used for SO_x removal	Reused or recycled to melting furnace
Refractory materials	Landfilled

[5] In the context of this note, recycling means the residue is returned to the process from where it has been produced, re-use means that the residue is used for another purpose

Waste packaging, containers	Recycled to appropriate recycler

BAT	
70	The operator should carry out an annual review to demonstrate that the best environmental options are being used for dealing with the waste streams listed on Table 7.
71	The operator should regularly investigate potential markets for the recovery/re-use of wastes that are currently disposed of to landfill. As the majority of waste produced by the glass process is recycled internally the potential for further recycling is limited and a time scale of three years is suggested for this work.

Energy

3.146 BAT for energy efficiency under the PPC Regulations will be satisfied provided the operator meets the following conditions:

either
• the operator meets the basic energy efficiency requirements below and is a participant to a Climate Change Agreement (CCA) or a Direct Participation Agreement (DPA) with the Government or EUETS commitments
or
• the operator meets the basic energy efficiency requirements below and the additional energy efficiency requirements

Basic energy efficiency requirements

3.147 The requirements of this section are basic, low cost, energy standards that apply whether or not a CCA or DPA is in force or the operator has EUETS commitments for the installation.

BAT	
72	The operator should produce a report annually on the energy consumption of the installation.
73	The operator should monitor energy flows and target areas for reduction that should be updated annually. ("Sankey" diagrams and energy balances would be useful as aids.)
74	In order to optimise combustion, the operator should, where practicable, monitor carbon monoxide and oxygen in waste gases.
75	The operator should ensure that all plant is operated and maintained to optimise the use and minimise the loss of energy.
76	The operator should ensure that all appropriate containment methods, (e.g. seals and self-closing doors) are employed and maintained to minimise energy loss.

Additional energy efficiency requirements

3.147 The energy efficiency of melting can be increased by a number of measures that may include:

- improving the level of furnace insulation to minimise heat loss
- fitting continuous carbon monoxide (CO) and oxygen (O_2) monitoring in order to optimise combustion
- increasing the amount of cullet used as this requires less energy to melt compared with virgin raw materials
- for a multi-port cross-flow regenerative furnace, separation of the regenerators in such a way that air flows and stoichiometries can be adjusted for each burner port
- using waste heat to preheat raw material or cullet, or to raise steam in a waste heat boiler
- use of oxy-fuel for firing

3.148 Within IPPC it is valid to consider both the emission of direct (heat and emissions from on-site generation) and indirect (emissions from a remote power station) pollution when considering options for energy efficiency. It should also be noted that energy efficiency may be affected by the choice of emissions reductions techniques

BAT

Energy efficiency techniques

77 The following techniques should be considered:
- heat recovery from different parts of the processes
- minimisation of water use and closed circulating water systems
- optimised insulation
- plant layout to reduce pumping distances
- phase optimisation of electronic control motors
- optimised efficiency measures for combustion plant.

Energy supply techniques

78 The following techniques should be considered:
- utilising waste heat from cooling operations to provide space heating
- generation of energy from waste
- use of less polluting fuels

Accidents

3.149 For accident management, there are three particular components:
- **identification of the hazards** to the environment posed by the installation/activity
- **assessment of the risks** (hazard x probability) of accidents and their possible consequences
- implementation of **measures to reduce the risks** of accidents, and contingency plans for any accidents that occur

3.150 Further guidance can be found in chapter 20 of the General Guidance Manual and provide guidance that may be relevant in the event of fire. See also **Ref 10** and **Ref 11**.

Identification of the hazards

3.151 In identifying the hazards particular areas to consider may include, but should not be limited to, the following:
- transfer of substances (e.g. loading or unloading from or to silos or storage tanks)
- overfilling of silos or tanks
- failure of plant and/or equipment (e.g. extraction fans or pumps, over-pressure of storage silos and pipework, blocked drains)
- failure of containment (e.g. bund and/or overfilling of drainage sumps)
- fires and problems arising from fighting fires such as failure to contain firewaters
- making the wrong connections in drains or other systems

- emission of an effluent before adequate checking of its composition has taken place
- steam main issues
- vandalism
- vehicle movements

Identification of the risks

3.152 The hazards having been identified, the process of assessing the risks should address the following:

- how likely is the particular event to occur (source frequency)?
- what substances are released and how much of each (risk evaluation of the event)?
- where do the released substances end up (emission prediction - what are the pathways and receptors)?
- what are the consequences (consequence assessment – what are the effects on the receptors)?
- what are the overall risks (determination of overall risk and its significance to the environment)?
- what can prevent or reduce the risk (risk management – measures to prevent accidents and/or reduce their environmental consequences)?

Measures to reduce the risks (identified by risk assessment)

3.153 Risk reduction can be achieved by process management controls and preventative measures. The following techniques will be relevant to most installations, although this is not an exhaustive list.

Process management controls

- process design, alarms, trips and other failsafe control techniques to ensure the safe operation of the plant
- security systems to prevent unauthorised access
- records of all incidents, near-misses, changes to procedures, abnormal events and findings of maintenance inspections and procedures to learn from such incidents
- personnel suitably trained in accident management
- guidance for specific accident scenarios
- procedures to ensure good communication among operations staff during shift changes and maintenance or other engineering work
- safe shutdown procedures
- established communication routes with relevant authorities and emergency services

Preventative measures

- procedures to ensure that the composition of the contents of a bund /sump is checked before treatment or disposal
- drainage sumps equipped with a high-level alarm with automatic pump to storage (not to discharge)
- high-level alarms etc. (which should not be routinely used as the primary method of level control)
- adequate standby plant or equipment maintained and tested to operational standards
- sufficient storage to contain process waters, site drainage waters, emergency firewater, chemically contaminated waters and spillages of chemicals, which should be routed where necessary, having regard to a site-specific assessment of risks, to the effluent system
- provision to contain surges and storm-water flows, which should be treated where necessary, having regard to a site-specific assessment of risks, before emission to controlled waters or sewer
- spill contingency procedures to minimise the risk of accidental emission of raw materials, products and waste materials and to prevent their entry into water
- procedures should be in place for checking and handling raw materials and wastes to ensure compatibility with other substances with which they may accidentally come into contact.
- suitable barriers to prevent damage to equipment from the movement of vehicles, as appropriate, having regard to a site-specific assessment of risks
- there should be procedures for responding to and learning from incidents, near-misses, etc.
- the roles and responsibilities of personnel involved in incident management should be formally specified.
- where indicated by the site-specific assessment of risks, containment or abatement for accidental emissions from vents and safety relief valves/bursting discs should be provided.
- where this may be inadvisable on safety grounds, attention should be focused on reducing the probability of the emission

BAT

Accidents/incidents/non conformance

79 There should be written procedures for investigating incidents and near misses, including identifying and following up suitable corrective action.

80 The operator should maintain an accident management plan covering the matters listed in paragraphs 3.147 to 3.149 above and to the satisfaction of the regulator. The plan should be available for inspection by the regulator.

81 In the case of abnormal emissions arising from an accident, such as a spillage for example, the operator should:

- Investigate undertake remedial action immediately
- promptly record the events and actions taken
- ensure the regulator is made aware without delay

Specific conditions

82 Specific conditions may need to be included within permits to prevent accidents. Examples of these are given below.

Operators should provide for safe storage and conveying systems for both raw materials and wastes in order to minimise the potential for vandalism or accidental damage. Regular inspection should be carried out on pipelines, valves and pumps to inspect for damage and wear.

The operator should maintain procedures for the control of spills to ensure containment, collection and disposal in order to prevent or minimise pollution.

Systems should be used to avoid excessive transfer rates of solids by pneumatic conveyors that might lead to over pressurisation and filter failure or tank / silo overfilling leading to spillage of liquids or powders.

Operators should ensure that materials are charged into the correct silo or tank to minimise the potential for causing waste or spillage.

Noise and Vibration

3.154 Within this section, “noise” should be taken to refer to noise and/or vibration as appropriate, detectable beyond the site boundary.

3.155 The most significant source of noise arises as a result of the following activities:

- cullet handling (deliveries and handling)
- other raw material handling
- fans and motors
- vehicle movements
- production of compressed air

3.156 Noise surveys, measurement, investigation (which can involve detailed assessment of sound power levels for individual items of plant) or modelling may be necessary for either new or existing installations depending upon the potential for generating significant noise. Operators may have a noise management plan as part of their management system. Where an installation poses no risk of noise related environmental impact because the activities undertaken are inherently quiet or remote from receptors; these measures would not normally be required.

3.157 Following investigation of the impact of the installation, systems to minimise the environmental impact of the noisiest operations should be employed. The level of noise control required depends on the scale of operations and the proximity of operations to the public. Table 10 identifies the noisiest operations and the control measures the have been employed to mitigate problems.

3.158 Further guidance can be found in chapter 16 of the General Guidance Manual.

Table 8: Noise Mitigation Measures

Operation	Control Measure
Cullet handling	▪ Minimise handling, where conveyed minimise drop heights
Air compression	▪ Use a number of small compressors rather than one large one, install in appropriate soundproofing enclosure.
Site Vehicle Movements	▪ Using vehicles with "directional and localised sound" for reverse alarms to concentrate noise at the area of immediate danger ▪ Replacing diesel powered forklift trucks with electric or LPG powered ▪ Minimising vehicle movements at night and other sensitive times. ▪ Using even roadways for vehicle movements ▪ Ensure vehicles are well maintained
Fans, pumps and motors	▪ Acoustic screens, enclosures and baffles ▪ Fitting silencers to avoid noise travelling along ducting ▪ Selection of less noisy engineering equipment ▪ Fitting resilient hangers for wall-mounted equipment
General	▪ Fitting noise reducing flaps to outside doors ▪ Maintaining a closed doors policy ▪ Improving sound insulation of buildings ▪ Holes and openings closed off (use mechanical where necessary) ▪ Enclose operations within buildings ▪ Fitting anti-vibration mounts on plant ▪ Using flexible connections between vibrating and fixed plant ▪ Preventative maintenance programme e.g. equipment wear, bearings

BAT

83 The operator should identify key plant and equipment with the potential to give rise to significant noise and take such measures as are necessary by way of mitigation and maintenance of existing plant and equipment in order to minimise noise having regard to paragraph 3.157 and Table 10 above.

84 Cullet handling systems should be so designed, where practicable (having regard to legitimate space constraints) to minimise both handling and the drop height for deliveries and charging operations.

Monitoring

3.159 This section describes general monitoring and reporting requirements for emissions to all environmental media. Guidance is provided for the selection of the appropriate monitoring methodologies, frequency of monitoring, compliance assessment criteria and environmental monitoring. The specific monitoring requirements with respect to emissions to air are described in **Table 3**.

Standards for monitoring equipment and procedures

3.160 The Environment Agency has introduced its Monitoring Certification Scheme (MCERTS) to improve the quality of monitoring data and to ensure that the instrumentation and methodologies employed for monitoring are fit for purpose.

- operators should ensure their monitoring arrangements comply with the requirements of MCERTS where available, e.g. using certified instruments and equipment, and using a registered stack testing organisation etc.

See **http://www.environment-agency.gov.uk** for listing of MCERTS equipment.

Sampling and analysis standards

3.161 The sampling analytical methods selected for compliance monitoring given in Table 3 should normally be used in the following order of priority:

- Comité Européen de Normalisation (CEN)
- International Standardisation Organisation (ISO)
- British Standards Institution (BSI)
- United States Environmental Protection Agency (US EPA)
- American Society for Testing and Materials (ASTM)
- Deutsches Institut für Normung (DIN)
- Verein Deutcher Ingenieure (VDI)
- Association Française de Normalisation (AFNOR)

3.162 Guidance on standards for monitoring releases (to air, water and land) relevant to IPPC can be found in **Ref 8.**

3.163 When selecting monitoring test methods, it is important to note that test methods are normally applicable to specific matrices (in relation to water) and concentrations of various pollutants (in relation to air). It is necessary to identify the most appropriate method in consideration of the hierarchy of methods. For example, if two methods are appropriate, the hierarchy is used to determine priority.

3.164 If in doubt the operator should consult the regulator.

Monitoring and sampling protocols

3.165 Where monitoring is needed the operator should devise and agree with the regulator a monitoring strategy to address the following:

- determinands to be monitored
- selection of monitoring points
- monitoring methods and procedures (selection of appropriate Standard Reference Methods)
- reference conditions and averaging periods
- measurement uncertainty of the proposed methods and the resultant overall uncertainty
- drift correction for continuous analysers
- quality assurance (QA) and quality control (QC) protocols, including accreditation and certification
- equipment calibration and maintenance, sample storage and chain of custody/audit trail
- reporting procedures, data storage, interpretation and review of results, reporting format for the provision of information to the regulator

Monitoring frequency

3.166 The frequency of testing should be increased, for example, as part of the commissioning of new or substantially changed activities, or where the emission levels are near to or approach the emission limit.

3.167 Where non-continuous quantitative monitoring is required, the frequency may be varied. Where there is consistent compliance with emission limits, regulators may consider reducing the frequency. When determining 'consistent compliance' factors to consider include:

- the variability of monitoring results, for example, results which range from 15 - 45 mg/m^3, against an emission limit of 50 mg/m^3 might not qualify for a reduction in monitoring
- the margin between the results and the emission limit, for example, results which range from 45 - 50 mg/m^3 when the limit is 50 mg/m^3 might not qualify for a reduction in monitoring

3.168 Consistent compliance should be demonstrated using sequential results from, for example, at least three or more monitoring exercises within two years, or two or more monitoring exercises in one year supported by continuous monitoring. Any significant process changes which might have affected the results should be taken into account.

3.169 Where effective surrogates are available they may be used to minimise monitoring costs.

3.170 Where monitoring shows that substances are not emitted in significant quantities, consideration can be given to a reduced monitoring frequency.

Monitoring emissions to air

3.171 The reference conditions of substances in releases to air from point sources are: dry, temperature 273.15 K (0°C), pressure 101.3 kPa (1 atmosphere). The concentration of pollutants in furnace emissions should be normalised to 8% oxygen content measured dry. For oxy-fuel fired systems the expression of the emissions should be discussed in terms of specific mass emissions (kg per tonne of glass melted) as correction to 8% oxygen is of little value. To convert measured values to reference conditions, see Technical Guidance Note M2 (**Ref. 8**) for more information.

3.172 The measurement of emissions can be affected by several factors, some of which are particularly important in glass melting processes. These include:

- waste gas temperature
- size distribution of dust
- waste gas velocity
- waste gas moisture
- gaseous and particulate form of pollutants
- sampling time

3.173 Waste gas temperature: the flue gas temperature from the furnace can vary substantially (generally from 100 to 850^{o}C at the stack), depending on the heat recovery systems and the abatement technique applied. Measurement errors due to the waste gas temperature should be minimised by:
– use of appropriate filters and probes for dust measurements
– appropriate conditioning of the filters before use at high temperatures
– use of heated probes and filters at low waste gas temperatures

3.174 Size distribution of dust: the particle diameter of dust generated by the melting process is normally very small (less than 1mm, and generally 0.02 – 0.5mm). During sampling the particles easily agglomerate and, when alkaline filtering materials are used, tend to react with the acid gaseous substances present in the flue gas. In order to avoid this, chemically inert filters should be selected for sampling. When particulate matter is measured continuously, the fine particles can be difficult to remove from the optical parts of the measuring equipment, leading to erroneous data. A suitable cleaning system should be applied.

3.175 Waste gas velocity: particulate measurements should be carried out isokinetically. The geometry of the duct and the position of the sampling point should be selected in order to allow a correct measurement of the flue gas velocity.

3.176 Waste gas moisture: the presence of high percentages of water in the waste gases is very common in the case of oxy-fuel melting and air/gas furnaces when water is used as coolant prior to abatement equipment. The determination of the gas dew point should be carried out in order to avoid condensation during sampling. Gaseous pollutants should be measured using heated probes any time there is risk of condensation during sampling, especially in SO_x rich flue gases. This is also the case for some downstream processes employing wet scrubbers. Where water condensation does occur, the resulting liquid should be checked to determine the possible absorption of gaseous pollutants, e.g. oxides of sulphur.

3.177 Gaseous and particulate form of pollutants: some pollutants can be released into the atmosphere in both gaseous and particulate form, for example, some substances from the melting process such as certain boron compounds, selenium and arsenic. In these cases the sampling train should be equipped with a combined system for the simultaneous collection of both particulate and gaseous compounds.

3.178 Sampling time: in the case of regenerative furnaces, in addition to the standard procedures which require an adequate sampling time for collecting a representative sample, a good practice should take into consideration the reversal cycle of the regenerators. Emissions from the melting process can vary substantially with the temperature cycle of the chambers. In order to carry out measurements with comparable results the sampling time should cover an even number of firing cycles. This can also be an issue with cleaning cycles on abatement equipment.

Monitoring emissions to water

3.179 The appropriateness of the monitoring requirements in Section 2 will vary depending upon the sensitivity of the receiving water and should be proportionate to the scale of the operations, nature of the discharge and receiving water. For each release point the following information is required:

- the specific volume flow from the process to controlled water
- the quality of the receiving water
- the volume of discharge compared to the percentage dry river flow of the receiving water

Environmental monitoring (beyond installation)

3.180 Environmental monitoring may be required, for example, when:

- there are vulnerable receptors
- the emissions are a significant contributor to an Environmental Quality Standard (EQS) which may be at risk
- the operator is looking for departures from standards based on lack of effect on the environment
- the operator is required to validate modelling work

3.181 Further guidance is given in chapter 15 of the General Guidance Manual.

Monitoring of process variables

3.182 Some process variables will have potential environmental impact and these should be identified and monitored where they have an environmental relevance. For glass making activities, examples of monitoring these variables include:

- keeping inventories of materials used and disposed of
- monitoring for contaminants in raw materials where cullet is used or where there is inadequate supplier information
- monitoring temperature or pressure where relevant, for example melt temperature, pressure drop across bag filters
- plant production efficiency and product mix.

BAT

Monitoring and reporting

85 The operator should monitor emissions, make tests and inspections of the process and keep records; in particular the operator should keep records of audits, inspections, tests and monitoring, including all non-continuous monitoring, inspections and visual assessments. Monitoring may include process variables and operating conditions where relevant to emissions. In such cases:

- current records should be kept on site and be made available for the regulator to examine
- records should be kept by the operator for at least two years

86 The operator should notify the regulator at least 7 days before any periodic monitoring exercise is carried out to determine compliance with emission limit values. The operator should state the provisional time and date of monitoring, pollutants to be tested and the methods to be used

87 The results of non-continuous emission testing should be forwarded to the regulator within 8 weeks of the completion of the sampling. Results from continuous monitoring systems should be recorded and be made available for inspection by the regulator.

88 All results submitted to the regulator should include details of process conditions at the time of

monitoring, monitoring uncertainty as well as any deviations from the procedural requirements of standard reference methods and the error invoked from such deviations.

89 Results exceeding the emission limit value from **any** monitoring activity (both continuous and non-continuous) and malfunction or breakdown leading to abnormal emissions should be investigated and corrective action taken immediately. The operator should ensure that the regulator is notified without delay identifying the cause and corrective action taken. Where there is immediate danger to human health, operation of the activity should be suspended.

90 Sampling points on new plant should be designed to comply with CEN or other standards. e.g. BS EN 13284-1 or BS ISO 9096: 2003 for sampling particulate matter in stacks

91 Continuous monitoring is normally expected for the main abated releases in Table 3. Where continuous monitoring is required by the permit, instruments should be fitted with audible and visual alarms, situated appropriately to warn the operator of arrestment plant failure or malfunction, the activation of alarms should be automatically recorded and readings should be on display to appropriately trained operating staff

92 All continuous monitors should be operated, maintained and calibrated (or referenced) in accordance with the appropriate standards and manufacturers' instructions, which should be made available for inspection by the regulator. Instruments should be designed for less than 5% downtime over any 3-month period and all relevant maintenance and calibration (or referencing) should be recorded

93 Where available, operators should use monitoring equipment and instruments certified to MCERTS and use a stack-testing organisation accredited to MCERTS standards or such alternative requirements as approved by the regulator..

Monitoring and reporting of emissions to air

94 Exhaust flow rates of waste gases should be consistent with the efficient capture of emissions, good operating practice and meeting the requirements of the legislation relating to the workplace environment.

95 The introduction of dilution air to achieve emission concentration limits should not be permitted.

96 Dilution air may be added where justified for waste gas cooling or improved dispersion. In such cases, monitoring should be carried out upstream of the dilution air input or procedures designed to correct for the ratio of input air to the satisfaction of the regulator.

97 Monitoring to determine compliance with emission limit values should be corrected to the following standard reference conditions: - dry, temperature 273.15 K (0°C), pressure 101.3 kPa (1 atmosphere).

98 Periodic visual assessment of releases should be undertaken as required by the regulator to ensure that all final releases are colourless, free from persistent visible emissions and free from droplets.

99 Where abatement equipment is required to comply with the stack particulate matter provisions of this note then the particulate matter emissions should be continuously monitored to indicate the performance of the abatement plant.

Monitoring and reporting emissions to water and sewer

100 The appropriateness of the monitoring requirements will vary depending upon the sensitivity of the receiving water and should be proportionate to the scale of the operations, nature of the discharge and receiving water. For each release point the following information is required:

- the specific volume flow from the process to controlled water
- the sensitivity of the receiving water
- the volume of discharge compared to the percentage dry river flow of the receiving water

101 Increased monitoring should be carried out where substances to which the local environment may be susceptible could be released from the installation, e.g. where releases of heavy metals may occur.

102 A full analysis, to include the substances listed in Schedule 5 of the Regulations, should be carried out

annually on a representative sample from each release point, unless it is agreed with the regulator that this is inappropriate.

Monitoring and reporting of waste

103 The following should be monitored and recorded:

- quantity nature and origin of the waste
- the physical description of the waste
- a description of the composition of the waste
- any relevant hazardous properties (hazard and risk phrases)
- European Waste Catalogue code
- handling precautions and substances with which it cannot be mixed

Information Provisions

3.183 This guidance note contains many provisions relating to information. There are two general categories of information identified in this note:

- Reports or notifications
- Additional information

3.184 Reports are required and notifications are information that should be sent to the regulator at a frequency that is specified in this guidance. Such information provisions are summarised in Table 11a below.

Table 9a: Summary of Provisions for Reporting and Notification

BAT Clause	Provision	Information Category	Frequency
24	Following investigation of the cause, notify regulator of any persistent visible emissions	Notification	Reactive
50	Provide regulator with a list of environmentally critical equipment	Report	Within 12 months of publication of this note
53	Provide regulator with the name of the competent person who will liase with the public regarding complaints	Report	Within 6 months of issue of the permit
81	Notify regulator of the results of investigations into any abnormal emissions arising from an accident without delay*	Notification	Reactive
86	Notification at least 7 days before any proposed monitoring exercise to determine compliance with ELV's	Notification	Reactive
87	Report of results from non-continuous monitoring to be forwarded to the regulator	Report	Within 8 weeks of monitoring
89	Notification without delay* of regulator of results of investigations either where during periodic monitoring an emission limit value is exceeded or any malfunction or breakdown has occurred that led to an abnormal emission	Notify	Reactive

***Without delay** In most cases it should be enough to notify the local authority (by telephone or facsimile) within an hour of the start or detection of the emission. Local authorities will wish to consider what notification arrangements to require outside working hours.

3.185 Additional information relates to procedures or records (including details of assessments, investigations and audits). Such information should be held by the operator and be accessible so that the regulator may view the information. For much of the information, on-site inspection may be sufficient for the regulator, subject to the particular circumstances. Regulators may be more likely to ask operators to send them copies of those items marked with an asterisk. The majority of this information is likely to be the same as would be required in any event when using an effective EMS, so documents can be produced which serve both purposes.

3.186 Annex 4 of ISO 14001 gives some detailed examples of information and document control but by way of generality A.4.4 states that "The extent of the environmental management system documentation may differ from one organization to another depending on

(a) the size and type of organization and its activities, products of services,
(b) the complexity of processes and their interactions, and
(c) the competence of personnel

Examples of documents include

- statements of policy, objectives and targets,
- information on significant environmental impacts,
- procedures,
- process information,
- organisational charts,
- internal and external standards,
- site emergency plans, and
- records"

3.187 Relating to documentation, Annex I of the EC Regulation No 761/2001 on the eco-management and audit scheme (EMAS) states that "the organisation shall establish and maintain procedures for controlling all documents required by this International Standard…". The Annex goes on to provide details on what is required and includes the following headings:

- Structure and responsibility
- Training, awareness and competence
- Management review
- Communication
- Environmental management system documentation
- Document control
- Operational control
- Emergency preparedness and response
- Monitoring and measurement
- Non-conformance and corrective and preventive action
- Records
- Environmental management system audit

3.188 Additional information provisions are summarised in Table 11b below.

Table 9b: Summary of Provisions for Additional Information

BAT Clause	Category	Subject
42	Procedures	Leak prevention from subsurface structures (control, maintenance and inspection).
46	Procedures	Preventative maintenance programme for tanks bunds and sumps
48	Procedures	Environmental Management System. Records of EMS audits
49	Procedures	Operational and maintenance systems for all aspects of the installation whose failure could impact on the environment – annual review
54	Procedures	Formal structure of employee's responsibility for process control and environmental impacts and training provisions
56	Procedures	Provision of instructions to contractors while working on site
57	Procedures	Provision of procedures regarding accidents
58	Procedures	Procedures relating to specification of raw materials
79	Procedures	Incidents and near misses investigation. Corrective action and following up
35	Records	Inspections and maintenance of interceptors
41	Records	Subsurface structure mapping
46	Records	Visual inspection of tanks, bunds and sumps
47	Records	Odour assessments
52	Records	Analysis of breakdowns in order to eliminate common failure modes.

55	Records	Production and maintenance of training records
59 & 64	Records	Raw material and water usage benchmarks
60*	Records	Waste minimisation audits and improvement programme
62 & 63*	Records	Water efficiency audit and water efficiency improvement programme
65	Records	Water usage measurements
66*	Records	Waste inventory and treatment method
70*	Records	Annual review of waste disposal and recovery options
72	Records	Annual energy audit
80*	Records	Accident management plan
83	Records	Identification of key plant and equipment with the potential to give rise to significant noise. Mitigation measures
85	Records	Results from continuous monitoring systems
92	Records	Maintenance and calibration of continuous monitoring systems
102	Records	Analysis for Schedule 5 substances (where needed)
103	Records	Records of waste monitoring and recording
** Information that Regulators may be more likely to ask operators to send them copies of rather than relying only on inspection*		

3.187 The amount of information and size of reports or documents required under the information provisions should be decided on a 'fit for purpose' basis. The label 'report' or 'record' should not be taken to imply that a sizeable document must be submitted if the required information can be provided in much shorter form. A report could comprise a paragraph or two if that was agreed to be sufficient for the purpose. Alternatively, lengthy documents may be necessary in particular circumstances.

All the information listed in tables 11a and b is considered necessary either

a) for regulators to keep a watch on the performance of an installation (e.g. monitoring data and who is the competent person to liaise with over complaints) or on the operator's efforts to improve performance (e.g. waste minimisation and energy audits), and/or

b) for operators to maintain an appropriate level of control over the installation, and to which regulators should have access should they wish to check that the information is being properly kept or to examine the information for regulatory purposes.

References

Environment Agency documents referred to below are available from the Environment Agency website **http://www.environment-agency.gov.uk**. Many of the references below are being made available free of charge for viewing or download on the website. The same information can also be accessed via the SEPA website **http://www.sepa.org.uk**, or the NIEHS website **www.ehsni.gov.uk**

Ref. 1 *The Pollution Prevention and Control (England and Wales) Regulations (SI 1973 2000) as amended (***www.legislation.hmso.gov.uk)** or the Scottish equivalent SSI 323 2000

Ref. 2 *Secretary of State's Guidance (England and Wales): General Guidance Manual on Policy and Procedures for A2 and B Installations, March 2003* - available from the Defra website and, in hard copy, from the Defra
Publications line 08459 556000 **www.defra.gov.uk/environment/ppc/index.htm**

Ref. 3 *IPPC Reference Document on Best Available Techniques in the Glass Making Industry, European Commission* http://eippcb.jrc.es

Ref. 4 'Envirowise (formerly the Environmental Technology Best Practice Programme, ETBPP), Harwell International Business Centre, Didcot, Oxfordshire OX11 0QJ. Helpline 0800 585794. Good Practice Guides:
Good Practice Guide (GG83) Improving Cullet Quality
Good Practice Guide (GG263) Cost Savings from Reducing Waste in the Glass and Glazing Industry.

Ref. 5 *HMIP Technical Guidance Note (Dispersion) D1,* 1993 The Stationery Office ISBN 0 11 752794 7

Ref. 6 Water efficiency references available from Envirowise:
- GC22, Simple measures restrict water costs
- GG26, Saving money through waste minimisation: Reducing water use, GG26

Ref. 7 Management, Resource Efficiency and Waste Minimisation References
- Defra/DTI - Changing Patterns - UK Government Framework for Sustainable Consumption and Production Sept 2003
- National Industrial Symbiosis Programme **www.nisp.org.uk/**
- Envirowise, GG025, Saving money through waste minimisation: Raw Material Use

Ref. 8 Process Optimisation References
EG078 Environmental Performance in the Glass Industry

Ref. 9 Waste & Resources Action Programme (WRAP), The Old Academy, 21 Horse Fair, Banbury, Oxon. OX16 0AH. **helpline@wrap.org.uk**

Ref. 10 *BS 5908: Code of Practice for Fire Precautions in the Chemical and Allied Industries*

Ref. 11 *Environment Agency, Pollution Prevention Guidance Note* - Pollution prevention measures for the control of spillages and fire-fighting run-off, PPG 18, gives information on sizing firewater containment systems
(Environment Agency website)

Ref. 12 Monitoring Guidance **(Environment Agency website)**
- *M1 Sampling requirements for monitoring stack emissions to air from industrial installations,* Environment Agency July 2002
- *M2 Monitoring of stack emissions to air.* Environment Agency October 2004
- *Guidance on sampling and testing of wastes to meet landfill waste acceptance procedures*. Environment Agency Version 4.3a December 2003
- *MCERTS approved equipment link via* **http://www.environment-agency.gov.uk/business***" How and why we regulate your business/Principles and approaches"*
- *Direct Toxicity Assessment for Effluent Control: Technical Guidance (2000), UKWIR 00/TX/02/07*

Ref 13 The Groundwater Regulations 1998 require that List I substances are prevented from entering groundwater, and that List II substances are controlled so that pollution of groundwater does not occur. Any discharge of listed substances onto or into land must be subject to a prior investigation under the terms of the Groundwater Regulations, and this investigation should be carried out by the applicant and submitted in support of the permit application.

Ref 14 Groundwater Protection Code – Solvent Use and Storage, Defra 2004

Ref. 15 Surface water & Groundwater Protection Guidance

- AQ11 (05) - Regulating water discharges from A2 Installations. Available via the Defra website **www.defra.gov.uk**
- Groundwater Protection Code – Solvent Use and Storage, Defra 2004

Abbreviations

AQS	Air Quality Standard
BAT	Best Available Techniques
BOD	Biochemical Oxygen Demand
BREF	BAT Reference Document
CCA	Climate Change Agreement
CEM	Continuous Emissions Monitoring
CHP	Combined Heat and Power plant
COD	Chemical Oxygen Demand
COMAH	Control of Major Accident Hazards
COSHH	Control of Substances Hazardous to Health
DPA	Direct Participation Agreement
EA	Environment Agency
EAL	Environment Assessment Level
ELV	Emission Limit Value
EMS	Environmental Management System
EP	Electrostatic Precipitator
ETP	Effluent Treatment Plant
EUETS	European Union Emissions Trading Scheme
EQS	Environmental Quality Standard
GPZ	Groundwater Protection Zone
IPPC	Integrated Pollution Prevention and Control
ITEQ	International Toxicity Equivalents
LA	Local Authority
LoNOx	Low NOx emissions burner
MCERTS	Monitoring Certification Scheme
NIEHS	Northern Ireland Environment and Heritage Service
SAC	Special Areas of Conservation
SECp	Specific Energy Consumption
SEPA	Scottish Environment Protection Agency
SPA	Special Protection Area
TSS	Total Suspended Solids
TOC	Total Organic Carbon
VOC	Volatile Organic Compound
WAG	Welsh Assembly Government

Appendix 1: Summary of Changes

Reasons for the main changes are summarised below.

Table 10: Summary of changes

Section/ Paragraph/ Heading	Change	Reason	Comment
1. Introduction			
Table 1	Compliance timetable updated	New provisions of note	
2. Emission limits and other provisions			
Emissions to controlled waters	Clarification that benchmarks apply primarily to on-site treatment facilities	TWG request	
3. Techniques for pollution control			
Installation description and in-process controls			
Delivery and storage of raw materials	Process description and BAT requirements amalgamated		Minor changes to text
Furnace operations and downstream processes	Process description for melting activities and downstream processes amalgamated	Aids understanding of overall process. Follows review template	Minor changes to text
Emissions Control			
Dispersion and dilution of stack emissions	BAT for dispersion modelling added	Modelling widely used in sector	
Point source emissions to surface water and sewer	Additional BAT points included relating to run-off, interceptors and recycling of process water.	BAT/industry good practice	
Point source emissions to groundwater	Amended text	Issue of Groundwater Regulations - extra guidance to regulators and operators	
Fugitive emissions to surface water, sewer and groundwater	Description expanded. BAT provisions consolidated	BAT/industry good practice	
Odour	Inclusion of paragraphs on assessment, prevention and minimisation	Additional guidance for operators and regulators	
Management			
3.112 to 3.114	Additional BAT provisions for using an effective EMS	BAT/industry good practice	
3.116 and BAT 55	Addition of extra paragraph relating to training	BAT/industry good practice	
BAT 54	Requirement for formal structure for environmental control	BAT/industry good practice	
Raw Materials			
Addition of Table 6	Relates to selection procedure for choice of raw materials.	Extra guidance to regulators and operators	
3.134	Guidance on sustainable consumption and production	Extra guidance to regulators and operators	Government Policy
BAT 59	BAT provision - establishing benchmarks for efficiency in raw	BAT/industry good practice	

	materials useage		
BAT 82	BAT provision - establishing benchmarks for water use	BAT/industry good practice	
Waste Handling			
BAT box	Provisions consolidated	BAT/industry good practice	Number of BAT clauses reduced
Waste re-use, recovery, recycling or disposal			
Table 7	Added	Highlight waste streams	
BAT 70	Added requirement for a regular review of disposal options for waste streams		
Energy			
3.148 and BAT 77/78	Additional provisions for additional energy efficiency and supply techniques	BAT	Sector has Climate Change Agreement
Accidents			
3.152	Inclusion of text for identification of the risks	Extra guidance to regulators and operators	
BAT 82	Inclusion of examples of conditions relating to accident prevention	industry good practice	
Noise and Vibration			
3.157 and Table 10	Additional text and new Table identifying specific noise mitigation measures	BAT/industry good practice	
BAT 83 and 84	Additional provisions - identification of potential noise sources and implementation of mitigation measures	BAT/industry good practice	
Monitoring			
3.163 and 3.179	Considering appropriateness when selecting test methods	Extra guidance to regulators and operators	
BAT 88	Reporting of monitoring uncertainty	BAT	
BAT 89	Provision to clarify the reporting of abnormal emissions	BAT	
Information Provisions			
3.183 to 3.187 plus Tables 11a/b	Additional text and new Tables identifying notification and reporting provisions	Extra guidance to regulators and operators	
References and Appendices			
References	Amended list	New guidance and information available	
New Appendix 1	List of significant changes added		

Appendix 2: Some common monitoring and sampling methods

The Tables indicate preferred methods for measurement of common substances to water and air. As these methods change with time, information on the most appropriate method should be made by reference to the Environment Agency web site using the link below. This web page is regularly updated.

http://www.environment-agency.gov.uk/commercial/1075004/399393/401849/?lang=_e

Table 6: Measurement methods for common substances to water

Determinand	Method	Detection Limit uncertainty	Valid for range mg/l	Standard
Suspended solids	Filtration through glass fibre filters	1 mg/l 20%	10 - 40	ISO 11929:1997 EN872 - Determination of suspended Solids
COD	Oxidation with di-chromate	8 mg/l	Up to 400	SCA Chemical Oxygen Demand, (Dichromate Value), of Polluted and Waste waters, 1986
BOD5	Seeding with micro organisms and measurement of oxygen content	2 mg/l 20%	5 - 30	ISO 5815: 1989, Water Quality Determination of BOD after 5 days, dilution and seeding method EN 1899 (BOD 2 Parts)
AOX	Adsorption on activated carbon & combustion	- 20%	0.4 - 1.0	ISO 9562: 1998 EN1485 - Determination of adsorbable organically bound halogens.
Total P				BS 6068: Section 2.28 1997, Determination of phosphorus – ammonium molybdate spectrometric method
Total N				BS 6068: Section 2.62 1998, Determination of nitrogen Part 1 Method using oxidative digestion with peroxydisulphate, BS EN ISO 11905
pH				SCA The measurement of electric conductivity and the determination of pH, ISBN 0117514284
Turbidity				SCA Colour and turbidity of waters 1981, ISBN 0117519553 EN 27027:1999
Flow rate	Mechanical ultrasonic or Electro-magnetic gauges			SCA Estimation of Flow and Load ISBN 011752364X
Temperature				SCA temperature measurement for Natural, Waste and Potable Waters and other items of interest in the Water and Sewage Disposal Industry ISBN 0117520179
TOC				SCA The Instrumental Determination of Total Organic Carbon and Related Determinands 1995 ISNB 0117529796 EN 1484:1997
Fatty Acids				Determination of Volatile Fatty Acids in Sewage Sludge 1979 ISBN 0117514624
Metals				BS 6068: Section 2.60 1998 Determination of 33 elements by inductively coupled plasma atomic emission spectroscopy

Chlorine				BS6068: Section 2.27 1990 Method for the determination of total chlorine: iodometric titration method
Trichloro-methane (Chloroform) Bromoform				BS6068: Section 2.58, Determination of highly volatile halogenated hydrocarbons – Gas chromatographic methods
Determinand	Method	Detection Limit uncertainty	Valid for range mg/l	Standard
Dispersants Surfactants: Anionic Cationic Non-Ionic				SCA Analysis of Surfactants in Waters, Wastewaters and Sludges ISBN 01176058 EN 903:1993 (Used for anionic surfactants)
Formaldehyde				SCA The determination of formaldehyde, other volatile aldehydes, ketones and alcohols in water
Phospates & nitrates				BS 6068: Section 2.53 1997, Determination of dissolved ions by liquid chromatography
Sulphites & sulphates				BS 6068: Section 2.53 1997, Determination of dissolved ions by liquid chromatography
Grease and oils	IR adsorption	0.06 mg/kg		SCA The determination of hydrocarbon oils in waters by solvent extraction, IR absorption and gravimetry ISBN 011751 7283

Table 7: Measurement methods for common substances to air

Determinand	Method	Standard
Particulate matter	Weighed filter	BS EN 13284-1: 2002 BS ISO 12141: 2002 BS ISO 9096: 2003
NO_x	Continuous emission monitor	ISO 10849
SO_2	Impingement into hydrogen peroxide. Analysis by barium perchlorate titration	BS 6069:4.1:1990 (which is identical to ISO 7934:1989)
	Extractive sampling and analysis by UV fluorescence	BS 6069:4.4:1993 (which is identical to ISO 7935:1992)
Total Chloride	Impingement. Analysis by titration, spectroscopy or ion chromatography	BS EN 1911:1998 Parts 1 - 3
Fluorides	Isokinetic sample, impingement analysis by ion chromatography	US EPA Method 26A for aerosol and gas phase halides
		US EPA Method 26 for gas phase halides only
Fluorides Continuous emission monitors measure gas phase fluoride but not aerosol fluoride	DOAS	
	NDIR	
	FTIR	US EPA Method 320
	IMS	
	TDL	
VOC	Extract FID	BS EN 13526