Integrated Pollution Prevention and Control (IPPC)

Secretary of State's Guidance for Glass Manufacturing Activities with Melting Capacity More than 20 Tonnes per Day
Defra would like to acknowledge the work of the Environment Agency’s Local Authority Unit in the drafting of this guidance note.
## Contents

**Introduction** .......................................................................................................................... 1
- Background ............................................................................................................................ 1
- Best Available Techniques (BAT) ....................................................................................... 1
- Installations covered ............................................................................................................. 2
- Review and Upgrading Periods ............................................................................................ 3
  - Existing installations or activities ...................................................................................... 3
  - New installations or activities ............................................................................................ 5
  - Substantially changed installations or activities ........................................................... 5
- Permit reviews ...................................................................................................................... 5
- Summary of Releases .......................................................................................................... 6

**Emission limits and other provisions** .................................................................................... 7
- Contained emissions to air associated with the use of BAT ........................................... 7
- Benchmark emissions to water associated with the use of BAT ................................... 9

**Techniques for pollution control** .......................................................................................... 10
- Installation description and in-process controls .............................................................. 10
  - Main activities ................................................................................................................. 10
  - Overview of the activities in this sector ......................................................................... 10
  - Furnace operations .......................................................................................................... 12
  - Furnace types .................................................................................................................. 13
- Emissions control ................................................................................................................ 14
  - Point source emissions to air ......................................................................................... 14
  - Controlling emissions of oxides of nitrogen (NO\textsubscript{x}) ...................................... 15
  - Controlling emissions of particulates ............................................................................. 16
  - Controlling emissions of oxides of sulphur (SO\textsubscript{x}) ........................................... 17
  - Controlling emissions of chloride and fluorides ........................................................... 18
  - Downstream processes .................................................................................................... 19
  - Point source emissions to surface water and sewer .................................................... 25
  - Point source emissions to groundwater ....................................................................... 26
  - Fugitive emissions to air ................................................................................................. 26
  - Fugitive emissions to surface water, sewer and groundwater ...................................... 27
  - Odour ............................................................................................................................... 29
- Management .......................................................................................................................... 29
- Raw Materials ....................................................................................................................... 31
  - Raw materials selection ................................................................................................. 31
  - Raw materials handling, storage, mixing and transfer .................................................. 32
  - Waste minimisation (optimising the use of raw materials) ......................................... 32
  - Water use ........................................................................................................................ 33
- Waste handling .................................................................................................................... 34
- Waste re-use, recovery, recycling or disposal ................................................................. 34
- Energy .................................................................................................................................. 35
  - Basic energy efficiency requirements ............................................................................ 35
  - Additional energy efficiency requirements .................................................................. 36
- Accidents ............................................................................................................................... 36
- Noise and vibration ............................................................................................................. 38
- Monitoring ........................................................................................................................... 39
  - Monitoring emissions to air ............................................................................................ 40
  - Environmental monitoring (beyond installation) ......................................................... 41
  - Monitoring of process variables .................................................................................... 41

**References** .............................................................................................................................. 45

**Abbreviations** ........................................................................................................................ 46

**Appendix 1: Some common monitoring and sampling methods** ....................................... 47
List of Figures

Glassmaking activities .................................................................11

List of Tables

Compliance requirements ..............................................................4
Summary of direct releases ............................................................6
Contained emissions to air associated with the use of BAT ...........7
Emissions to water associated with the use of BAT ......................9
Outline of furnace descriptions ..................................................13
Measurement methods for common substances to water ..........47
Measurement methods for common substances to air .............49
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 more than 20 tonnes/day.

This sector guidance note takes into account information contained in the BREF (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.
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 1991: ‘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 Part A2(a) of Section 3.3 of Schedule 1 to the PPC Regulations 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)
1.13 The installation includes the main activities above plus the 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

Review and Upgrading Periods

Existing installations or activities

Upgrading

1.14 The previous guidance PG 3/3 (95) Secretary of State’s Guidance Note for Glass (excluding lead glass) Manufacturing Processes, relating to emissions to air, advised that upgrading to that standard should usually have been completed by 1st October 2001. Requirements still outstanding from any existing upgrading programme should be completed.

1.15 The new provisions of this note 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.

(a) Where this guidance note specifies standards or requirements which are additional to, higher than or different to those in PG note PG 3/3 (95), Secretary of State’s Guidance Note for Glass (excluding lead glass) Manufacturing Processes, only in exceptional circumstances should upgrading of existing installations and activities having regard to these additional/higher/different standards or requirements be completed later than the compliance date specified in Table 1 below. (This excludes different standards or requirements which fall within the following paragraph.)

(b) Where standards or requirements in PG 3/3 (95), Secretary of State’s Guidance Note for Glass (excluding lead glass) Manufacturing Processes have been deleted in this guidance note or where this guidance note specifies less stringent standards or requirements than those in PG 3/3 (95) Secretary of State’s Guidance Note for Glass (excluding lead glass) Manufacturing Processes, the new LA-IPPC permit should reflect this straightaway.

1.16 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

<table>
<thead>
<tr>
<th>Upgrading Requirement (reference paragraph)</th>
<th>Compliance Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMISSIONS TO AIR</td>
<td>Flat Glass</td>
</tr>
<tr>
<td>Audit of furnace configuration, and other primary measures (3.15 - 3.30)</td>
<td>With permit application by 31 July 2003</td>
</tr>
<tr>
<td>Particulates - Note 1 (Table 3)</td>
<td>1 April 2005 (subject to paragraph 1.18 below)</td>
</tr>
<tr>
<td>Particulates - Note 2 (Table 3)</td>
<td>1 April 2006 (subject to paragraph 1.18 below)</td>
</tr>
<tr>
<td>SO(_2) (Table 3) - Note 3</td>
<td>1 April 2007</td>
</tr>
<tr>
<td>Chloride / Fluoride (Table 3)</td>
<td>1 April 2007</td>
</tr>
<tr>
<td>Metals (Table 3)</td>
<td>1 April 2007</td>
</tr>
<tr>
<td>NO(_x) Abatement - Primary Techniques</td>
<td>As soon as reasonably practicable, which in most cases would normally be within 24 months of publication of the note.</td>
</tr>
<tr>
<td>NO(_x) Abatement - Secondary Techniques (Table 3)</td>
<td>1 April 2006</td>
</tr>
<tr>
<td>Groundwater Contamination Risk Audit (3.94, BAT 32, 33 &amp; 34)</td>
<td>1 April 2006</td>
</tr>
<tr>
<td>Energy Audit (BAT 56)</td>
<td>Within 12 months of issue of the permit.</td>
</tr>
<tr>
<td>Hazard Identification / Risk Analysis (3.131 &amp; 3.132 &amp; BAT 64)</td>
<td>1 April 2005</td>
</tr>
<tr>
<td>Noise &amp; Vibration (BAT 66)</td>
<td>Within 6 months of the publication of this note</td>
</tr>
<tr>
<td>All Other Requirements</td>
<td>To be complied with as soon as practicable, which in most cases should be within 12 months of the publication of this note</td>
</tr>
</tbody>
</table>

Note 1 - For existing plant not currently meeting the emission limit described in Secretary of State’s Process Guidance Note PG 3/3 (95).
Note 2 - For existing plant currently meeting 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.

1.17 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.
1.18 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

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

New installations or activities

1.20 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

1.21 For substantially changed installations or activities - as 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

1.22 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**

<table>
<thead>
<tr>
<th>Source</th>
<th>Raw Materials Handling, Storage and Mixing</th>
<th>Melting, Fining and Homogenisation</th>
<th>Forming</th>
<th>Annealing and Tempering</th>
<th>Flat Glass Coating</th>
<th>Container Glass Hot Coating</th>
<th>Container Glass Cold Coating</th>
<th>Cutting / Decorating</th>
<th>Acid Polishing</th>
<th>Cullet Handling / Recycle</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NO\textsubscript{x}</strong></td>
<td>A</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SO\textsubscript{x}</strong></td>
<td>A</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Particulates</strong></td>
<td>A</td>
<td>AL</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Chlorides</strong></td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Oxychlorides</strong></td>
<td>A</td>
<td></td>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fluorides</strong></td>
<td>A</td>
<td></td>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>BREF Group 2 Metals - Arsenic, Cobalt, Nickel, Selenium and Chromium VI</strong></td>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>BREF Group 3 Metals - Antimony, Lead, Chromium III, Copper, Manganese and Vanadium</strong></td>
<td>A</td>
<td></td>
<td>A</td>
<td>A</td>
<td>A</td>
<td></td>
<td>W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Organotin</strong></td>
<td></td>
<td></td>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>VOCs</strong></td>
<td></td>
<td></td>
<td>A</td>
<td>A</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Suspended solids</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>W</td>
<td>W</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Chemical Oxygen Demand (COD)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>W</td>
<td>W</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Acidic pH</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>W</td>
</tr>
<tr>
<td><strong>Ammoniacal nitrogen</strong></td>
<td></td>
<td></td>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sulphate</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>W</td>
</tr>
<tr>
<td><strong>Odour</strong></td>
<td></td>
<td>A</td>
<td>A</td>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Noise</strong></td>
<td></td>
<td>*</td>
<td>**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**KEY**

- A - Release to Air, W - Release to Water, L - Release to Land,
- *** - High, ** - Medium, * - Low

N.B. 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 Guidance is given below on emission limits and other requirements which are achievable for key substances using the best combination of techniques.

Table 3: Contained emissions to air associated with the use of BAT

<table>
<thead>
<tr>
<th>Source / Determinand</th>
<th>Limit (mg/m³)</th>
<th>Type of monitoring</th>
<th>Frequency of monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Furnace Operations</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NOₓ</td>
<td>Annual average 500</td>
<td>Annual extractive monitoring plus continuous indicative monitoring</td>
<td>Annual plus continuous</td>
</tr>
<tr>
<td></td>
<td>Daily average 700</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Particulate matter</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SO₂:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With no recycle of EP/bag filter dust</td>
<td>Gas fired 500 Oil fired 1200</td>
<td>Where mass flow exceeds 20 kg/h of chloride, continuous quantitative monitoring, otherwise annual monitoring</td>
<td>Continuous or annual</td>
</tr>
<tr>
<td>With recycle of EP/bag filter dust</td>
<td>800 1500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chlorides (expressed as HCl)</td>
<td>30</td>
<td>Where mass flow exceeds 20 kg/h of chloride, continuous quantitative monitoring, otherwise annual monitoring</td>
<td>Continuous or annual</td>
</tr>
<tr>
<td>Fluorides (expressed as HF)</td>
<td>5</td>
<td>Where mass flow exceeds 0.5 kg/h of fluoride, continuous quantitative monitoring, otherwise annual monitoring</td>
<td>Continuous or annual</td>
</tr>
<tr>
<td>Arsenic, Cobalt, Nickel, Selenium, Chromium VI</td>
<td>5</td>
<td></td>
<td>Annual</td>
</tr>
<tr>
<td>Antimony, Lead, Chromium III, Vanadium</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonia - only where SCR or SNCR is applied for NOₓ abatement</td>
<td>10</td>
<td>Continuous indicative monitoring</td>
<td>Continuous</td>
</tr>
<tr>
<td><strong>Downstream processes for flat glass sector</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Particulate matter</td>
<td>30</td>
<td>Continuous indicative monitoring</td>
<td>Continuous</td>
</tr>
</tbody>
</table>
Table 3: Contained emissions to air associated with the use of BAT

<table>
<thead>
<tr>
<th>Source / Determinand</th>
<th>Limit (mg/m³)</th>
<th>Type of monitoring</th>
<th>Frequency of monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chlorides (expressed as HCl)</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fluorides (expressed as HF)</td>
<td>5</td>
<td>Extractive monitoring</td>
<td>Annual</td>
</tr>
<tr>
<td>Arsenic, Cobalt, Nickel, Selenium, Chromium VI</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total metals</td>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Downstream processes for container glass sector**

<table>
<thead>
<tr>
<th>Source / Determinand</th>
<th>Limit (mg/m³)</th>
<th>Type of monitoring</th>
<th>Frequency of monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulate matter</td>
<td>30</td>
<td>Continuous indicative monitoring</td>
<td>Continuous</td>
</tr>
<tr>
<td>Tin</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Organotin</td>
<td>1</td>
<td>Extractive monitoring</td>
<td>Annual</td>
</tr>
<tr>
<td>Chlorides (expressed as HCl)</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>VOC measured as carbon</td>
<td>If annual solvent consumption is &gt;5 tonnes then limit is 100 If annual solvent consumption is &gt; 15 tonnes then limit is 50</td>
<td>In stack or extractive monitoring</td>
<td>Annual</td>
</tr>
</tbody>
</table>

**Downstream processes for domestic glass sector**

<table>
<thead>
<tr>
<th>Source / Determinand</th>
<th>Limit (mg/m³)</th>
<th>Type of monitoring</th>
<th>Frequency of monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulate matter</td>
<td>30</td>
<td>Continuous indicative monitoring</td>
<td>Continuous</td>
</tr>
<tr>
<td>Fluorides (expressed as HF)</td>
<td>5</td>
<td>Extractive monitoring</td>
<td>Annual</td>
</tr>
<tr>
<td>Total metals</td>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Downstream processes for special glass sector**

<table>
<thead>
<tr>
<th>Source / Determinand</th>
<th>Limit (mg/m³)</th>
<th>Type of monitoring</th>
<th>Frequency of monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particulate matter</td>
<td>30</td>
<td>Continuous indicative monitoring</td>
<td>Continuous</td>
</tr>
<tr>
<td>Fluorides (expressed as HF)</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arsenic, Cobalt, Nickel, Selenium, Chromium VI</td>
<td>1</td>
<td>Extractive monitoring</td>
<td>Annual</td>
</tr>
<tr>
<td>Total metals</td>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Benchmark emissions to water associated with the use of BAT

2.3 Limit values for water discharges will be specified in individual cases taking account of the receiving environment. Wastewater treatment systems can maximise the removal of metals using precipitation, sedimentation and possibly filtration. The reagents used for precipitation may be hydroxide, sulphide or a combination of both, depending on the mix of metals present. It is also practicable in many cases to re-use treated water. The following table provides information regarding achievable levels associated with the use of wastewater treatment systems.

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

<table>
<thead>
<tr>
<th>Determinand</th>
<th>Benchmark release concentration, mg/litre</th>
</tr>
</thead>
<tbody>
<tr>
<td>COD</td>
<td>130 (trade effluent consent) or 30 (surface water)</td>
</tr>
<tr>
<td>Total hydrocarbon oil</td>
<td>5</td>
</tr>
<tr>
<td>Total suspended solids</td>
<td>30</td>
</tr>
<tr>
<td>Ammoniacal nitrogen expressed as N</td>
<td>10</td>
</tr>
<tr>
<td>Sulphate</td>
<td>3000</td>
</tr>
<tr>
<td>Fluoride</td>
<td>30</td>
</tr>
<tr>
<td>Antimony</td>
<td>0.3</td>
</tr>
<tr>
<td>Total Chromium, Copper, Lead, Nickel</td>
<td>0.5</td>
</tr>
</tbody>
</table>

The appropriateness of the above release concentrations will vary depending upon the sensitivity of the receiving water and should be proportionate to the scale of the operations.
3 Techniques for pollution control

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 and the Groundwater Regulations 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

Main activities

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

Raw material, handling & storage → Mixing & transfer → Internal cullet recycle → External cullet → Melting & refining

- Pressing, blowing
- Float tank
- Rolling
- Press, blow, spin, handmake
- Press, blow, roll, ribbon process, spin, extrude, draw, cast, float, dissolution
- Direct cooling with water

- Surface coating
- Annealing (lehr)
- Surface coating
- Surface coating
- Surface coating
- Surface coating
- Surface coating
- Surface coating
- Surface coating
- Surface coating
- Surface coating
- Surface coating
- Surface coating
- Surface coating
- Surface coating
- Surface coating

- Annealing
- Cutting, grinding, blasting, etching
- Cutting
- Decoration
- Polishing
- Cutting
- Packaging / waste handling
- Packaging / waste handling
- Packaging / waste handling
- Packaging / waste handling
- Packaging / waste handling

- CONTAINER GLASS
- FLAT GLASS
- DOMESTIC GLASS
- SPECIAL GLASS
- WATER GLASS

Key:
- Core processes
- Optional processes
Furnace operations

Melting and refining processes

3.7 The temperature needed to melt and refine glass depends on the precise formulation but is typically between 1300°C and 1500°C heated by flames of up to 1650°C. The burning of fossil fuels releases combustion products namely carbon dioxide, water vapour, sulphur dioxide directly produced by the oxidation of the fuel. Nitrogen oxides (NO$_x$) are created by the high temperature oxidation of the nitrogen contained in the combustion air.

Primary melting

3.8 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.

Fining and homogenisation

3.9 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.

Molten glass conditioning

3.10 In the conditioning stage, lower temperature causes all remaining soluble bubbles to be re-absorbed into the melt. At the same time the melt cools slowly to a working temperature of between 900°C and 1300°C.
Furnace types

3.11 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. 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

<table>
<thead>
<tr>
<th>Furnace type</th>
<th>Principle of operation</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cross fired regenerative</td>
<td>Waste gases pre-heat “regeneration” chambers through which combustion air is passed and thus preheated</td>
<td>Combustion air pre-heated to 1400°C High thermal efficiency Can control furnace temperatures closely</td>
<td></td>
</tr>
<tr>
<td>End fired regenerative</td>
<td>Similar principle to the above.</td>
<td>Cheaper than cross fired regenerative</td>
<td>Less control of furnace temperature than cross fired regenerative and therefore used for lower capacity furnaces</td>
</tr>
<tr>
<td>Recuperative (unit melter)</td>
<td>Waste gases continuously pass over heat exchanger across which combustion air is passed</td>
<td>Can operate furnace at a lower temperature. Low NOx emissions (&lt;1kg NOx per tonne of glass melted)</td>
<td>Combustion air only pre-heated to 800°C Small furnaces</td>
</tr>
<tr>
<td>LoNOx melter</td>
<td>Proprietary technique Shallow furnace. Pre-heated combustion gas and preheated raw materials used</td>
<td>Can operate furnace at a lower temperature. Low NOx emissions (&lt;1kg NOx per tonne of glass melted)</td>
<td>&gt;70% cullet required in raw material</td>
</tr>
<tr>
<td>Electric melter</td>
<td>Resistive heating by electrodes.</td>
<td>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.</td>
<td>Small furnaces only due to cost of electricity compared to fossil fuels.</td>
</tr>
<tr>
<td>Pot furnaces, day tanks</td>
<td>Not continuous. Used to melt specific batches.</td>
<td>Small (&lt;20t/d)</td>
<td></td>
</tr>
<tr>
<td>Flex melter</td>
<td>Not continuous. Used to melt specific batches. Combination of electric and gas used for heating.</td>
<td>Small (&lt;20t/d)</td>
<td></td>
</tr>
<tr>
<td>Oxy-fuel fired</td>
<td>High percentage of oxygen used instead of 21% combustion air</td>
<td>Reduces volume of waste gases by up to 85%. Substantial energy savings.</td>
<td>Waste gases require cooling</td>
</tr>
</tbody>
</table>
Emissions control

Point source emissions to air

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

- sulphur dioxide
- oxides of nitrogen
- particulate matter
- chlorides
- fluorides
- heavy metals

Control of point source emissions from furnaces

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

3.14 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

3.15 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

3.16 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\textsubscript{x} emissions.

3.17 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.

3.18 Electricity can be used either as the main heat source, or as a boost to increase the throughput of a furnace.

3.19 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. 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 NOx emissions

### Enhancing energy efficiency

3.20 Achieving the best furnace efficiency means less fuel is used per tonne of glass produced which therefore yields less CO2, NOx and SOx. 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.

### Controlling emissions of oxides of nitrogen (NOx)

3.21 NOx 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 NOx, generated by the oxidation of nitrogen in the high temperature combustion atmosphere present in the glass furnaces (typically 1650 - 2000°C).

3.22 Reduction of NOx 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

1 A combination of the following techniques, in agreement with the regulator, should be used for the control of NOx emissions:

**Primary techniques**

• InNOx melter - capable of achieving emissions of <1kg of NOx per tonne of glass melted
• oxy-fuel melter - to be considered at major rebuild or for a new installation
• FENIX process - developing technology
• prevent ingress of air into the furnace - 10% reduction of NOx possible
• reduced air/fuel ratio - 40% reduction of NOx possible
• staged combustion - 35% reduction of NOx possible
• InNOx burners - 30% reduction of NOx possible

**Secondary techniques**

• 3R process - developing technology, 85% reduction of NOx possible
• reburning - 60% reduction of NOx possible
• SNCR - to be considered for a new installation, up to 70% reduction of NOx possible
Controlling emissions of particulates

3.23 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

3.24 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.

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

**Primary measures**

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

3.27 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

3.28 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
- electric boost, putting energy directly into the melt to improving convective currents in the glass
- the increased use of cullet will reduce the melting energy requirement allowing operation at a lower temperature and lower fuel usage

3.29 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.

3.30 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**

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

**Electrostatic precipitators**

3.32 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.

3.33 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. (It is possible that furnace rebuild may have to be brought forward to accommodate the 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.

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

3.35 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.

3.36 In applications where the gas stream may contain significant concentrations of acid gases (particularly SOx, HCl and HF) it is generally considered necessary to use some form of acid gas scrubbing to protect the EP.
3.37 Indicative costs for EPs and the major factors affecting them are included in the BREF (Ref 3).

Bag filters

3.38 Conventional filter fabrics have maximum operating temperature of between 130 and 220°C. This means that waste gas from furnaces (typically between 450 to 800°C) 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.

3.39 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.

3.40 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 particulates monitoring on the outlet must also be incorporated.

3.41 Bag filters have not become the technique of choice in many of the glass sectors due to the relatively high maintenance requirements and the potential for the fabric to blind, resulting in the need for costly replacement.

3.42 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.

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

### BAT

2 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
- (energy saving technology is currently under development which is expected to abate particulate emissions)

**Secondary abatement techniques:**
- electrostatic precipitator
- bag filter

### Controlling emissions of oxides of sulphur (SO\textsubscript{x})

3.44 Primary techniques for reduction of SO\textsubscript{x} emissions include selecting a low sulphur content fuel and reducing levels of sulphates added to the batch for refining and oxidation control purposes.

3.45 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\textsubscript{x} species to form a solid, which must be removed from the waste gas stream by an electrostatic precipitator or bag filter system.

3.46 In the dry process the absorbent is a dry powder (usually lime Ca(OH)\textsubscript{2}, sodium carbonate Na\textsubscript{2}(CO)\textsubscript{3} or sodium bicarbonate NaHCO\textsubscript{3}). In the semi-dry process the absorbent is added as a suspension or solution and water evaporation cools the gas stream.

3.47 The majority of installed SO\textsubscript{x} scrubbing systems operate with dry lime scrubbing at a temperature of around 400°C, which is the waste gas temperature obtained from an efficient regenerative type furnace. At these temperatures, a SO\textsubscript{x} reduction of around 50% can be achieved.
3.48 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\textsubscript{x} removal.

3.49 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\textsubscript{x} to air will purely reflect the sulphur input, via fuel and raw material, minus the quantity used in the glass manufacture.

3.50 For this reason a balance must be struck between the reduction of raw material consumption / production of solid waste and emission of SO\textsubscript{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.

3.51 With closed loop filter dust recycling, the SO\textsubscript{x} emission levels observed are generally in the range of 200 - 800 mg/Nm\textsuperscript{3} for natural gas firing and 800 - 1500 mg/Nm\textsuperscript{3} with 1% sulphur fuel oil.

3.52 Further detail on SO\textsubscript{x} scrubbing is presented in the BREF.

<table>
<thead>
<tr>
<th>BAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 A combination of the following techniques, in agreement with the regulator, should be used for the control of SO\textsubscript{x} emissions:</td>
</tr>
<tr>
<td>• selection of a low sulphur fuel - natural gas is essentially sulphur free</td>
</tr>
<tr>
<td>• reduction of sulphates used for refining and oxidation control purposes to the minimum practicable level</td>
</tr>
<tr>
<td>• recycling of particulates collected in abatement plant - the operator should provide a process sulphur balance if recycling particulates</td>
</tr>
<tr>
<td>• acid gas scrubbing</td>
</tr>
</tbody>
</table>

**Controlling emissions of chloride and fluorides**

3.53 Hydrogen fluoride (HF) and hydrogen chloride (HCl) emissions 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**

3.54 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
3.55 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
- burner positioning
- reduced air fuel ratio
- low NOx burner systems
- oxy-fuel melting
- electric melting

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

3.57 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

4 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

### Downstream processes

3.58 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

3.59 The two main processes for forming flat glass are the “float glass” process and the “rolling” process.

3.60 Where coating process are used, these often involve tin tetrachloride (SnCl4), hydrofluoric acid (HF), methanol (CH3OH), and a silane (SiH4).

#### The float glass process

3.61 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.

3.62 The float tank (or bath) consists of a 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.
3.63 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.

3.64 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, SO₂ 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°C to 60°C in order to reduce residual stresses, caused during the forming process, to an acceptable level.

3.65 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.

3.66 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.

3.67 In general, the emissions to air from non-melting activities in flat glass production (being combustion products from natural gas heaters and SO₂ 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.

3.68 Rolled glass is formed by a continuous double-roll process. Molten glass at about 1000°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°C.

3.69 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**

3.70 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 will normally be considered trivial

3.71 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".
3.72 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.

3.73 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°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.

3.74 To improve the performance of the products, surface coatings can be applied either immediately after forming while the articles are still above 500°C (“hot end coating”) or after annealing (“cold end coating”) or, more commonly, a combination of the two.

3.75 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 titanium compounds. The most common materials used are anhydrous tin tetrachloride (SnCl₄), anhydrous titanium tetrachloride (TiCl₄), and monobutyl tin chloride (C₄H₉SnCl₃). The emissions consist of hydrogen chloride, oxychlorides, tin and titanium oxides as fine particulate, as well as any unreacted coating materials.

Domestic glass

3.76 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.

3.77 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 re-melting.

3.78 In some installations patterns are cut on the blank glass articles use 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.

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

3.80 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

3.81 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 (CRT glass and lamp units)
(f) Ribbon process (light bulbs)
(g) Spinning process (borosilicate glass)
(h) Tube extrusion, the Danner and Vello processes (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)
(k) Floating (borosilicate glass)
(l) Dissolution (water glass solutions)

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

<table>
<thead>
<tr>
<th>BAT (Sheet 1 of 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat Glass - coating operations</td>
</tr>
<tr>
<td>5 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.</td>
</tr>
<tr>
<td>6 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.</td>
</tr>
<tr>
<td>7 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.</td>
</tr>
</tbody>
</table>
Dispersion and dilution of stack emissions

3.83 The basis upon which stack heights are calculated using HMIP Technical Guidance Note D1 (D1) (Ref 4) 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 limit 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 chose to meet a tighter emission limit in order to reduce the required stack height.
3.84 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

3.85 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

3.86 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

<table>
<thead>
<tr>
<th>BAT (Sheet 1 of 2)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>All releases to air</strong></td>
</tr>
<tr>
<td>The operator should:</td>
</tr>
<tr>
<td>17 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.</td>
</tr>
<tr>
<td>18 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.</td>
</tr>
<tr>
<td>19 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. If practicable a multi-flue stack should be used.</td>
</tr>
<tr>
<td>20 Ensure that stack heights are sufficient to ensure adequate dispersion under normal conditions.</td>
</tr>
<tr>
<td>21 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.</td>
</tr>
<tr>
<td>22 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.</td>
</tr>
<tr>
<td>23 Ensure that all discharges to air, other than water vapour, are free from persistent visible emissions.</td>
</tr>
<tr>
<td>24 Ensure that emissions of water vapour are free from droplet fallout.</td>
</tr>
<tr>
<td>25 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.</td>
</tr>
</tbody>
</table>
Point source emissions to surface water and sewer

3.87 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, and from fire-fighting. In addition to the techniques below, guidance on cost-effective effluent treatment techniques can be found in ETBPP Guides (Ref 5).

Control of point source emissions to water

3.88 In general, 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.

3.89 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. Concentrated effluents should be pretreated as necessary before discharge into the final effluent treatment system
• 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 the treatment plant

3.90 The nature of the receiving water should be taken into account, with regard to any pollutant released to this media. 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**

3.91 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.”

**Point source emissions to groundwater**

3.92 The Groundwater Regulations for the UK came into force on 1 April 1999. If List I or List II substances are discharged to groundwater or may be discharged to groundwater then the Environment Agency will provide advice as part of their statutory consultation duties. For further guidance see chapter 31 in the General Guidance Manual.

**Fugitive emissions to air**

3.93 Common sources of fugitive emissions are:

- 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
Operations should be controlled so as to minimise fugitive emissions. A record of fugitive emissions should be submitted on a regular basis, and normally at least once a year.

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
- prevent or minimise the release of VOCs during the transfer of volatile liquids. This should be achieved by the use of one or more of the following techniques, unless it can be demonstrated that emissions are minimal:
  - subsurface filling via filling pipes extended to the bottom of the container
  - the use of vapour balance lines that transfer the vapour from the container being filled to the one being emptied
  - an enclosed system with extraction to suitable abatement plant

With regard to subsurface structure, the operator should:

- establish and record the routing of all installation drains and subsurface pipework
- identify all subsurface sumps and storage vessels
- engineer systems to minimise leakages from pipes and ensure swift detection if they do occur, particularly where hazardous (i.e. listed) substances are involved
- provide, in particular, secondary containment and/or leakage detection for such subsurface pipework, sumps and storage vessels
- establish an inspection and maintenance programme for all subsurface structures, e.g. pressure tests, leak tests, material thickness checks or CCTV

For surfacing, the operator should:

- ensure that all operational areas are equipped with an impervious surface, spill containment kerbs, sealed construction joints, and connection to a sealed drainage system unless the operator justifies that this is not necessary to the satisfaction of the regulator.
- keep records of the design and condition of the surfacing of all operational areas - relevant information may include, as appropriate, capacities, thicknesses, falls, material, permeability, strength/reinforcement, and resistance to chemical attack
- have an inspection and maintenance programme of impervious surfaces and containment kerbs
- justify where operational areas have not been equipped with:
  - an impervious surface
  - spill containment kerbs
  - sealed construction joints
  - connection to a sealed drainage system
34 The operator should ensure that all tanks containing liquids whose spillage could be harmful to the environment are contained. The operator should ensure that all bunds:
- are impermeable and resistant to the stored materials
- have no outlet (that is, no drains or taps) and drain to a blind collection point
- have pipework routed within bunded areas with no penetration of contained surfaces
- are designed to catch leaks from tanks or fittings
- have a capacity of at least 110% of the largest tank
- are visually inspected weekly and any contents pumped out or otherwise removed under manual control after checking for contamination
- where not frequently inspected, are fitted with a high-level probe and an alarm as appropriate
- have an annual maintenance inspection (normally visual but extending to water testing where structural integrity is in doubt)

35 All sumps should:
- be impermeable and resistant to stored materials
- be subject to regular visual inspection agreed with the regulator and any contents pumped out or otherwise removed after checking for contamination

36 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
- have delivery connections located within a bunded area, fixed and locked when not in use
- have their integrity inspected, recorded and documented, particularly where corrosive substances are involved. These inspections should be included in the maintenance schedule

37 Storage areas and containers should be designed and operated to minimise the risk of fugitive releases to surface water, sewer and groundwater, in particular:
- storage areas should be located away from watercourses and should be protected against vandalism
- the maximum storage capacity of storage areas should be stated and not exceeded
- the maximum storage period for containers should be specified
- storage areas and silos should be inspected at least once a week to check for signs of leakage or potential leakage

* A Code of Practice on the use and storage of solvents is currently being drawn up and will be published on the Defra website. [www.defra.gov.uk/environment/water/ground/solvents/index](http://www.defra.gov.uk/environment/water/ground/solvents/index) Where the Code, when published, contains anything more stringent as regards bunding, account should be taken of it.
Odour

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

3.96 Odour can arise from activities such as cullet pre-heating, oil storage, use of SO₂ for surface treatment and use of VOCs e.g. from silvering of flat glass.

3.97 Implementation of the best available techniques and the emission limit values and provisions of this note should ensure that offensive odours are not perceived beyond the site boundary, other than where unavoidable plume grounding occurs. It may be necessary to include additional controls to avoid offensive odours, for example where local meteorological conditions frequently lead to poor dispersion conditions.

3.98 The locality will influence the assessment of the potential for odour impact, for example, where the site has a low odour impact due to its remoteness from sensitive receptors, the escape of offensive odour beyond the installation would be unlikely to cause harm. In these circumstances it is expected that the operations should be optimised to minimise odour emissions and also that effective process management is applied. Assessment of the potential for offensive odour beyond the site boundary should take account of all predicted wind directions and weather conditions, which are typical of the location in question.

Management

3.99 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.

3.100 An effective Environmental Management System (EMS) will help the operator to maintain compliance with regulatory requirements and to manage other significant environmental impacts.

Operations and maintenance

3.101 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

3.102 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.

3.103 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.
**Operations and maintenance**

38 Effective operational and maintenance systems should be employed on all aspects of the installation whose failure could impact on the environment, in particular there should be:

- documented operational control procedures  
- a documented preventative maintenance schedule, covering all plant whose failure could lead to impact on the environment, including major ‘non productive’ items such as tanks, pipework, retaining walls, bunds, ducts and filters; this should be reviewed and updated annually  
- documented procedures for monitoring emissions

39 The regulator should be provided with a list of key process equipment and abatement equipment. Such equipment should be provided with alarms or other warning systems 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.

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

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

42 A competent person should be appointed to liaise with the regulator and the public with regard to complaints. The regulator should be informed of the designated individual.

**Competence and training**

43 Training systems, covering the following items, should be in place for all relevant staff:

- awareness of the regulatory implications of the permit  
- awareness of all potential environmental impacts under normal and abnormal circumstances  
- awareness of the procedures for dealing with a breach of the permit conditions  
- prevention of accidental emissions and action to be taken when accidental emissions occur  
- awareness of all operating procedures

44 The skills and competencies necessary for key posts (which may include contractors and those purchasing equipment and materials) should be documented and records of training needs and training received for these posts maintained.

45 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.
Raw Materials

3.104 This section covers the use of raw materials and water and the techniques for both optimising their use and minimising their impact by selection (Energy and fuels are covered under Energy).

3.105 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

3.106 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

3.107 In some cases liquids and gases are also used.

3.108 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 pollutant load that arises through chemical decompositions in the furnace.

3.109 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%

3.110 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.

**BAT**

46 The operator should:

- maintain an inventory covering the principal types of raw materials used
- annually review alternatives for the principal types of raw materials used with regard to their environmental impact
- have quality procedures to control the specification of raw materials used, in order to minimise any potential environmental impact
- complete any long term studies needed into the less polluting options and make any material substitutions identified within the review period
Raw materials handling, storage, mixing and transfer

3.111 The raw materials are combined by weight to give a precisely formulated batch which is conveyed to the furnace for melting.

BAT

47 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

Waste minimisation (optimising the use of raw materials)

3.112 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”.

3.113 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.

3.114 Key operational features of waste minimisation will 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

3.115 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.

3.116 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.

BAT

48 The operator should carry out a waste minimisation audit at least as frequently as the review period of the 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.

49 If an audit has not been carried out in the 2 years prior to submission of the application then the first audit should take place within 18 months of the issue of the permit.

50 Specific improvements resulting from the recommendations of audits should be carried out within a timescale approved by the regulator.
Water use

3.117 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.

3.118 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 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
- cost savings where water is purchased or disposed of to another party
- associated benefits within the process such as reduced energy requirements for heating and pumping, and reduced dissolution of pollutants into the water leading to reduced sludge generation in the effluent treatment plant

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 5.

3.119 The following general principals 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

### BAT

| 51 | The operator should carry out a regular review of water use (water efficiency audit). Where one has not been carried out recently, an initial comprehensive audit should be carried out at the earliest opportunity. Audits should be at least as frequent as the IPPC permit reviews. |
| 52 | Using this information, 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. |
| 53 | The volume of mains and abstracted water used in the activities should be directly measured when the installation is operating once a day for at least a fortnight and thereafter, once a week with an annual exercise taking daily measurements for at least a fortnight. All measurements should be recorded and the records held on site. |
Waste handling

3.120 Good segregation of materials is essential to facilitate opportunities for recovery, recycling and re-use.

3.121 In general the waste streams comprise of:
   • off-spec cullet that cannot be recycled
   • dust collected in EP / bag filters
   • waste resulting from furnace maintenance and rebuild, including refractory material
   • used filter bags
   • packaging

Waste re-use, recovery, recycling or disposal

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

3.123 It is good practice to ensure that:
   • all waste 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
   • dust collected in electrostatic precipitator or bag filter is recycled to the furnace and used to substitute for raw materials as far as possible without breaching emission limits for SOx
   • hexafluorosilicic acid (H2SiF6) 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

BAT

54 The operator should:
   • record 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
   • ensure that waste storage areas are clearly marked and signed, and that containers are clearly labelled
   • ensure that appropriate storage facilities are provided for substances that are flammable, sensitive to heat or light etc, and that incompatible waste types are kept separate
   • ensure that containers are stored with lids, caps and valves secured and in place (This also applies to emptied containers)
   • ensure that procedures are in place to deal with damaged or leaking containers
   • segregate waste wherever practicable
   • identify the disposal route for all waste, which should be as close to the point of production as possible

BAT

55 The operator should carry out an annual review to demonstrate that the best environmental options are being used for dealing with all waste from the installation.
Energy

3.124 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
   • the operator meets the basic energy efficiency requirements below and the additional energy efficiency requirements

Basic energy efficiency requirements

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

3.126 The energy efficiency of melting can be increased by a number of measures that include:
   • improving the level of furnace insulation to minimise heat loss
   • fitting continuous carbon monoxide (CO) and oxygen (O₂) 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

BAT

56 The operator should produce a report annually on the energy consumption of the installation.

57 The operator should monitor energy flows and target areas for reduction which should be updated annually. ("Sankey" diagrams and energy balances would be useful as aids.)

58 In order to optimise combustion, the operator should, where practicable, monitor carbon monoxide and oxygen in waste gases.

59 The operator should ensure that all plant is operated and maintained to optimise the use and minimise the loss of energy.

60 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

3.127 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.

Accidents

3.128 For accident management, there are three particular components:
- identification of the hazards 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

3.129 Further guidance can be found in chapter 20 of the General Guidance Manual.

3.130 Accidents might for example include fires or explosions in furnaces or other fired plant, spillage of oil, raw materials or coating process reagents, release of ammonia abatement reagent if SCR or SNCR is used. Ref 6 and Ref 7 provide guidance that may be relevant in the event of fire.

Identification of the hazards

3.131 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
- preventing incompatible substances coming into contact
- unwanted reactions and/or runaway reactions
- emission of an effluent before adequate checking of its composition has taken place
- steam main issues
- vandalism
- vehicle movements

Measures to reduce the risks (identified by risk assessment)

3.132 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 redundancy or standby plant with maintenance and testing to the same standards as the main plant
- 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
- suitable barriers to prevent damage to equipment from the movement of vehicles, as appropriate, having regard to a site-specific assessment of risks
- 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
Noise and vibration

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

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

3.135 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 noise problems. 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.

3.136 The most significant source of noise arises as a result of cullet handling. This and other noise arising from fans, motors, material handling, vehicle movements, engineering activities and compressed air systems should be dealt with by good operational techniques and design of noise abatement measures.

66 The operator should employ basic good practice measures for the control of noise, in particular:
- identification of key plant and equipment with the potential to give rise to noise nuisance
- documented maintenance systems for the identified key plant and equipment
Monitoring

3.137 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

3.138 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](http://www.environment-agency.gov.uk) for listing of MCERTS equipment.

Sampling and analysis standards

3.139 The analytical methods given in Table 3 and Appendix 1 should normally be used. In the event of other substances needing to be monitored, standards 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)

3.140 Further guidance on standards for monitoring gaseous releases relevant to IPPC is given in the Technical Guidance Note M4 (Monitoring) (see Ref 8). A series of updated Guidance Notes covering this subject is currently in preparation. This guidance specifies manual methods of sampling and analysis, which will also be suitable for calibration of continuous emission monitoring instruments. Further guidance relevant to water and waste is available from the publications of the Standing Committee of Analysts. See [http://dwi.gov.uk/regs/pdf/scabb202.pdf](http://dwi.gov.uk/regs/pdf/scabb202.pdf)

3.141 If in doubt the operator should consult the regulator.

Monitoring and sampling protocols

3.142 Where monitoring is needed the operator should address the following:

- determinands to be monitored
- monitoring strategy and selection of monitoring points
- monitoring methods and procedures (selection of Standard Reference Methods)
- reference conditions and averaging periods
- measurement uncertainty of the proposed methods and the resultant overall uncertainty
- drift correction
- quality assurance (QA) and quality control (QC) protocols, 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
- the accreditation held by samplers and laboratories or details of the people used and the training/competencies
Monitoring frequency

3.143 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.

3.144 Emission flow rates must be consistent with good operating practice and meeting the requirements of the legislation relating to workplace safety.

3.145 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/m³, against an emission limit of 50 mg/m³ 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/m³ when the limit is 50 mg/m³ might not qualify for a reduction in monitoring

3.146 Consistent compliance should be demonstrated using the results from 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.

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

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

Monitoring emissions to air

3.149 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.

3.150 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

3.151 Waste gas temperature: the flue gas temperature from the furnace can vary substantially (generally from 100 to 850°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
3.152 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.

3.153 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.

3.154 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 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 SOX 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.

3.155 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.

3.156 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.

Environmental monitoring (beyond installation)

3.157 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


Monitoring of process variables

3.159 Some process variables will have potential environmental impact and these should be identified and monitored where they have an environmental relevance. For glass 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
- combustion efficiency monitoring, for example burner efficiency
Monitoring and reporting

67 The need for and scope of testing and the frequency and time of sampling depend on local circumstances, operational practice, and the scale of operation. As part of proper supervision 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

68 The regulator needs to be informed of monitoring to be carried out and the results. The results should include process conditions at the time of monitoring.

69 The operator should notify the regulator at least 7 days before any periodic monitoring exercise 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.

70 The results of non-continuous emission testing should be forwarded to the regulator within 8 weeks of the completion of the sampling.

71 Adverse results from any monitoring activity (both continuous and non-continuous) should be investigated immediately. The operator should ensure that:

- the cause has been identified and corrective action taken
- as much detail as possible is recorded regarding the cause and extent of the problem and the action taken to rectify the situation
- re-testing to demonstrate compliance is carried out as soon as possible, and
- the regulator is notified

72 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 air. Such problems may arise within the process itself or with the abatement plant, for example.

73 In the case of abnormal emissions, malfunction or breakdown leading to abnormal emissions:

- investigation and remedial action should be undertaken immediately
- the process or activity should be adjusted to minimise those emissions; and
- the events and actions taken should be promptly recorded
- In the case of non-compliance causing immediate danger to human health operation of the activity should be suspended
<table>
<thead>
<tr>
<th><strong>BAT (Sheet 2 of 3)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>74</strong> The regulator should be informed without delay:</td>
</tr>
<tr>
<td>- if there is an emission that is likely to have an effect on the local community or</td>
</tr>
<tr>
<td>- in the event of the failure of key abatement plant, for example, bag filtration plant or scrubber units</td>
</tr>
<tr>
<td>- if continuous monitoring shows an emission concentration exceeding double the limit value</td>
</tr>
<tr>
<td><strong>75</strong> Care is needed in the design and location of sampling systems in order to obtain representative samples for all release points.</td>
</tr>
<tr>
<td>- sampling points on new plant should be designed to comply with the British or equivalent standards. e.g. BS ISO 9096: 2003 or BS EN 13284-1 for sampling particulate matter in stacks</td>
</tr>
<tr>
<td>- the operator should ensure that adequate facilities for sampling are provided on stacks or ducts</td>
</tr>
<tr>
<td>- where monitoring is not in accordance with the main procedural requirements of the relevant standard, deviations should be reported as well as an estimation of any error invoked</td>
</tr>
<tr>
<td><strong>76</strong> Continuous monitoring is normally expected for the main abated releases identified in Section 3. Where continuous monitoring is required by the permit it should be carried out as follows:</td>
</tr>
<tr>
<td>- all continuous monitoring readings should be on display to appropriately trained operating staff</td>
</tr>
<tr>
<td>- instruments should be fitted with audible and visual alarms, situated appropriately to warn the operator of arrestment plant failure or malfunction</td>
</tr>
<tr>
<td>- the activation of alarms should be automatically recorded</td>
</tr>
<tr>
<td>- all continuous monitors should be operated, maintained and calibrated (or referenced) in accordance with the manufacturers’ instructions, which should be made available for inspection by the regulator. The relevant maintenance and calibration (or referencing) should be recorded</td>
</tr>
<tr>
<td>- all new continuous monitoring equipment should be designed for less than 5% downtime over any 3-month period</td>
</tr>
</tbody>
</table>

**Monitoring and reporting of emissions to air**

| 77 | 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. |
| 78 | The introduction of dilution air to achieve emission concentration limits should not be permitted. |
| 79 | Dilution air may be added for waste gas cooling or improved dispersion where justified, but this should not be considered when determining the mass or concentration of the pollutant in the waste gases. |
| 80 | 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. |
| 81 | Calibration and compliance monitoring should meet the following requirements as appropriate. No result should exceed the emission concentration limits specified, except where either: |
| (a) | data is obtained over at least 5 sampling hours in increments of 15 minutes or less; or |
| (b) | at least 20 results are obtained where sampling time increments of more than 15 minute are involved; AND in the case of (a) or (b) |
| (c) | no daily mean of all 15-minute mean emission concentrations should exceed the specified emission concentration limits during normal operation (excluding start-up and shut-down); and |
| (d) | no 15-minute mean emission concentration should exceed twice the specified emission concentration limits during normal operation (excluding start-up and shut-down) |
82 Where continuous quantitative monitoring is undertaken, compliance with (c) and (d) above should be demonstrated on a daily basis.

**Monitoring and reporting emissions to water and sewer**

83 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 sewer/controlled water
- the quality of the receiving water
- the volume of discharge compared to the percentage dry river flow of the receiving water

84 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 common pesticides or heavy metals may occur.

85 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**

86 The following should be monitored and recorded:
- the physical and chemical composition of the waste
- its hazard characteristics
- handling precautions and substances with which it cannot be mixed
References

Environment Agency documents referred to below are available from the Environment Agency website [http://www.environment-agency.gov.uk](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](http://www.sepa.org.uk), or the NIEHS website [www.ehsni.gov.uk](http://www.ehsni.gov.uk).


Ref 4  HMIP Technical Guidance Note (Dispersion) D1, 1993 The Stationery Office ISBN 0 11 752794 7 (Environment Agency website - summary only)

Ref 5  Water efficiency references:

- ETBPP, Simple measures restrict water costs, GC22
- ETBPP, Effluent costs eliminated by water treatment, GC24
- ETBPP, Saving money through waste minimisation: Reducing water use, GG26
- ETBPP (is now Envirowise) Helpline 0800 585794

Ref 6  BS 5908: Code of Practice for Fire Precautions in the Chemical and Allied Industries

Ref 7  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 8  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 November 2002
- Direct Toxicity Assessment for Effluent Control: Technical Guidance (2000), UKWIR 00/TX/02/07.
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAT</td>
<td>Best Available Techniques</td>
</tr>
<tr>
<td>BOD</td>
<td>Biochemical Oxygen Demand</td>
</tr>
<tr>
<td>BREF</td>
<td>BAT Reference Document</td>
</tr>
<tr>
<td>CCA</td>
<td>Climate Change Agreement</td>
</tr>
<tr>
<td>CEM</td>
<td>Continuous Emissions Monitoring</td>
</tr>
<tr>
<td>CHP</td>
<td>Combined Heat and Power plant</td>
</tr>
<tr>
<td>COD</td>
<td>Chemical Oxygen Demand</td>
</tr>
<tr>
<td>DPA</td>
<td>Direct Participation Agreement</td>
</tr>
<tr>
<td>ELV</td>
<td>Emission Limit Value</td>
</tr>
<tr>
<td>EMS</td>
<td>Environmental Management System</td>
</tr>
<tr>
<td>EP</td>
<td>Electrostatic Precipitator</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>EQS</td>
<td>Environmental Quality Standard</td>
</tr>
<tr>
<td>ITEQ</td>
<td>International Toxicity Equivalents</td>
</tr>
<tr>
<td>MCERTS</td>
<td>Monitoring Certification Scheme</td>
</tr>
<tr>
<td>NIEHS</td>
<td>Northern Ireland Environment and Heritage Service</td>
</tr>
<tr>
<td>SAC</td>
<td>Special Areas of Conservation</td>
</tr>
<tr>
<td>SCR</td>
<td>Selective Catalytic Reduction</td>
</tr>
<tr>
<td>SECp</td>
<td>Specific Energy Consumption</td>
</tr>
<tr>
<td>SEPA</td>
<td>Scottish Environment Protection Agency</td>
</tr>
<tr>
<td>SNCR</td>
<td>Selective Non-Catalytic Reduction</td>
</tr>
<tr>
<td>SPA</td>
<td>Special Protection Area</td>
</tr>
<tr>
<td>TSS</td>
<td>Total Suspended Solids</td>
</tr>
<tr>
<td>TOC</td>
<td>Total Organic Carbon</td>
</tr>
<tr>
<td>VOC</td>
<td>Volatile Organic Compounds</td>
</tr>
<tr>
<td>WAG</td>
<td>Welsh Assembly Government</td>
</tr>
</tbody>
</table>
# Appendix 1: Some common monitoring and sampling methods

## Table 6: Measurement methods for common substances to water

<table>
<thead>
<tr>
<th>Determinand</th>
<th>Method</th>
<th>Detection limit</th>
<th>Valid for range mg/l</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspended solids</td>
<td>Filtration through glass fibre filters</td>
<td>1 mg/l 20%</td>
<td>10-40</td>
<td>ISO 11929:1997 EN872 - Determination of suspended solids</td>
</tr>
<tr>
<td>COD</td>
<td>Oxidation with di-chromate</td>
<td>12 mg/l 20%</td>
<td>50-400</td>
<td>ISO 6060: 1989, Water Quality - Determination of chemical oxygen demand</td>
</tr>
<tr>
<td>BOD5</td>
<td>Seeding with micro-organisms and measurement of oxygen content</td>
<td>2 mg/l 20%</td>
<td>5-30</td>
<td>ISO 5815: 1989, Water Quality Determination of BOD after 5 days, dilution and seeding method EN 1899 (BOD 2 Parts)</td>
</tr>
<tr>
<td>AOX</td>
<td>Adsorption on activated carbon and combustion</td>
<td>-- 20%</td>
<td>0.4 - 1.0</td>
<td>ISO 9562: 1998 EN1485 - Determination of adsorbable organically bound halogens.</td>
</tr>
<tr>
<td>Tot P</td>
<td></td>
<td></td>
<td></td>
<td>BS 6068: Section 2.28 1997, Determination of phosphorus – ammonium molybdate spectrophotometric method</td>
</tr>
<tr>
<td>Tot N</td>
<td></td>
<td></td>
<td></td>
<td>BS 6068: Section 2.62 1998, Determination of nitrogen Part 1 Method using oxidative digestion with peroxydisulphate, BS EN ISO 11905</td>
</tr>
<tr>
<td>pH</td>
<td></td>
<td></td>
<td></td>
<td>SCA The measurement of electric conductivity and the determination of pH, ISBN 0117514284</td>
</tr>
<tr>
<td>Flow rate</td>
<td>Mechanical ultrasonic or electromagnetic gauges</td>
<td></td>
<td></td>
<td>SCA Estimation of Flow and Load ISBN 011752364X</td>
</tr>
<tr>
<td>Temperature</td>
<td></td>
<td></td>
<td></td>
<td>SCA temperature measurement for Natural, Waste and Potable Waters and other items of interest in the Water and Sewage Disposal Industry ISBN 0117520179</td>
</tr>
<tr>
<td>Fatty acids</td>
<td></td>
<td></td>
<td></td>
<td>Determination of Volatile Fatty Acids in Sewage Sludge 1979 ISBN 0117514624</td>
</tr>
</tbody>
</table>
### Table 6: Measurement methods for common substances to water

<table>
<thead>
<tr>
<th>Determinand</th>
<th>Method</th>
<th>Detection limit uncertainty</th>
<th>Valid for range mg/l</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metals</td>
<td></td>
<td></td>
<td></td>
<td>BS 6068: Section 2.60 1998 Determination of 33 elements by inductively coupled plasma atomic emission spectroscopy</td>
</tr>
<tr>
<td>Chlorine</td>
<td></td>
<td></td>
<td></td>
<td>BS6068: Section 2.27 1990 Method for the determination of total chlorine: iodometric titration method</td>
</tr>
<tr>
<td>Trichloroform (Chloroform)</td>
<td></td>
<td></td>
<td></td>
<td>BS6068: Section 2.58, Determination of highly volatile halogenated hydrocarbons – Gas chromatographic methods</td>
</tr>
<tr>
<td>Surfactants:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anionic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cationic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-ionic</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formaldehyde</td>
<td></td>
<td></td>
<td></td>
<td>SCA The determination of formaldehyde, other volatile aldehydes, ketones and alcohols in water</td>
</tr>
<tr>
<td>Phosphates and nitrates</td>
<td></td>
<td></td>
<td></td>
<td>BS 6068: Section 2.53 1997, Determination of dissolved ions by liquid chromatography</td>
</tr>
<tr>
<td>Sulphites and sulphates</td>
<td></td>
<td></td>
<td></td>
<td>BS 6068: Section 2.53 1997, Determination of dissolved ions by liquid chromatography</td>
</tr>
<tr>
<td>Grease and oils</td>
<td>IR absorption</td>
<td>0.06 mg/kg</td>
<td></td>
<td>SCA The determination of hydrocarbon oils in waters by solvent extraction, IR absorption and gravimetry ISBN 011751 7283</td>
</tr>
</tbody>
</table>
Table 7: Measurement methods for common substances to air

<table>
<thead>
<tr>
<th>Determinand</th>
<th>Method</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO&lt;sub&gt;x&lt;/sub&gt;</td>
<td>Continuous emission monitor</td>
<td>ISO 10849</td>
</tr>
<tr>
<td>SO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>Impingement into hydrogen peroxide. Analysis by barium perchlorate titration</td>
<td>BS 6069:4.1:1990 (which is identical to ISO 7934:1989)</td>
</tr>
<tr>
<td></td>
<td>Extractive sampling and analysis by UV fluorescence</td>
<td>BS 6069:4.4:1993 (which is identical to ISO 7935:1992)</td>
</tr>
<tr>
<td>Total chloride</td>
<td>Impingement Analysis by titration, spectroscopy or ion chromatography</td>
<td>BS EN 1911:1998 Parts 1 - 3</td>
</tr>
<tr>
<td>Fluorides</td>
<td>Isokinetic sample, impingement analysis by ion chromatography</td>
<td>US EPA Method 26A for aerosol and gas phase halides</td>
</tr>
<tr>
<td></td>
<td></td>
<td>US EPA Method 26 for gas phase halides only</td>
</tr>
<tr>
<td>Fluorides</td>
<td>DOAS</td>
<td></td>
</tr>
<tr>
<td>Continuous emission monitors measure gas phase fluoride - but not aerosol fluoride</td>
<td>NDIR</td>
<td></td>
</tr>
<tr>
<td></td>
<td>FTIR</td>
<td>US EPA Method 320</td>
</tr>
<tr>
<td></td>
<td>IMS</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TDL</td>
<td></td>
</tr>
<tr>
<td>VOC</td>
<td>Extract FID</td>
<td>BS EN 13526</td>
</tr>
</tbody>
</table>