Waste Protocols Project

Blast furnace slag (BFS)

A technical report on the manufacturing of blast furnace slag and material status in the UK.
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Executive summary

Original purpose of this report

The original purpose was to provide information to the Environment Agency about the production, use and material classification of blast furnace slag (BFS) via the production of a technical report by a BFS Technical Advisory Group (TAG). This information would have enabled the Environment Agency to re-consider its view of the material status of BFS; the Environment Agency was (and is) of the opinion that BFS is a waste whereas, in the view of the industry, BFS is a by-product which, provided certain conditions are satisfied, is not a waste.

Following the report’s publication and a subsequent Environment Agency legal review, the TAG would then aim to produce a quality protocol that set out clearly at what point and what measures were required for the material to cease to be classified as a waste.

Revised purpose of this report

While the report was being prepared, the Commission of the European Communities published guidance in the form of a Communication to assist Member States to distinguish between ‘by-products’ and ‘wastes’. As a result of this Communication, which cites BFS as an example of a by-product and a non-waste, the Environment Agency indicated it was prepared to review its classification of BFS.

The revised purpose of this report is to help the Environment Agency review its legal position regarding the material status of BFS by providing:
- much of the planned content of the original technical report; and
- evidence pertaining to the requirements for ‘by-product’ status as set out in the communication from the commission to the council and the European Parliament.

The report’s conclusions and recommendations are summarised below.

Conclusions

The TAG has provided evidence on current conditions in the BFS industry in the UK compared with:
- the European Commission’s Communication and its guiding principles;
- the Environment Agency’s interpretation of this guidance.

The TAG drew the following conclusions:
- A technical choice is made at the start of the production process that determines the type of BFS produced. The iron making process is adapted to ensure the BFS has the requisite technical qualities.
- BFS can be used directly at the end of the production process without further processing, i.e. crushing of BFS to obtain the appropriate particle size is an integral part of the BFS production process.
- BFS is supplied to a number of clearly defined end uses in the UK and demand is high.
- There are no differences in ‘operational circumstances’ between the BFS market in the UK and the example cited in Annex 1 of the communication from the commission to the council and the European Parliament.
- The information set out by the TAG in this technical report provides sufficient evidence that the UK situation mirrors and meets the subsequent Environment Agency interpretation and guiding principles.
Recommendations

The TAG recommends that:

- BFS could be considered to fall outside the definition of waste in the UK and that it should normally be classified as a by-product and not a waste; and
- existing material controls, as identified in the Integrated Pollution Prevention Control (IPPC) Directive, and its associated BREF (Best Available Techniques reference document), are adequate in the regulation of BFS.

This technical report is representative of the TAG’s findings and the current UK position. This document should therefore be referred to in relation to any other BFS classification issues.

It will be the responsibility of the manufacturer to review the status of BFS in relation to any changes in relevant EU or UK Legislation and European Court of Judgement decisions.
1. Introduction

1.1 The Waste Protocols Project is a joint Environment Agency and Waste & Resources Action Programme (WRAP) initiative, funded by the Department for Environment Food and Rural Affairs (Defra) Business Resource Efficiency and Waste (BREW) Programme.

1.2 Uncertainty over the point at which ‘waste’ is fully recovered and ceases to be waste has meant that some materials have continued to be controlled under the EU Waste Framework Directive1 and, in some cases, disposed of to landfill. To provide more certainty, to stop materials being landfilled unnecessarily and to increase the use of waste as a resource, we have set up the Waste Protocols Project.

1.3 Depending on the circumstances of the sector concerned, the project seeks to achieve one or more of the following outcomes:

- to produce a Quality Protocol defining the point at which waste may become a non-waste product or material that can be either reused by business or industry, or supplied into other markets. This would mean that recovered products could be used without needing waste regulation controls;
- to produce a statement, in accordance with the Environment Agency’s low risk regulatory policy2, indicating that the use of the waste is considered to be such low risk that it would not normally be in the public interest to take enforcement action for failure to obtain a waste management licence; and
- to produce a statement that confirms to the business community what legal obligations they must comply with to use the treated waste material.

1.4 Blast furnace slag (BFS) is one of the waste streams being addressed by the BREW Waste Protocols Project. A Technical Advisory Group (TAG) was set up to bring together representatives from the Environment Agency, WRAP and industry. Appendix A contains a list of TAG members and Appendix B gives its terms of reference.

1.5 The TAG’s original aim was to produce a technical report for the Environment Agency to consider. The Environment Agency currently takes the view that BFS is a waste until it has been solidified – either through air cooling or water quenching (granulation) – and processed to the extent necessary to demonstrate compliance with the quality criteria in various standards.

1.6 The purpose of the technical report was to review this position and the TAG initially set out to produce a document recognised by the industry, and produced with its support, that defined when BFS has been processed to such a level that it is considered to be fully recovered and no longer subject to the requirements of the waste regulations.

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1 Waste Framework Directive 2006/12/EC
3 See http://www.environment-agency.gov.uk/subjects/waste/1416460/1334460/1098094/
1.7 However, the purpose of this report changed with the publication of the European Commission guidance in February 2007\(^4\) to assist Member States in distinguishing between 'by-products' and 'wastes'. As a result of this new guidance, which cites BFS as an example of a by-product and a non-waste, the Environment Agency indicated it was prepared to review its classification of BFS\(^5\). The report’s purpose was therefore revised to provide evidence to the Environment Agency to assess whether BFS meets the by-product criteria as set out in the Commission’s guidance.

1.8 The report looks at the production of BFS, materials derived from BFS, and the point at which waste regulation controls no longer apply at present. It uses the information initially collated by the Technical Advisory Group and is intended to assist the Environment Agency in its decision-making process regarding the material status of BFS in the UK.

1.9 The report includes:
- a description of major markets and appropriate end uses for BFS;
- an overview of the current legislative framework;
- examples of market specifications that BFS can achieve and the quality of material; and
- information relating to risks to human health and the environment from the use of BFS in the markets identified.

1.10 The report makes suggestions as to the way forward when BFS can be regarded as fully recovered and no longer a waste once strictly defined conditions are met.

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2. Key markets and production of BFS

2.1 The TAG identified the main UK markets, production centres and products applicable to BFS.

2.2 The main UK markets for BFS are:
- aggregates for use in trafficked and non-trafficked areas including the unbound and bound mixtures (in particular asphalt) identified in Table 2.1; and
- ground granulated BFS (GGBFS) as a cementitious addition for use in concrete (also indicated in Table 2.1).

2.3 UK production of BFS originates today from the three remaining integrated steel-making facilities in the UK. These are plants owned by Corus UK Ltd at Teesside, Scunthorpe and Port Talbot. Together these plants typically produce around three million tonnes of BFS annually.

2.4 Approximately 75 per cent of BFS production in the UK is converted into GGBFS and the remainder into air-cooled BFS (ACBFS). Virtually all GGBFS produced is for sale to the UK concrete market, whereas ACBFS is crushed and screened for UK aggregate sales.

2.5 Aggregates produced from BFS are incorporated within the British and European Aggregate product standards and contribute about 1.5 per cent of the UK total construction aggregate market demand of some 214 million tonnes per year.\(^7\)

<table>
<thead>
<tr>
<th>Table 2.1 Key markets and products of BFS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bound and unbound aggregates</strong></td>
</tr>
<tr>
<td>Capping layers</td>
</tr>
<tr>
<td>Road sub-base</td>
</tr>
<tr>
<td>Base (road base), binder (base) course</td>
</tr>
<tr>
<td>Surface (wearing) course</td>
</tr>
<tr>
<td>Chippings for surface dressing</td>
</tr>
<tr>
<td>Bituminous bound material in general</td>
</tr>
<tr>
<td>Concrete coarse aggregates</td>
</tr>
<tr>
<td>Structural fill and backfill</td>
</tr>
<tr>
<td>Pipe bedding</td>
</tr>
<tr>
<td>Rail track sub-ballast</td>
</tr>
</tbody>
</table>

6 The Corus Group was recently acquired by the Tata Group.
7 Position paper on ferrous slags prepared for Clare McCallan (Environment Agency) by the QPA Slag Group HLR 20 July 2005.
3. UK legislative position

3.1 Current legislative position in the UK

3.1.1 The collection and storage of BFS is regulated under:
- Environmental Protection Act 1990; and
- Waste Management Licensing Regulations (as amended).  

3.1.2 The following apply in relation to BFS production.
- The production of BFS for commercial purposes is regulated under the Pollution Prevention and Control (PPC) Regulations and all production activities (i.e. iron-making facilities within an integrated works) can only operate within the conditions identified in their PPC permit.
- Sites operating under a PPC permit do not require a waste management licence as all aspects of waste storage and management are already regulated through the permit conditions.
- In iron making facilities, specific regulatory controls often apply to other aspects of the manufacturing process. These controls may not be directly related to the material (BFS) produced at the facility, but may be required as a result of the processing activity (e.g. controls on releases to air).

<table>
<thead>
<tr>
<th>Type of operation</th>
<th>Current legislative control</th>
<th>Current approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>All PPC regulated sites</td>
<td>BFS delivered for processing is considered to be waste, so the Duty of Care Regulations apply.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>All BFS produced within an integrated steel works is subject to operating conditions stipulated by the site PPC permit to operate.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Once BFS is sold and leaves the integrated works, no further processing of the material occurs. It is used as delivered by the purchaser. At that point, the material remains covered by waste management licensing regulations.</td>
<td></td>
</tr>
<tr>
<td>Non-PPC regulated sites</td>
<td>BFS is covered by waste management licensing regulations.</td>
<td></td>
</tr>
</tbody>
</table>

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8 See http://www.environment-agency.gov.uk/subjects/waste/1416440/
9 http://www.environment-agency.gov.uk/business/1745440/1745496/298441/
10 See http://www.defra.gov.uk/environment/waste/legislation/duty.htm
3.2 New guidance from the European Commission

3.2.1 The Communication\(^\text{11}\) issued by the European Commission in February 2007 aimed to:

‘improve the legal certainty of waste legislation, and to make the definition of waste easier
to understand and apply’.

It also sought to:

‘guide competent authorities in making case by case judgements on whether a given
material is a waste or not’.

3.2.2 BFS is cited in Annex 1 of the Communication as an example of material that could be
considered to fall outside the definition of waste. The guidance states that:

‘Blast furnace slag is produced in parallel with hot iron in a blast furnace. The production
process of the iron is adapted to ensure that the slag has the requisite technical qualities.
A technical choice is made at the start of the production process that determines the type
of slag that is produced. Moreover, use of the slag is certain in a number of clearly defined
end uses, and demand is high. Blast furnace slag can be used directly at the end of the
production process, without further processing that is not an integral part of this production
process (such as crushing to get the appropriate particle size). This material can therefore
be considered to fall outside of the definition of waste’\(^\text{12}\).

3.2.3 This citation of BFS as an example of a material that falls outside the definition
of waste clarified its position from an EU perspective.

3.2.4 The Communication also provided a context to the example by setting out specific
criteria for making decisions on classifying materials as wastes or by-products.

3.3 Environment Agency’s interpretation of the Commission’s ruling

3.3.1 The European Commission guidance had significant implications as the guidance
appeared to conflict with the Environment Agency’s position regarding BFS and its
material status.

3.3.2 The Environment Agency released its interpretation of the Communication shortly
afterwards. This interpretation is set out below:\(^\text{13}\)

‘The Environment Agency welcomes the Communication. The Commission’s aim is to
improve legal certainty and to make the definition of waste in relation to by-products easier
to understand and apply. We will take account of the communication as we make case by
case judgements on whether a given material is a waste or not. We would urge operators
to ensure they provide full relevant details of their processes if seeking our advice.’

3.3.3 Background:

‘The Commission’s Communication delivered guidelines that were within the legally binding
criteria set out by the European Court of Justice (ECJ). They regard guidelines as a flexible
tool, adaptable to new evidence and technologies. The Commission considers that such
guidelines are better suited to delivering legal clarity than a definition of by-products in
the Waste Framework Directive or other options, including any list type approach.’

3.3.4 In its position statement, the Environment Agency noted that the European Court of
Justice (ECJ) had, in recent jurisprudence, set out guiding principles that should be
used to assess production residues in order to establish their status as a waste or
a by-product. The Environment Agency accepted the need to consider these guiding
principles, which are set out in the Communication from the European Commission
(Table 3.2).

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Table 3.2 Conditions where a production residue would not be waste*

<table>
<thead>
<tr>
<th>Test</th>
<th>Guidelines</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Is the further use of the material a certainty and not a mere possibility?</td>
<td>If certain use cannot be guaranteed for all the material concerned, then the material should start as a waste.</td>
</tr>
<tr>
<td>2. Can the material be used again without any further processing?</td>
<td>If an additional recovery process is required before further use, even if such subsequent use is certain, this is evidence that the material is a waste until the process has been completed.</td>
</tr>
<tr>
<td>3. Can the material be used again as part of the production process?</td>
<td>However, further processing which is carried out as an integral part of the production process will not prevent the material from being considered as a by-product. The case law indicates a narrow rather than a broad approach to the notion of production process; however each material must be considered on a case-by-case basis.</td>
</tr>
</tbody>
</table>


3.3.5 The Environment Agency's position in relation to Annex 1 to the Communication was that:

'These [examples] are designed to illustrate some cases in which materials may be classified as wastes or by-products. They are taken from a number of different sectors, but are neither definitive nor comprehensive. The examples may vary across the EU in some circumstances – notably there may be certainty of use for a given by-product in one region or Member State, but not in another.’

3.3.6 In summary:

'The Environment Agency welcomed the Commission’s Communication and stated that it was keen to see further clarity regarding the definition of waste and by-products. The Environment Agency noted the Commission’s guidelines on the interpretation of the three-part test and encouraged operators to take similar careful note. The Environment Agency was also mindful that a ‘list based’ approach had been rejected in favour of case-by-case decision approach; thus any examples cited couldn’t be regarded as definitive.’

3.4 Impact of these developments on the protocol process

3.4.1 Given the position adopted by the Environment Agency following the publication of the Commission’s Communication and its implications for the material status of BFS, the TAG agreed to:

- review the evidence obtained to date versus the guiding principles; and
- form a position via the production of a revised technical report.

3.4.2 The report would summarise the UK position, thus enabling the Environment Agency to re-consider its legal position in relation to the material status of BFS.
4. BFS versus the guiding principles

4.1 This section considers BFS in relation to the guiding principles set out in Table 3.2 and is derived from evidence provided by the TAG. The aim to provide an up-to-date snapshot of the status of the material in the UK from which the TAG can derive conclusions in relation to:
- certainty of use;
- further processing; and
- whether BFS production is part of the continuous production process.

4.2 TAG evidence in relation to certainty of use

4.2.1 Annual BFS output in the UK is typically around 3 million tonnes (Section 2.3). To put this figure into context in relation to UK demand, market information indicates that the UK steel industry produced approximately 4.3 million tonnes of BFS in 2002. In contrast, 4.55 million tonnes of BFS was used in the UK in 2002. Thus consumption exceeded production, with the shortfall being made up by UK stock movements to bridge the imbalance.

4.2.2 BFS production has declined since 2002 with the closure by Corus UK of the two blast furnaces at Llanwern Steelworks in south Wales. This reduced the availability of UK-produced BFS, resulting in higher levels of imported BFS to satisfy UK demand. The UK BFS industry has increased import capability with the development of new facilities on the Thames Estuary at Purfleet in Essex.14

4.2.3 Market information shows that demand outstripped supply even before the closure of the BFS production facilities at Llanwern. Since the closure, UK demand has remained high and the UK BFS market has reacted by developing larger import facilities in order to satisfy UK customers. Thus, the certainty of use of BFS (principle 1 in Table 3.2) in the UK does not appear to be an issue at present.

4.3 TAG evidence in relation to further processing requirements

4.3.1 A ‘chain of tasks’ (i.e. the production of BFS via granulation or air-cooling, drying, quenching, crushing and size-separation) forms an ‘integral part of the continuing process of (BFS) production’.15 This ‘integral part’ prerequisite is quoted in the Commission’s Communication.16 In addition, the Communication does not classify such tasks as ‘further processing’; it reserves the term ‘further processing’ for situations where additional ‘recovery’ processes are required. BFS was therefore a product, which was not classified as a ‘recovery process’.

4.3.2 For the further processing principles identified by the Environment Agency in response to the Commission’s Communication (principles 2 and 3 in Table 3.2), the processes above are an integral part of the continuing process of production. These operations are necessarily conducted in order to prepare BFS for use as a product. Thus, as stated previously, the material is required as part of the primary activity of the manufacturer. It is evident therefore that the material concerned is not a waste or the result of a recovery process.

15 Analysis of blast furnace slag against tests in EU Commission Communication, DD Higgins, Quarry Products Association (QPA), 1 March 2007.
4.4 TAG evidence in relation to continual process of production

4.4.1 In addressing the case-by-case approach required (principle 3 in Table 3.2), TAG members stated that BFS is an industrial material produced during the making of iron whose chemical and physical properties are tightly controlled within specific parameters.

4.4.2 The high level of BFS quality control ensures that:
- iron quality requirements are met; and
- the consistent chemical composition and physical properties of BFS are maintained in accordance with the product standards required for the end use. This will either be air cooled blast furnace slag (ACBFS) or ground granulated blast furnace slag (GGBFS).

4.4.3 The production of BFS is described in Section 5.
5. Process description

5.1 During the iron making process in a blast furnace, acidic impurities from iron ore are removed using limestone. In the heat of the blast furnace, the calcium carbonate in the limestone breaks down to form carbon dioxide and calcium oxide. The calcium oxide then reacts with the acidic impurities to form BFS as a molten liquid. This liquid has a lower density than the molten iron, so it sits above the iron in the hearth of the furnace and can therefore be removed or tapped. Figure 5.1 illustrates this process and the basic chemical reactions that occur within it.

Figure 5.1 Simplified process flow diagram

Making iron: the blast furnace

Figure courtesy of BBC learning website (http://www.bbc.co.uk/learning)
5.2 The chemical and physical properties of BFS are tightly controlled within specific parameters to ensure that the liquid metal quality requirements are met. The result is BFS with a consistent chemical composition and physical properties, ensuring the product standards are met for its end uses.

5.3 The production of BFS with specific properties is integral to the iron making processes, i.e. the intention of the iron producer is to design and regulate BFS quality through selection of raw materials (fluxes) and process controls to ensure the iron is produced of the desired quality. Operating practices in iron and steel making have been developed to ensure that designed slag compositions are achieved, with slag being sampled regularly during the manufacturing process to check for compliance.

5.4 BFS is separated from liquid metal via a taphole for the liquid metal and a slag notch for BFS, which sits above and to the side of the taphole. BFS is then run either into pits at the side of the furnace or to a granulator located within the furnace cast house. BFS is then converted into ACBFS or GGBFS as outlined in Sections 5.6 and 5.7 respectively.

5.5 The design of a specific composition of BFS not only allows furnace operators to achieve a high quality ferrous material (iron) but is also fundamental to the efficient and cost-effective operation of the processes involved. For example, the BFS composition controls alkali retention in a blast furnace which, in turn, is a major factor in determining the life of the lining of that blast furnace.

5.6 Producing air cooled blast furnace slag (ACBFS)

5.6.1 Molten BFS is allowed to flow from the blast furnace into open air pits located beside the furnaces where the material is quenched with water applied by sprays to facilitate cooling and BFS crystallisation (this handling method enhances the properties by reducing the BFS density). Once sufficiently cooled, ACBFS is dug from the open air pits and transported to a nearby crushing and screening (aggregate) plant, where it is processed into aggregates.

5.7 Producing ground granulated blast furnace slag (GGBFS)

5.7.1 Molten BFS is allowed to flow from the blast furnace down launders (runner beds) into a purpose-built granulation plant where the BFS is quenched rapidly with high volumes of warm water. This results in vitrified (glassy) material with a sand-like appearance, with particles typically 1–3 mm in size. The granulated BFS (GBFS) is then transported to a grinding mill for conversion into GGBFS.
6. Material composition and quality standards

6.0.1 This section identifies standards and specifications that can be met during BFS production, though processing may vary depending upon the scale of the operations and the type of equipment used. The aim is to assist the Environment Agency in its decision-making by providing information on:
- chemical composition of BFS; and
- current quality standards and environmental best practice.

6.1 Chemical properties

6.1.1 BFS is chemically and mineralogically more consistent than naturally occurring aggregates. It consists primarily of the silicates and aluminosilicates of calcium and magnesium together with other compounds of sulphur, iron, manganese and other trace elements.

6.1.2 A typical chemical analysis of BFS is shown in Table 6.1. In terms of its mineralogy, BFS is usually melilite (a solid solution series of gehlenite, 2CaO.Al₂O₃.SiO₂, and akermanite, 2CaO.MgO.2SiO₂), with a small amount (<1 per cent) of calcium sulphide (oldhamite). Sometimes merwinite (3CaO.MgO.2SiO₂) is also present and more rarely dicalcium silicate 2CaO.SiO₂.

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaO</td>
<td>41.0</td>
</tr>
<tr>
<td>SiO₂</td>
<td>35.0</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>14.0</td>
</tr>
<tr>
<td>MgO</td>
<td>7.0</td>
</tr>
<tr>
<td>S</td>
<td>0.8</td>
</tr>
</tbody>
</table>

6.2 Quality standards

6.2.1 The European standards organisation, CEN, has finalised the following standards:
- EN 13242:2002/AC:2004 Aggregates for unbound and hydraulically bound mixtures for use in civil engineering work and road construction;
- EN 13285:2003 Unbound mixtures – specification;
- EN 13043:2002/AC:2004 Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas; and

6.2.2 These standards refer to the use of BFS as an aggregate in unbound, hydraulically bound, asphalt and concrete mixtures respectively.

6.2.3 BFS is used widely throughout the UK as a construction aggregate and complies fully with the physical and chemical quality requirements detailed in EN 13242. This standard supersedes a variety of aggregate standards including British Standard BS 1047 and recognises BFS as a manufactured aggregate suitable for use alongside aggregates from natural and recycled sources.
6.2.4 In order to standardise BFS usage, most of the national standards relevant to the aggregates industry have been harmonised in recent years. Table 6.2 lists the most relevant European standards in relation to BFS.

6.2.5 The TAG advised that the required quality standards can be met if BFS adheres to the quality criteria contained within the range of EN standards applicable to aggregates, mixtures and GGBFS.

6.2.6 All forms of BFS when sold must comply with the relevant product standards. Non-complying materials are rectified in accordance with procedures laid down in the BFS supplier’s quality management systems. Non-conforming BFS is never sold and product safety data sheets are available upon request for all BFS products.

6.2.7 Potential environmental impacts are discussed further in Section 7.

<table>
<thead>
<tr>
<th>Standard/guidance</th>
<th>Description</th>
<th>Comments</th>
<th>How these standards deal with potential human, health and environmental impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>BS EN 13043</td>
<td>Aggregates for use in asphalt</td>
<td>Contains detailed quality requirements to be met by aggregates for use in asphalt and other surface treatments.</td>
<td>In all EN standards, the aggregate supplier is held responsible for ensuring appropriate measures are taken to mitigate environmental impact. The next generation of EN standards will address environmental issues in more detail. Solidified BFS is not considered to pose any risk to human health.</td>
</tr>
<tr>
<td>BS EN 13242</td>
<td>Aggregates for use in unbound and hydraulically bound mixtures</td>
<td>Contains detailed quality requirements to be met by aggregates for use in unbound and hydraulically bound materials.</td>
<td>Control of leachate: joint guidelines from the industry and the Environment Agency (see Section 7.5) provide simple practical guidance for end users to avoid leaching of sulphur into groundwater.</td>
</tr>
<tr>
<td>BS 1047</td>
<td>Withdrawn British Standard for BFS</td>
<td>Superseded by EN standards for aggregates including EN 13242 and EN 13043.</td>
<td></td>
</tr>
<tr>
<td>BS EN 14227-2</td>
<td>BFS bound mixtures</td>
<td>Contains detailed quality requirements to be met by aggregate mixtures bound by GGBFS.</td>
<td></td>
</tr>
<tr>
<td>BS EN 14227-12</td>
<td>Hydraulic bound mixtures – specifications for soil treated by BFS</td>
<td>Contains detailed quality requirements to be met by GGBFS cement.</td>
<td></td>
</tr>
<tr>
<td>BS EN 15167</td>
<td>GGBFS for use in concrete, mortar and grout</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
7. Potential environmental impacts

7.01 This section describes evidence from the TAG and from research about the potential environmental impacts from the production, storage and use of BFS in the UK.

7.1 BFS production and carbon dioxide

7.1.1 The production of cementitious products from BFS contributes towards the reduction in carbon dioxide (CO₂) emissions derived from traditional cement manufacturing. Typically, 50 per cent of the CO₂ emissions associated with concrete production are avoided by partially replacing ordinary Portland cement (OPC) with GGBS – when comparing the life cycle assessment (LCA) of GGBS with that of Portland cement.¹⁹

7.2 BFS production and hydrogen sulphide

7.2.1 Granulation releases lower levels of hydrogen sulphide (H₂S) compared with conventional ‘air cooling’ and associated water quenching practices. In recent years the BFS industry has invested heavily in BFS granulation plants to reduce its airborne emissions and thus its environmental impact. This approach has been encouraged and endorsed by the Environment Agency.

7.3 Recent BFS related incidents

7.3.1 For the purposes of this report, UK environmental incidents relating to BFS for 2006 were investigated. Details of these incidents taken from the Environment Agency’s National Incident Reporting Service (NIRS) are given in Appendix C.

7.3.2 Three incidents were recorded during the year relating to H₂S emissions caused by BFS quenching activities. Two of these incidents were substantiated and directly attributed to BFS granulators not being utilised. The use of such plant is known to emit less H₂S than conventional slag quenching activities (i.e. use of pits).

7.4 Previous Environment Agency/industry guidance

7.4.1 The use of ACBFS as an unbound aggregate is known to present a potential environmental hazard due to bacterial or chemical action on BFS under specific ground conditions (e.g. poorly drained soils). The subsequent leachate can give rise to sulphides and other compounds that can be harmful if they enter the water environment.

7.4.2 This problem is acknowledged in guidelines produced jointly in 1997 by the Environment Agency and the British Aggregate Construction Materials Industry (BACMI) – now the Quarry Products Association (QPA). The guidance advises the following measures to mitigate this potential hazard:

- utilise materials stored in exposed stockpiles in preference to freshly made BFS;
- do not use unbound BFS in water logged or poorly drained areas;
- do not use unbound BFS below the water table;
- where unbound BFS is used in the construction of large exposed trafficked areas, use compaction and avoid ponding to minimise ingress of water;
- identify situations where the use of large quantities of unbound BFS could give rise to water pollution at the materials selection stage of the construction project; and
  - Produce a method statement setting out details of:
    - how the BFS will be stored and handled; and
    - the measures taken to protect the aquatic environment.

7.5 Specific environmental protection guidance

7.5.1 Modern BFS usage is subject to stringent production quality control and to a quality controlled natural weathering regime that is compliant with the European aggregates standards (e.g. EN13242, EN 13285 and EN 13043). This regime requires the following:

- the material selection stage of the construction project must include a review of the environmental implications related to the use of any proposed aggregate source. The contractor must produce a method statement identifying all recognised measures to protect the aquatic environment;
- unbound BFS should not be used in water logged or poorly drained areas. This will minimise any release of lime and sulphur compounds that could otherwise result in groundwater pH increase and oxygen depletion;\(^{20}\)
- wherever possible, BFS should not come into contact with the water table to avoid similar conditions developing as outlined above;
- where unbound BFS is used in the construction of large exposed areas such as vehicle parks and major carriage ways, good practice should be followed to minimise the time the slag surface is exposed prior to overlay; and
- if in doubt concerning the suitability of material for a particular application, contact the BFS supplier.

7.6 Sulphur content of BFS

7.6.1 BFS is mildly alkaline and exhibits a pH in solution in the range of 8 to 10. It contains a small component of elemental sulphur (typically 0.8 per cent) and the leachate tends to be slightly alkaline.

7.6.2 Leachate issues are identified in the risk assessment section of this report (Section 8) and potential environmental impacts are acknowledged in the joint BACMI/Environment Agency guidelines.\(^{21}\) These issues and impacts arise when BFS aggregate is placed in contact with groundwater.

7.6.3 Further information on the leaching behaviour of a wide range of aggregates, including BFS, is provided by CIRIA Report 167.\(^{22}\) Page 132 of the report contains a summary of leaching test data which, for BFS, show that chloride, sulphate, alkali earth metals and ammoniacal nitrogen can be elevated relative to water quality standards (drinking water standards and/or Environmental Quality Standards). Heavy metals are generally below detection limits.

7.6.4 On the basis of the CIRIA data, weathered BFS can be used as a limestone substitute in most settings. But in sensitive locations (e.g. within Source Protection Zone I of abstraction boreholes or water bodies within ecologically sensitive areas), the Environment Agency may require site-specific risk assessments to show that concentrations of chloride, sulphate, alkali earth metals and ammoniacal nitrogen are not likely to exceed relevant local statutory water objectives.\(^{23}\)

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\(^{20}\) Natural aggregates such as limestone and recycled aggregates such as crushed concrete can also elevate groundwater pH.

\(^{21}\) Section 3 (Slag and the water environment) states: 'BS 1047 recognises that under specific ground conditions such as poorly drained soils, bacterial or chemical action on slag and leachate can give rise to sulphides and other compounds that can be harmful if they enter the water environment'.


\(^{23}\) As per the Water Resources Act 1991, Section 82 which provides for the establishment, via regulations, of systems of classifying water quality according to various criteria and Section 83 of the Act, which provides for the setting of statutory water quality objective (SWQOs) for individual stretches of water as well as estuaries, coastal waters, lakes and groundwater.
7.6.5 The TAG felt that it was important to note that the sulphur is bound up inside the BFS matrix, i.e. it is effectively encapsulated and not available for leaching. Only the sulphur present on the surface of BFS aggregates is potentially leachable and then only if it comes into contact with surface water/groundwater.

7.7.6 The TAG stated that all construction materials that utilise BFS (i.e. concrete, asphalt and unbound materials) are typically well compacted when placed in-situ. This further reduces the likelihood of water ingress and lessens the risk of any leaching occurring.

7.7 Possible effects on human health and ecology

7.7.1 Evidence was obtained from the abstract of a comprehensive study \(^{24}\) of the potential human health risks associated with the environmental applications (e.g. fill, road base, landscaping) of iron and steel making slags which examined characterisation data for 73 samples of slags collected from blast furnaces, basic oxygen furnaces and electric arc furnaces.

7.7.2 These data were compared with US regulatory health-based ‘screening’ benchmarks to determine constituents of interest. Antimony, beryllium, cadmium, trivalent and hexavalent chromium, manganese, thallium, and vanadium were measured above screening levels and were assessed in an application-specific exposure assessment using standard US Environmental Protection Agency risk assessment methods.

7.7.3 A stochastic analysis was conducted to evaluate the variability and uncertainty in the inhalation exposure and risk estimates, and the oral bio-accessibility of certain metals in the slags was quantified.

7.7.4 The risk assessment found no significant hazards to human health as a result of the environmental applications of steel industry slag. However, the abstract indicated that site-specific ecological risk assessments may be required for slag applications in and around small water bodies with limited dilution volumes. This was due to high pH and aluminium levels, which were found to be at levels that might be harmful to aquatic life.

7.7.5 However, the abstract \(^{25}\) did not distinguish between BFS and other steel making slags when discussing the potential effects on aquatic life.

7.7.6 This assessment relates directly to the joint BACMI/Environment Agency guidance, which states that slag should not be placed in stagnant ground water conditions.

7.8 Other available research information

7.8.1 Other sources of information on the possible environmental impacts of BFS were identified and reviewed by the TAG are listed in Appendix D. These sources supported the conclusions reached by the TAG (see Section 9).

\(^{24}\) Proctor DM, Shay EC, Fehling KA, and Finley BL, 2002 Assessment of human health and ecological risks posed by the uses of steel-industry slags in the environment. Human and Ecological Risk Assessment, 8(4), 681-711.

8. BFS risk assessment

8.1 Table 8.1 presents the findings of a detailed risk assessment into the production and use of BFS. This assessment was made by the TAG based on information available in relation to the potential environmental effects of BFS.

8.2 Based on the risk assessment, the TAG considers that the risks from the hazards identified in relation to BFS are low provided appropriate mitigation is taken.

<table>
<thead>
<tr>
<th>Hazardous event and potential pathway</th>
<th>Receptor(s)</th>
<th>Risk before mitigation</th>
<th>Issues and possible mitigation measures required at each phase (production, storage, use)</th>
<th>Risk after mitigation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise</td>
<td>People and the local environment</td>
<td>✓</td>
<td>1. No issues identified but local authority planning permission controls should be adhered to.</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✓</td>
<td>2. No issues identified.</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✓</td>
<td>3. No issues identified.</td>
<td>✓</td>
</tr>
<tr>
<td>Odour</td>
<td>People and the local environment</td>
<td>✓</td>
<td>1. Production of hydrogen sulphide from quenching and cooling processes can generate complaints from the general public. In-line granulation significantly reduces such odour and the potential for these types of complaints.</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✓</td>
<td>2. Once BFS has solidified and been processed into aggregates, there are no odour release issues.</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td>✓</td>
<td>3. If BFS is not applied correctly, it is theoretically possible for such odour releases (from leachate generation) – though they are likely to be very minor. No direct evidence in relation to odour emerged during this study.</td>
<td>✓</td>
</tr>
<tr>
<td>Spillage</td>
<td>People and the local environment</td>
<td>✓</td>
<td>1. Good housekeeping required at handling and processing facilities in line with PPC permit conditions.</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. Good housekeeping at storage facilities required.</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3. Good housekeeping required during usage/application stage.</td>
<td>✓</td>
</tr>
<tr>
<td>Hazardous event and potential pathway</td>
<td>Receptor(s)</td>
<td>Risk before mitigation</td>
<td>Issues and possible mitigation measures required at each phase (production, storage, use)</td>
<td>Risk after mitigation</td>
</tr>
<tr>
<td>--------------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------------------------</td>
<td>--------------------------------------------------------------------------------------------</td>
<td>-----------------------</td>
</tr>
</tbody>
</table>
| Contaminated run-off/release of contaminated site drainage to the environment | Properties Ecosystems Surface water Groundwater                               | ✓                      | 1. Possible run-off issues from all BFS production activities are subject to PPC permit conditions. Reference should be made to BACMI/Environment Agency guidance.  
2. All BFS stockpiles (pre-sales) are located within an integrated works complex and regulated via PPC permit conditions; refer to BACMI/Environment Agency guidance. Stockpiles must be within contained areas or similar with controlled/enclosed good draining systems. Control and clean-up spillages of material required.  
3. BFS delivered to construction sites for use in unbound applications should be stored according to BACMI/Environmental Agency guidance. BFS used in asphalt or concrete poses no environmental risk because the slag is fully bound by bitumen or cement | ✓                      |
| Wind-borne litter                    | People Properties Ecosystems                                                 | ✓  ✓                   | 1. Good housekeeping required to prevent possibility of becoming airborne.  
2. As above.  
3. As above. | ✓  ✓  ✓                  |
| Airborne dust, powders or particulars | People Properties Ecosystems                                                 | ✓  ✓  ✓                | 1. Course grain >2mm material.  
2. As above.  
3. As above. | ✓  ✓  ✓                  |
| Combustion potential of BFS          | People Properties Ecosystems Atmosphere Surface water Groundwater             | ✓                      | Not applicable as melting point of BFS is >1,400°C. | ✓                      |
| BFS storage                          | People Properties Ecosystems                                                 | ✓                      | BFS delivered to construction sites for use in unbound applications should be stored according to BACMI/Environmental Agency guidance. BFS used in asphalt or concrete poses no environmental risk because the slag is fully bound by bitumen or cement. | ✓                      |
| BFS disposal                         | People Properties Ecosystems                                                 | ✓                      | Not applicable – full usage of material during all phases of production, storage and use. | ✓                      |
9. TAG conclusions and recommendations

9.0.1 The TAG is of the opinion that BFS production and quality control is fundamental to the iron production process, with the production of ACBFS or GGBFS being an integral part of this process. BFS production and operations that are necessarily carried out on BFS are required to prepare it for use as a product. BFS is ‘essential’ for the BFS processing activities conducted by Tarmac Ltd and Civil and Marine Ltd; without it the businesses would not exist.26

9.1 Conclusions

9.1.1 Current quality standards:
- BFS manufactured in the UK consistently meets the quality specifications contained within the suite of European product standards relating to aggregates and GGBFS (e.g. BS EN 13242, BS EN 13285, BS EN 13043, BS EN 14227-2, BS EN 12620, BS EN 15167).
- Meeting a wide range of standards gives confidence in the quality of BFS material, making it acceptable to the market and thereby assuring certainty of use.

9.1.2 Potential environmental impacts:
- The quality parameters specified in all aggregate standards can be achieved through the processing of BFS. However, difficulties may be experienced due to leachate generation and potential environmental damage.
- BFS contains a small amount of leachable sulphur (less than 1 per cent) found on the surface of the aggregate, which can leach on contact with groundwater. Sulphur leaching is rare and only occurs when BFS is placed in close contact with groundwater.
- The environmental risks associated with BFS are acknowledged but are mitigated with effective implementation of the joint BACMI/ Environment Agency guidelines published in 1997.
- In sensitive locations such as within Source Protection Zone 1 of abstraction boreholes or water bodies within ecologically sensitive areas, the Environment Agency may require site-specific risk assessment to show that concentrations of chloride, sulphate, alkali earth metals and ammoniacal nitrogen are not likely to exceed relevant local statutory water quality objectives.27
- Based on this risk assessment, the TAG considers that the risks from the hazards identified in relation to the production and use of BFS remain low provided appropriate mitigation is taken.

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26 Analysis of blast furnace slag against tests in EU Commission Communication, DD Higgins, Quarry Products Association (QPA), 1 March 2007, page 3.
27 As per the Water Resources Act 1991, Section 82 which provides for the establishment, via regulations, of systems of classifying water quality according to various criteria and Section 83 of the Act, which provides for the setting of statutory water quality objective (SWQOs) for individual stretches of water as well as estuaries, coastal waters, lakes and groundwater.
9.1.3 The quality protocol process

- If a quality protocol were required for the use of BFS, it should specify that:
  - BFS must meet the criteria specified in:
    - BS EN 13242 Aggregates for use in unbound and hydraulically bound materials;
    - BS EN 13285 Unbound mixtures;
    - BS EN 13043 Aggregates for use in asphalt;
    - BS EN 14227-2 Slag bound mixtures (SBM);
    - BS EN 12620 Aggregates for use in concrete; and
    - BS EN 15167 GGBFS for use in concrete, mortar and grout.
  - testing is carried out in accordance with the methods specified in these standards;
  - every shipment sale of BFS is accompanied by a delivery ticket which specifies the standard the product conforms to;
  - testing frequency is in accordance with the quality management system of the slag supplier;
  - test records are held on site indefinitely except for aggregate gradings, which are to be retained only typically for 10 years; and
  - the quality controls and mitigation measures identified in the report are adopted.

9.1.4 TAG position in relation to the Environment Agency’s guiding principles

- A technical choice is made at the start of the production process that determines the type of slag produced. The iron making process is adapted to ensure that the slag has the requisite technical qualities.
- BFS can be used directly at the end of the production process without further processing; i.e. crushing BFS to obtain the appropriate particle size is an integral part of the slag production process.\(^\text{28}\)
- BFS is supplied to a number of clearly defined end uses in the UK and demand is high.
- There are no differences in ‘operational circumstances’ between the BFS market in the UK and the example cited in Annex 1 of the Communication from the European Commission issued in February 2007.
- There is sufficient evidence that the UK situation mirrors and meets the subsequent Environment Agency interpretation and guiding principles.

9.2 Recommendations

9.2.1 From the evidence gathered from the TAG and presented in conjunction with the Environment Agency’s interpretation of the European Commission Communication and the fact that the Commission cites BFS as a direct example of a by-product, the TAG recommends that:
- BFS could be considered to fall outside the definition of waste in the UK and that it should normally be classified as a by product and not as waste; and
- existing material controls as identified in the Integrated Pollution Prevention Control (IPPC) Directive 96/61/EC and its associated BREF (Best Available Techniques reference document), are adequate in the regulation of this material.

9.2.2 This technical report is representative of the TAG’s findings and the current UK position. This document should therefore be referred to in relation to any other BFS classification issues.

9.2.3 The TAG notes it will be the responsibility of the manufacturer to review the status of BFS in relation to any changes in relevant EU or UK legislation and European Court of Judgement decisions.

\(^{28}\) Position paper on ferrous slags prepared for Clare McCallan (Environment Agency) by the QPA Slag Group HLR 20 July 2005.
## Appendix A  Technical Advisory Group membership

<table>
<thead>
<tr>
<th>Organisation</th>
<th>Representative</th>
<th>Type of member</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tarmac Ltd</td>
<td>Professor Howard Robinson</td>
<td>Attending</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corus Group plc</td>
<td>Graham Wadelin/ Louise Payne</td>
<td>Attending</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cementitious Slag Maker Association</td>
<td>Dr Dennis D Higgins</td>
<td>Attending</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Entec UK</td>
<td>Alex Macleod</td>
<td>Attending</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environment Agency</td>
<td>Suzanne Laidlaw</td>
<td>Attending</td>
</tr>
<tr>
<td></td>
<td>Michelle Steer</td>
<td>Attending</td>
</tr>
<tr>
<td></td>
<td>Dominic O’Neil</td>
<td>Attending</td>
</tr>
<tr>
<td></td>
<td>Neil Goodlad</td>
<td>Correspondence</td>
</tr>
<tr>
<td></td>
<td>Aoife O’Sullivan</td>
<td>Correspondence</td>
</tr>
<tr>
<td></td>
<td>Clare McCallan</td>
<td>Correspondence</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environment Agency Wales</td>
<td>Rebecca Favager</td>
<td>Correspondence</td>
</tr>
<tr>
<td></td>
<td>Mark Broom</td>
<td>Correspondence</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>National Industrial Symbiosis Programme</td>
<td>Professor Nizar Ghazireh</td>
<td>Attending</td>
</tr>
<tr>
<td>(NISP)</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scottish Environment Protection Agency (SEPA)</td>
<td>John Harris</td>
<td>Correspondence</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste &amp; Resources Action Programme (WRAP)</td>
<td>John Barritt</td>
<td>Attending</td>
</tr>
<tr>
<td></td>
<td>Sarah Clayton</td>
<td>Attending</td>
</tr>
<tr>
<td></td>
<td></td>
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</tr>
<tr>
<td>Veolia Environmental Services</td>
<td>Sarah Moseley</td>
<td>Correspondence</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix B TAG terms of reference

1. **Background**
   The industry and the Environment Agency have conflicting views on how the ECJ jurisprudence on the definition of waste should be interpreted in relation to BFS. The Environment Agency is of the view that BFS is a ‘waste’. The view of the industry is that BFS is a co-product which, provided certain conditions are satisfied, is not a ‘waste’.

2. **Mission statement**
   The aim of the Technical Advisory Group (TAG) is to produce a technical report recognised by – and produced with the support of – industry that defines when BFS is considered to be fully recovered and no longer subject to the requirements of the regulatory waste regime.

   If this is not achievable, the TAG will consider whether the technical report could usefully provide guidance to business that will:
   - define when BFS is recovered to a state where the Environment Agency considers that its use is acceptable in accordance with its low risk regulatory principles; or
   - confirm to the business community what legal obligations remain to control the reuse of the treated waste material.

3. **Desired outcomes/outputs**
   The TAG will produce a technical report that will identify and establish:
   - which end products the quality protocol should address;
   - the existing standards and specifications for each end product;
   - the positive and negative environmental benefits and what, if any, mitigation methods are needed to ensure that reclassification will not result in overall negative environmental impacts;
   - the costs and benefits of the different end uses (with the aid of project economist); and
   - a standard terminology.

4. **Limitations**
   - All members of the TAG must sign off the technical report output.
   - The Environment Agency must be satisfied with the TAG’s determination of the point at which BFS has been fully recovered. The TAG must agree any changes that the Environment Agency applies.
   - If the point of full recovery of BFS cannot be defined or agreed, the report will record the reasons for this.
   - In view of the large number of existing British and European standards for BFS products, it is unlikely that lack of specifications and standards will delay the TAG’s work.
## Appendix C  Pollution incidents related to BFS in the UK in 2006

Table C1 reproduces four incidents obtained from a search of the National Incident Recording System (NIRS) for January to December 2006.

NIRS covers England and Wales only.

<table>
<thead>
<tr>
<th>Event No.</th>
<th>Incident Operational Region</th>
<th>Grid Ref. (confirmed)</th>
<th>Air Env. Impact Level</th>
<th>Land Env. Impact Level</th>
<th>Water Env. Impact Level</th>
<th>Pollutant (Tier2)</th>
<th>Pollutant detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>379181</td>
<td>EA Wales</td>
<td>SS 77510 88617</td>
<td>Category 3 (Minor)</td>
<td>Category 4 (No impact)</td>
<td>Category 4 (No impact)</td>
<td>Smoke</td>
<td>Grey/white smoke</td>
</tr>
<tr>
<td>387783</td>
<td>EA Wales</td>
<td>SS 77500 88617</td>
<td>Category 3 (Minor)</td>
<td>Category 4 (No impact)</td>
<td>Category 4 (No impact)</td>
<td>Sulphide odour</td>
<td>Rotten egg odour</td>
</tr>
<tr>
<td>400795</td>
<td>EA Wales</td>
<td>SS 78409 87801</td>
<td>Category 3 (Minor)</td>
<td>Category 4 (No impact)</td>
<td>Category 4 (No impact)</td>
<td>Smoke</td>
<td>Red dust</td>
</tr>
<tr>
<td>438217</td>
<td>Midlands Region</td>
<td>SE 87450 10157</td>
<td>Category 3 (Minor)</td>
<td>Category 4 (No impact)</td>
<td>Category 4 (No impact)</td>
<td>Sulphide odour</td>
<td>Grey/white smoke</td>
</tr>
</tbody>
</table>
Appendix D Other information sources

Individual authors


Lisin V, 2003 Ways and Means of Environmental protection Improvement in Blast Furnace Slag Recycling on open sites, STAL' 2003 Part 1, pages(s) 107 METALLURGIIA 0038-920X


Official documents


### Useful websites

<table>
<thead>
<tr>
<th>Source</th>
<th>URL*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pollution Prevention Guidance Notes (PPGs)</td>
<td><a href="http://www.environment-agency.gov.uk/business/444251/444731/ppg/">http://www.environment-agency.gov.uk/business/444251/444731/ppg/</a></td>
</tr>
<tr>
<td>European Court of Justice (ECJ): list of leading cases and judgements on the environment</td>
<td><a href="http://ec.europa.eu/environment/law/cases_judgements.htm">http://ec.europa.eu/environment/law/cases_judgements.htm</a></td>
</tr>
<tr>
<td>Waste &amp; Resources Action Programme (WRAP)</td>
<td><a href="http://www.wrap.org.uk">http://www.wrap.org.uk</a></td>
</tr>
</tbody>
</table>
Blast furnace slag (BFS) is an industrial co-product whose production is controlled within specific parameters during the manufacturing of iron. BFS is chemically and mineralogically as consistent as naturally occurring aggregates. It consists, comprising primarily of the silicates and aluminosilicates of calcium and magnesium together with other compounds of sulphur, iron, manganese and other trace elements. A typical chemical analysis is shown below:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaO</td>
<td>41.0</td>
</tr>
<tr>
<td>SiO₂</td>
<td>35.0</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>14.0</td>
</tr>
<tr>
<td>MgO</td>
<td>7.0</td>
</tr>
<tr>
<td>S</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Controlled waste is household, commercial and industrial waste. Controlled waste is defined in section 30 of the Control of Pollution Act 1974, section 75 of the Environmental Protection Act 1990 and the Controlled Waste Regulations 1992 (as amended). Paragraphs 9(2) and 10(3) to Schedule 4 of the Waste Management Licensing Regulations 1994 provide that any reference to ‘waste’ in Part I of the 1974 Act or Part II of the 1990 Act includes a reference to Directive waste.

The Duty of Care is set out in section 34 of the Environmental Protection Act 1990 and associated regulations. It applies to anyone who is the holder of controlled waste.

Persons concerned with controlled waste must ensure that the waste:
- is managed properly;
- is recovered or disposed of safely;
- does not cause harm to human health or pollution of the environment;
- is transferred only to someone who is authorised to receive it.

The duty applies to any person who produces, imports, carries, keeps, treats or disposes of controlled waste or, as a broker, has control of such waste.

A Quality Protocol sets out criteria for the production of a product from a specific waste type. Compliance with these criteria is considered sufficient to ensure that the recovered product may be used without risk to the environment or harm to human health, and therefore without the need for waste regulatory control. In addition, the Quality Protocol indicates how compliance may be demonstrated and points to best practice for the use of the recovered product.

A person who transports controlled waste, within the UK, including journeys into and out of the UK.

The Waste Framework Directive requires that establishments and undertakings that collect or transport waste on a professional basis or which arrange for the disposal or recovery of waste (dealers or brokers) must be registered. This is implemented in domestic legislation by the Control of Pollution (Amendment) Act 1989. Persons who carry waste as part of their business are required to be registered with the Environment Agency/SEPA/Environment and Heritage Service (as appropriate).