

**Position Paper**  
**on the Status of Ferrous Slag**

complying with the  
**Waste Framework Directive (Articles 5 / 6)**  
**and the REACH Regulation**

**April 2012**



**The European Slag Association**

SECRETARY:

Bliersheimer Strasse 62 47229 Duisburg GERMANY

Phone

Fax

E-Mail [info@euroslag.org](mailto:info@euroslag.org)



**The European Steel Association**

Avenue Ariane, 5 1200 Brussels BELGIUM

Phone

Fax

E-Mail [@eurofer.be](mailto:@eurofer.be)

**Position Paper on the status of Ferrous Slag  
complying with the Waste Framework Directive 2008/98/CE (Articles 5 / 6) and the REACH  
Regulation**

(April 2012)

**INDEX**

<b>0. Preamble</b>	<b>1</b>
<b>1. Introduction and objectives of the paper</b>	<b>1</b>
<b>2. Legal background</b>	<b>2</b>
2.1 Waste Framework Directive 2008/98/CE – Article 5	2
2.2 Waste Framework Directive 2008/98/CE – Article 6	2
2.3 Communication of the EU Commission 2007	4
2.4 European Waste Catalogue	4
<b>3. Current situation on slag</b>	<b>5</b>
3.1 Ferrous slag types available in the European countries and their registration under REACH	5
3.2 Present status of slag in the European countries	7
3.3 Production and use statistics	8
3.4 Standardisation of ferrous slag and quality control during production	10
3.5 Fields of application	12
<b>4. Ferrous slag and the environment</b>	<b>13</b>
4.1 Evaluation of ferrous slag within REACH	14
4.2 Additional benefits	14
<b>5. Slag in the light of the WFD requirements</b>	<b>14</b>
5.1 The relevance of the criteria of Article 5 regarding slag	14
5.2 The relevance of the criteria of Article 6 regarding ferrous slag	16
<b>6. Conclusion</b>	<b>17</b>

**Position Paper on the status of Ferrous Slag  
complying with the Waste Framework Directive 2008/98/CE (Articles 5 / 6) and the  
REACH Regulation**

(April 2012)

**0. Preamble**

This paper has been developed by EUROSLAG. It outlines the view of the European steel and slag industry (including processing companies) as represented by the members of EUROSLAG and EUROFER in relation with the classification of ferrous slags (blast furnace and steel slag) and based on the prerequisites given by the Waste Framework Directive (Directive 2008/98/EC) [1]. It aims at supporting the coming comitology procedure to classify ferrous slags especially with respect to Article 5 "By-products" and Article 6 "End-of-waste status".

This paper deals only with blast furnace and steel slag, excluding other types of slag e.g. non ferrous slag.

**1. Introduction and objectives of the paper**

The legal status of ferrous slag – i.e. their classification as either waste, product or by-product has been discussed worldwide for more than 25 years. EUROSLAG has presented its views on this issue in 2006 by the position paper entitled "Legal Status of Slags" [2]. By this document, it was stressed that a general classification of slag as waste completely disregards its actual handling by the steel works, as well as by processors, or producers of slag derived building and fertilising materials and by the market. Therefore the general classification of slag by national regulators as waste is not accepted by the industry. A conclusion of the above-mentioned document was that slags are intentionally generated by-products.

In December 2008, the revised Waste Framework Directive 2008/98/CE - WFD - came into force and the deadline for its transposition in the Member States was 12/12/2010. Regarding Articles 5 and 6, the WFD now allows for a clear definition of criteria characterising a by-product (Article 5) as well as a substance or material which shall cease to be regarded as waste (Article 6) and finally becomes a useful product/secondary raw material.

In the case of ferrous slags, there are two possibilities:

- Slag is considered as a by-product already in the liquid state, directly after its manufacture, with or without processing steps.
- Slag is first considered as waste but ceases to be waste after a number of recovery measures.

By this position paper the steel and slag industry intends to provide the necessary elements to substantiate their claim that ferrous slag is either a by-product or a product/secondary raw material relating to the possible cases given above.

## 2. Legal background

### 2.1 Waste Framework Directive 2008/98/CE – Article 5

The Waste Framework Directive (Directive 2008/98/EC) introduced **Article 5 "By-products"** defining the conditions needed to classify a material as a by-product by the following criteria:

1. *A substance or object, resulting from a production process, the primary aim of which is not the production of that item, may be regarded as not being waste referred to in point (1) of Article 3 but as being a by-product only if the following conditions are met:*
  - (a) *further use of the substance or object is certain;*
  - (b) *the substance or object can be used directly without any further processing other than normal industrial practice;*
  - (c) *the substance or object is produced as an integral part of a production process; and*
  - (d) *further use is lawful, i.e. the substance or object fulfils all relevant product, environmental and health protection requirements for the specific use and will not lead to overall adverse environmental or human health impacts.*
2. *On the basis of the conditions laid down in paragraph 1, measures may be adopted to determine the criteria to be met for specific substances or objects to be regarded as a by-product and not as waste referred to in point (1) of Article 3. Those measures, designed to amend non-essential elements of this Directive by supplementing it, shall be adopted in accordance with the regulatory procedure with scrutiny referred to in Article 39(2).*

*Article 39: Committee procedure*

1. *The Commission shall be assisted by a committee.*
2. *Where reference is made to this paragraph, Article 5a(1) to (4) and Article 7 of Decision 1999/468/EC shall apply, having regard to the provisions of Article 8 thereof.*
3. *Where reference is made to this paragraph, Articles 5 and 7 of Decision 1999/468/EC shall apply, having regard to the provisions of Article 8 thereof.*

*The period laid down in Article 5(6) of Decision 1999/468/EC shall be set at three months.*

The reference to Article 39 means that the EU Commission intends to decide on criteria when materials or substances have to be regarded as by-products by the so-called comitology procedure. Until now a comitology procedure to classify slag as by-products has not yet been started but representatives of the EU Commission announced that it is planned for 2012 or 2013.

### 2.2 Waste Framework Directive 2008/98/CE – Article 6

The Waste Framework Directive (Directive 2008/98/EC) also introduced **Article 6 "End of Waste Status"** defining conditions for materials that fall outside the definition of by-products according to Article 5 but have the potential to cease to be waste. Such materials or substances are initially regarded as waste but may leave the waste regime and become a product/secondary raw material by fulfilling the following criteria:

1. *Certain specified waste shall cease to be waste within the meaning of point (1) of Article 3 when it has undergone a recovery, including recycling, operation and complies with specific criteria to be developed in accordance with the following conditions:*

- (a) the substance or object is commonly used for specific purposes;*
- (b) a market or demand exists for such a substance or object;*
- (c) the substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products; and*
- (d) the use of the substance or object will not lead to overall adverse environmental or human health impacts.*

*The criteria shall include limit values for pollutants where necessary and shall take into account any possible adverse environmental effects of the substance or object.*

2. *The measures designed to amend non-essential elements of this Directive by supplementing it relating to the adoption of the criteria set out in paragraph 1 and specifying the type of waste to which such criteria shall apply shall be adopted in accordance with the regulatory procedure with scrutiny referred to in Article 39(2). End-of-waste specific criteria should be considered, among others, at least for aggregates, paper, glass, metal, tyres and textiles.*

3. *Waste which ceases to be waste in accordance with paragraphs 1 and 2, shall also cease to be waste for the purpose of the recovery and recycling targets set out in Directives 94/62/EC, 2000/53/EC, 2002/96/EC and 2006/66/EC and other relevant Community legislation when the recycling or recovery requirements of that legislation are satisfied.*

4. *Where criteria have not been set at Community level under the procedure set out in paragraphs 1 and 2, Member States may decide case by case whether certain waste has ceased to be waste taking into account the applicable case law. They shall notify the Commission of such decisions in accordance with Directive 98/34/EC of the European Parliament and of the Council of 22 June 1998 laying down a procedure for the provision of information in the field of technical standards and regulations and of rules on Information Society services where so required by that Directive.*

Concerning the development of specific criteria mentioned in point (1) of Article 6, the Commission has asked the European Commission's Joint Research Center (JRC), Seville, to draft the Reports "End of waste criteria, Part: Aggregates" [3] and "Study on the selection of waste streams for End of Waste assessment" [4]. In these reports it was stressed that concerning environmental issues, the leaching requirements are a key aspect and will need to be specifically documented. Among others the JRC-Studies suggest to use leaching requirements that are established to define inert waste in the Landfilling Directive [5] [5a] or to develop new European end of waste pollutant limit values for recycled and secondary aggregates that cease to be waste. However, the steel industry has always been pointing out that the Landfilling Directive is not applicable to building products.

In this context, also a comitology procedure is being considered at either the European level or, alternatively, at each Member States' own level. At the end of 2010, the Institute for Prospective Technological Studies (IPTS) in Sevilla (which is one of the seven scientific institutes of the JRC) has invited to tender studies on methodological aspects regarding limit values for pollutants in aggregates in the context of the development of end-of-waste criteria under WFD. Early in 2011, this study has been awarded by the EU Commission to DHI consultancy (Denmark).

### 2.3 Communication of the EU Commission 2007

Before the revision of the Waste Framework Directive there was no definition of by-products in the European legislation. However, the Commission already acknowledged the need for clarification and released the "Communication from the Commission to the Council and the European Parliament on the Interpretative Communication on waste and by-products" [COM(2007)59 final] [6]. One of the examples of material falling out of the definition of waste given in the Communication is blast furnace slag. The Commission came to the following decision stressed by Annex I, paragraph 1:

*"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.**"*

Parallel to this statement it is stressed by "Annex II – a decision tree for waste versus by-product decisions" that in the case the material

- is ready for use without further processing (other than normal processing as an integral part of the production process) and
- is produced as an integral part of the production process

it can be classified as a **non-waste by-product**.

This classification accepted by the EU Commission could only be achieved because the iron and steel industry was able to demonstrate already in 2007 that all criteria given now in Article 5 of WFD have been fulfilled by blast furnace slag producers in Europe.

However, Annex 1, paragraph 1, also reads:

"In contrast to blast furnace slag, de-sulphurisation slag is produced due to the need to remove sulphur prior to the processing of iron into steel. The resulting slag is rich in sulphur, cannot be used or recycled in the metallurgical circuit and is therefore usually disposed of in a landfill."

In 2007, the European Steel Industry accepted the classification of de-sulphurisation slag as waste, but meanwhile some steel companies stopped disposing of it and are now processing this slag in such a way that it can be used as a fertilising agent.

In this case de-sulphurisation slag may initially be regarded as waste but ceases to be a waste after being processed to become a fertiliser. Thus, Article 6 of the WFD may be applied for this specific type of slag.

### 2.4 European Waste Catalogue

The European Waste Catalogue (EWC) [7] established by the Commission Decision 2000/532/ECC of May 3<sup>rd</sup>, 2000 contains two entries regarding slag:

- 10 02 01 waste from the processing of slag
- 10 02 02 unprocessed slag

The steel industry has accepted that, in some cases, a slag may be classified by either entry 10 02 01 or 10 02 02, but with regard to unprocessed slag it is important to stress that already in 2002, and on the request of Germany, the EU Commission agreed that industrial operations such as:

- granulation,
- pelletisation,
- foaming,
- proper solidification connected with a specified heat treatment and
- separation, crushing, sieving (screening), milling (grinding)

are examples of slag processing [8].

Even though the treatment of liquid slag with  $O_2$  and  $SiO_2$  as well as with Borax and other similar stabilisation substances was not specifically mentioned by the Commission, as it was still under development at that time, it is used today as well-established industrial process to stabilize steel slag already in the liquid stage.

Thus, the criteria given above mean that a slag which has undergone one or more of these processes is not covered by the EWC. This slag has no EWC number and should not be classified as waste.

It should also be stressed that the industrial processes listed above, belong today to a fully integrated slag generation process and do not change the inherent chemical composition of the slag but merely improve its physical and mechanical properties as a continuation of the production process without any interruption.

### **3. Current situation on slag**

#### **3.1 Ferrous slag types available in the European countries and their registration under REACH**

Ferrous slag is generated during iron and steel making processes. Depending on the steel production process different slag types can be manufactured. In Europe, generally the following four different slag families can be identified:

- blast furnace slag (air-cooled or granulated)
- basic oxygen furnace slag
- electric arc furnace slag (from carbon or stainless/high alloy steel production)
- secondary metallurgical slag (e.g., de-sulphurisation slag)

Just after implementation of the REACH regulation in 2007 [9], the members of the FEhS-Institute and EUROSLAG initiated - in agreement with EUROFER - the registration of iron and steel slags as substances. Assuming that slags in general are not wastes but by-products or products/secondary raw materials, in 2009 the REACH Ferrous Slag Consortium – RFSC was founded to prepare the registration of ferrous slag before December 1<sup>st</sup>, 2010. During the registration process, the available data on slag compositions and corresponding production processes from all European countries were evaluated and intensively discussed. As a result, the existing EINECS definitions have been revised. It was agreed to register all slag types as UVCB substances which are best described by their production process. Other identifiers are the most frequently found mineral components and, as additional information, the chemical composition.

Because of differing properties, the family for electric arc furnace slag was split. One family covering slag generated during carbon steel production and another family covering slag from high alloy/stainless steel production. In 2009, ECHA agreed on the separation of these slag types. Subsequently, new EINECS numbers (but no CAS numbers) were issued for these slag families (see Table 1). Finally, the registration was successfully filed by RFSC-members which altogether represented 97 % of the European steel production of the year 2007. The registered slag families and the relevant CAS- and EINECS-numbers are given in Table 1. Usually, the so-called ABS and GBS are summarized as "blast furnace slag", while BOS, EAF C, EAF S and SMS are called "steel slags" (see table 1). The families SMS and EAF S include secondary metallurgical slag.

Family no.	Common name		EINECS name	EINECS No. CAS No.
1	Granulated Blast furnace Slag	GBS	Slag, ferrous metal, blast furnace (granulated)	266-002-0 65996-69-2
	Air-cooled Blast furnace Slag	ABS	Slag, ferrous metal, blast furnace (air-cooled)	266-002-0 65996-69-2
2	Basic Oxygen furnace Slag (converter slag)	BOS	Slag, steelmaking, converter	294-409-3 91722-09-7
3a	Electric Arc Furnace slag (from Carbon steel production)	EAF C	Slag, steelmaking, elec. furnace (carbon steel production)	932-275-6 294-410-9 <sup>a</sup> 91722-10-0 <sup>a</sup>
3b	Electric Arc Furnace slag (from Stainless/ high alloy steel production)	EAF S	Slag, steelmaking, elec. furnace (stainless/high alloy steel production)	932-476-9 294-410-9 <sup>a</sup> 91722-10-0 <sup>a</sup>
4	Steelmaking slag	SMS	Slag, steelmaking	266-004-1 65996-71-6

Table 1: Slag families and corresponding CAS- and EINECS-numbers; <sup>a</sup> = "old" EINECS or CAS numbers

As the production processes of the relevant slag types are the most import criteria for their identification, descriptions are given in the following:

#### **Slag, ferrous metal, blast furnace (granulated - GBS or air cooled - ABS)**

Blast furnace slag is manufactured during the production of iron by thermo-chemical reduction in a blast furnace. It is formed in a continuous process by the fusion of limestone (and/or dolomite) and other fluxes with the residues from the carbon source and the non-metallic components of the iron bearing materials (e.g. iron ore, iron sinter). Blast furnace slag is generated at temperatures above 1500 °C. Dependent on the way of cooling of the liquid slag it can be distinguished between crystalline air-cooled blast furnace slag (ABS) and glassy granulated blast furnace slag (GBS).

#### **Slag, steelmaking, converter - BOS**

Converter slag is formed during the conversion of liquid iron (hot metal) into steel during a batch process in a basic oxygen furnace. The slag is generated by the addition of fluxes, such as limestone and/or dolomite, during blowing oxygen into the melt. Due to the oxidising conditions some elements (like Fe and Mn) are partly oxidised and contribute to the formation of the slag. Furthermore some components are either oxidised to gas (like carbon) or are chemically bound in the slag (like silicon or phosphorus). The liquid slag which has tapping temperatures of around 1600 °C is air-cooled under controlled conditions in pits forming crystalline slag.

#### **Slag, steelmaking, elec. furnace - EAF C (carbon steel production)**

Electric arc furnace slag from carbon steel production is formed during melting steel scrap in an electric arc furnace. The slag is generated by the addition of fluxes, such as limestone



and/or dolomite. Furthermore some elements of the melt are oxidised and contribute to the formation of the slag. The liquid slag which has tapping temperatures of around 1600 °C is air cooled (possibly applying small amounts of water) under controlled conditions in pots or pits forming crystalline slag.

### **Slag, steelmaking, elec. furnace - EAF S (stainless/high alloy steel production)**

Electric arc furnace slag from stainless steel production is formed during the manufacture of stainless or high alloy steel in different metallurgical vessels, e. g. electric arc furnace, converter and ladles. In this process, scrap (in some cases direct reduced iron) together with alloys is melted to stainless or special steel by means of electrical and chemical energy. The slag is generated by the addition of fluxes and reducing agents, e.g. lime and/or dolomite, silicon compounds or aluminium. The liquid slag which has tapping temperatures of around 1600°C is controlled and treated if necessary to improve the properties of the slag. Then, the slag is cooled under controlled conditions in pots or pits forming crystalline slag.

### **Slag, steelmaking**

Steelmaking slags are generated during the steel production process. They arise e.g., from the conversion of hot metal to steel, from melting scrap in an electric arc furnace or from the subsequent treatment of crude steel. The composition of the slags varies depending on the process step in which they are produced. The molten slag which has tapping temperatures of around 1600°C is discharged into pots or pits where it cools and solidifies to provide an artificial aggregate having a crystalline structure.

## **3.2 Present status of slag in the European countries**

The situation concerning the evaluation of substances and materials that are generated in parallel to the production of a main product is not uniform within the Member States of Europe. Table 2 gives some examples of the different classifications of ferrous slag in the EU. Due to expertise and agreements with environmental authorities in various countries, some of the slag types are recognized as non-wastes, products or by-products (e.g., in Belgium, Finland, Germany, Austria and the United Kingdom) but still have a waste status in some other countries. Steel slags in particular are often considered as waste, especially in the liquid state and before treatment.

Country/year	Slag Type	Classification as
Austria 1991	GBS	non waste
Austria 1999	GBS	product
Germany 1997	EAF-slag produced by BSW	non waste
Germany 1999 North-Rhine-Westphalia	processed BOS	Product
Germany 2006/2007 North Rhine-Westphalia	ABS/GBS/BOS	non waste
Belgium 2007	GBS	by-product (as basic component for cement production)
EU 2007	ABS/GBS	by-product
UK 2007	ABS/GBS	by-product
Finland 2002	ferrous slag	waste
Finland 2008	ABS/GBS and steel slag fertiliser	product

**Table 2:** Examples for national decisions on the classification of ferrous slag in EU member states; (BSW = Badische Stahlwerke GmbH, Kehl, Germany)

This uncertain situation concerning the classification of slag as waste, non-waste, product or by-product results in serious restrictions in the domestic and cross-border shipment of these materials in Europe. In most cases, requirements of the waste shipment regulation are to be used during cross border operations although in cases where the by-product status has been recognized by the EU Commission, e.g. for blast furnace slag [6], waste requirements should not be mandatory (see chapter 2.3).

In detail, the following negative consequences in marketing of ferrous slag are to be considered:

- unfair competition due to different interpretations of the waste definition among the member states
- potential obligation for the production facilities to obtain a permit as waste treatment facilities (delay, loss of production, investment, expenses)
- more bureaucracy and documentation obligations (permission procedure, accompanying documents, monitoring, waste recovery and disposal records)
- increased handling expenses (transport regulations, taxation import/export)
- trade restrictions (European Waste Shipment Regulation)

### **3.3 Production and use statistics**

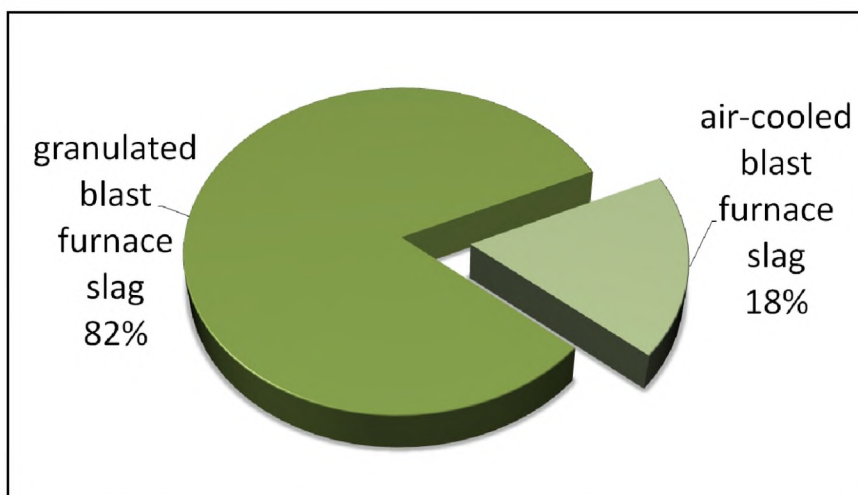
To assess the importance of the different slag types and of the products manufactured from them, EUROSLAG has conducted a series of surveys among European steelworks every two years since 2000. The results of the 2010 questionnaire are given in Figures 1 - 4.<sup>\*</sup> In total, 45.3 million tonnes of ferrous slags were generated in 2010.

#### **3.3.1 Blast furnace slag**

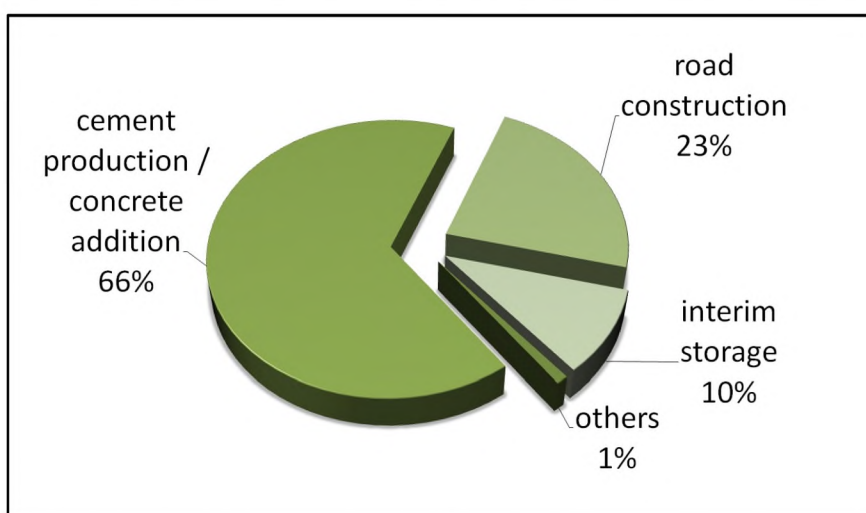
The blast furnace slag generated, amounted to about 23.5 million tonnes in 2010. About 82 % of this amount was granulated, 18 % accrued as air-cooled crystalline slag. The rate of utilization of these slags was somewhat higher (25.6 million tonnes, figure 2) than the production rate because slag from deposits was also used.

About 66 % of the generated blast furnace slag was used as a component for the cement production or as concrete addition (figure 2). Other uses such as aggregate in road construction account for approximately 23 %. Usually, most European countries have a utilization rate of about 100 %. Only in the year 2010, the utilization rate fell to about 90 %.<sup>\*</sup>

<sup>\*</sup> Note: The year 2010 was still substantially influenced by the economic steel crisis of 2009, resulting in higher interim storage and disposal rates in the statistics as compared to normal conditions.



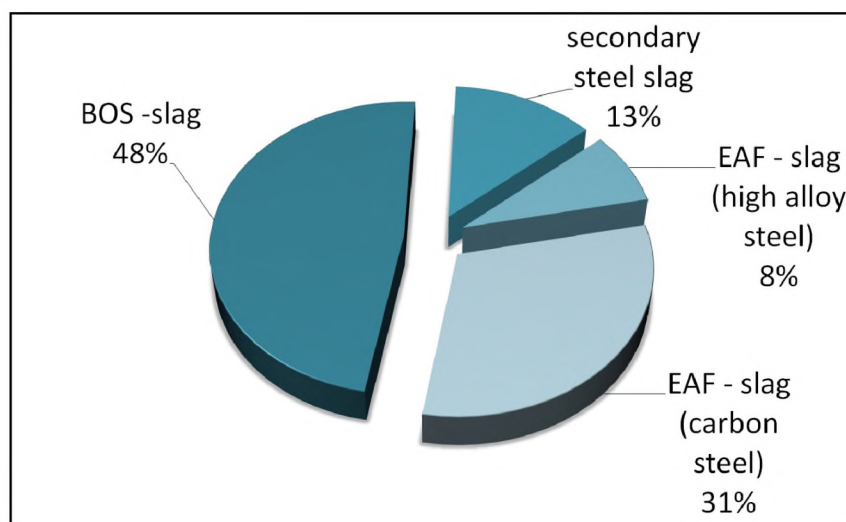
**Figure 1:** Production of blast furnace slag in 2010: 23.5 million tonnes



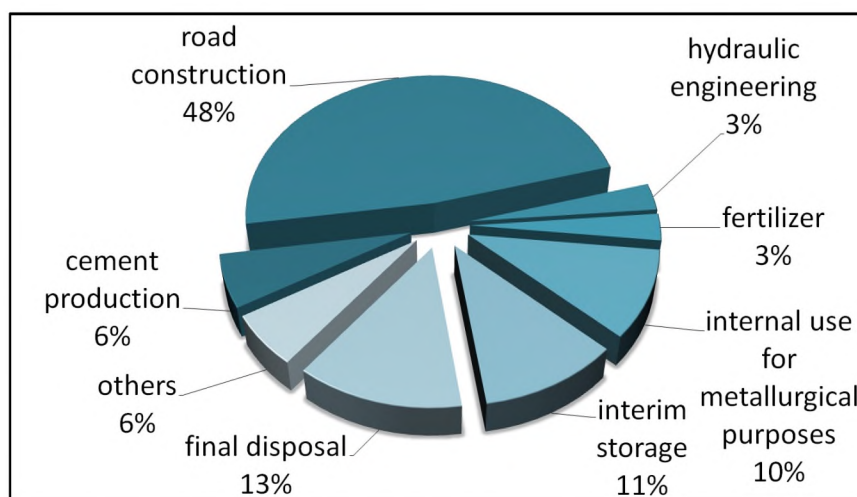
**Figure 2:** Use of blast furnace slag in 2010: 25.6 million tonnes

### 3.3.2 Steel slag

The amount of steel slag produced in 2010 totals about 21.8 million tonnes (figure 3). About 48 % of this amount was generated as basic oxygen furnace slag, 39 % as electric arc furnace slag and 13 % as secondary metallurgical slag. Dependent on the market situation and based on technical and legal considerations, about 76 % of the produced slag was used in qualified fields of application. About 11 % was temporarily stored to be used at a later time. Only a small part of steel slag (mostly secondary metallurgical slag) was taken to a final deposit; mostly due to their fine grain size and adverse properties with regard to leaching. The final deposit rate of 13 % in 2010 is much higher than in former years (which was about 6 % or less) due to the economic crisis. However, the main fields of application for steel slag are the production of aggregates for road construction (48 %). A small amount, between 1 and 10 %, is used for other purposes such as fertilizer, hydraulic engineering and internal use for metallurgical purposes.



**Figure 3:** Production of steel slag in 2010: 21.8 million tonnes



**Figure 4:** Use of steel slag in 2010: 22.3 million tonnes

### 3.4 Standardisation of ferrous slag and quality control during production

A prerequisite for the successful use of ferrous slag on the long term is the existence of approved standards where the relevant requirements, dependent on the field of use, are given. All ferrous slags placed on the market meet the requirements of national standards and specifications related to both technical and environmental aspects with regards to the intended use.

Starting in 1990, most of the requirements given in national standards relevant for the building industry have been harmonised and replaced by European standards. The most important European standards for the today's use of slag in the building sector and as fertilizer are given in [Table 3](#).

EN 197-1:	Cement - Part 1: Composition, specifications and conformity criteria for common cements
EN 206:	Concrete
EN 1744-1:	Tests for chemical properties of aggregates – Part 1: Chemical analysis
EN 1744-3:	Tests for chemical properties of aggregates – Part 3: Leaching of aggregates
EN 12945:	Fertiliser
EN 12620:	Aggregates for concrete
EN 13139:	Aggregates for mortar
EN 13043:	Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas
EN 13242:	Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction
EN 13383-1:	Armourstone - Part 1: Specification
EN 13383-2:	Armourstone - Part 2: Test methods
EN 13285:	Unbound mixtures – specifications
EN 14227-2:	Hydraulically bound mixtures - Specifications - Part 2: Slag bound mixtures
EN 14227-12:	Hydraulically bound mixtures – Specifications – Part 12: Soil treated by slag
EN 15167-1:	Ground granulated blastfurnace slag for use in concrete, mortar and grout Part 1: Definitions, specifications and conformity criteria
EN 13282:	Hydraulic road binders – Composition, specifications and conformity criteria
EN 13450	Aggregates for railway ballast

Table 3: Relevant European standards for the use of ferrous slag

These standards meet high levels of technical issues, especially as these standards also apply to primary raw materials and other materials from secondary sources.

Concerning the health and environmental protection, national regulations are still to be applied as no common European standards or regulations regarding the evaluation of harmful substances are yet available. Most of the European countries have developed their own directives and regulations as a basis for marketing by-products or secondary raw materials/products. The “Besluit bodemkwaliteit” of The Netherlands (Soil quality decree) [10], the planned German “Ersatzbaustoffverordnung” (Regulation for the utilization of alternative materials as building materials) [11], the most recent publication of the French Guidelines “Acceptabilité de matériaux alternatifs en technique routière – Evaluation environnementale” (environmental acceptance of secondary sources materials in road works) [12] and regional decrees in Spain (Basque Country, Catalonia and Cantabria) [13] are examples for such regulations.

However, the given chemical, physical and ecological requirements are consistently fulfilled by the generated slag that is intended to be placed on the market. Some slag-derived products even exceed the technical properties of competitive natural products by far.

Continuous production controls made by the producer in accordance with the relevant factory production control (FPC) system, as described in the particular standard, allows for the proper qualification of a slag for a given use. All European standards relevant for slag contain conformity criteria mainly based on a FPC system. In fact and for instance, the FPC is mentioned in the recently published Construction Product Regulation 305/2011 [14] as a means of ensuring the fulfilment of the relevant harmonised technical specifications. In most EU countries the producer’s FPC system is certified by a third party and most slag products are labelled and traded with a CE-mark.

### 3.5 Fields of application

Table 4 gives typical fields of application of slag produced in European countries. Based on the long term experience concerning various fields of applications, it has to be stated that the use of blast furnace and steel slag – crystalline or vitrified – is as environmentally sound as that of similar natural primary products and does not present any increased risk to human health or the environment (see chapter 4.1).

Slag	Nomenclature	Manufacturing Process	Applications (examples)
Blast Furnace Slag, air – cooled - ABS	Slag, ferrous metal, blast furnace (air-cooled)	Crushing and screening of the air cooled slag. Also available as uncrushed slag.	<b>As aggregate for:</b> <ul style="list-style-type: none"> <li>- bituminous and hydraulically bound mixtures (asphalt, concrete, road binder etc.)</li> <li>- unbound mixtures (unbound surface layers and wearing courses etc.)</li> <li>- waste water treatment</li> <li>- embankments and fill</li> <li>- railway ballast</li> <li>- roofing</li> <li>- ground stabilisation</li> </ul> <b>For the manufacture of:</b> <ul style="list-style-type: none"> <li>- stone wool</li> <li>- glass (blended with other components)</li> <li>- fertilizer</li> </ul>
Blast furnace slag, granulated – GBS or GGBS	Slag, ferrous metal, blast furnace (granulated or ground granulated)	Rapid quenching of the molten slag with high pressure, high volume water sprays, grinding of the granulated slag to cement fineness	<b>As aggregate for:</b> <ul style="list-style-type: none"> <li>- bituminous and hydraulically bound mixtures (asphalt, concrete, road binder etc.)</li> <li>- unbound mixtures (unbound surface layers and wearing courses etc.)</li> <li>- embankments and fill</li> <li>- sand blasting</li> <li>- ground stabilisation</li> </ul> <b>For the manufacture of:</b> <ul style="list-style-type: none"> <li>- cement and other hydraulically binders</li> <li>- concrete (as GGBS)</li> <li>- fertilizer (ground)</li> <li>- stone wool</li> <li>- glass (blended with other components)</li> </ul>
Basic Oxygen Furnace Steel Slag - BOS	Slag, steelmaking, converter	Crushing and screening of the slag that has been air cooled and watered.	<b>As aggregate for:</b> <ul style="list-style-type: none"> <li>- bituminous and hydraulically bound mixtures (asphalt, concrete, road binder etc.)</li> <li>- top layers for high skid resistance</li> <li>- unbound mixtures (unbound surface layers and wearing courses etc.)</li> <li>- dams (road construction and noise protection)</li> <li>- waste water treatment</li> <li>- embankments and fill</li> <li>- railway ballast</li> <li>- sealing in surface layers to protect deposits</li> <li>- roofing</li> <li>- armour stone</li> <li>- gabions and noise absorbing walls</li> <li>- ground stabilisation</li> </ul> <b>For the manufacture of:</b> <ul style="list-style-type: none"> <li>- cement and other hydraulic binders</li> <li>- stone wool</li> <li>- glass (blended with other components)</li> <li>- fertilizer</li> </ul>

Electric Arc Furnace Steel Slag – EAF C	Slag, steelmaking, elec. furnace (carbon steel production)	Crushing and screening of the slag that has been air cooled and watered.	<b>As aggregate for:</b> <ul style="list-style-type: none"> <li>- bituminous and hydraulically bound mixtures (asphalt, concrete, road binder etc.)</li> <li>- top layers for high skid resistance</li> <li>- unbound mixtures (unbound surface layers and wearing courses etc.)</li> <li>- dams (road construction and noise protection)</li> <li>- waste water treatment</li> <li>- embankments and fill</li> <li>- railway ballast</li> <li>- sealing in surface layers to protect deposits</li> <li>- roofing</li> <li>- armour stone</li> <li>- gabions and noise absorbing walls</li> <li>- ground stabilisation</li> </ul> <b>For the manufacture of:</b> <ul style="list-style-type: none"> <li>- cement and other hydraulic binders</li> <li>- stone wool</li> <li>- glass (blended with other components)</li> </ul>
Electric Arc Furnace Steel Slag –EAF S	Slag, steelmaking, elec. furnace (stainless/high alloy steel production)	Crushing and screening of the slag that has been air or water cooled and watered.	<b>As aggregate for:</b> <ul style="list-style-type: none"> <li>- bituminous and hydraulically bound mixtures (asphalt, concrete, road binder etc.)</li> <li>- unbound mixtures (unbound surface layers and wearing courses etc.)</li> <li>- dams (road construction and noise protection)</li> <li>- embankments and fill</li> <li>- sealings in surface layers to protect deposits</li> <li>- top layers for high skid resistance</li> <li>- roofing</li> <li>- armour stone</li> <li>- gabions and noise absorbing walls</li> <li>- industrial neutralisation product</li> <li>- ground stabilisation</li> </ul> <b>For the manufacture of:</b> <ul style="list-style-type: none"> <li>- cement and other hydraulic binders</li> <li>- stone wool</li> <li>- glass (blended with other components)</li> </ul>

**Table 4:** Typical slag applications practiced in Europe

Additionally, steel slag materials show promising results as a filter material for the removal of phosphorus and heavy metals from wastewaters. Some available results and data of full scale slag filters, assume an average removal of 75 % and a max retention of 1.25 g P/g slag in a real wastewater environment. However, the fact that steel slag aggregates are often considered as waste in the legislative language hampers the recognition process of steel slag as a water filtration material.

Beyond Europe, new fields of applications, with good environmental returns, are currently being developed. They include the development of new materials for restoring seaweed beds and marine fertilizer products to restore sea desertification areas. Another innovative use, already in practice in some countries, is a scientific, safe and environmentally friendly method for the transplantation of corals using slags as a major part of the process of restoration and protection of the existing reefs, and building new artificial reefs. It has achieved the challenge of reducing the cost involved in rebuilding/creating a reef to populate a lifeless area.

#### 4. Ferrous slag and the environment

So far, no case of negative environmental impact by ferrous slag has ever been reported when slag was used strictly in accordance with the requirements of the relevant regulation(s).

#### 4.1 Evaluation of ferrous slag within REACH

During the REACH registration process, numerous tests and investigations were required addressing the chemistry as well as the environmental and ecological effects of the registered substance. The effect of use of the substance on human health and the environment were especially investigated. In this context an extensive literature research was performed on the one hand. On the other hand, numerous additional toxicity (e.g., skin and eye irritation, skin sensitisation, gene mutation in bacteria, cytogenicity in mammalian cells) and ecotoxicity (e.g., short- and long-term toxicity on invertebrates, effects on soil micro-organisms, toxicity to terrestrial plants, growth inhibition of algae) tests were carried out. On the basis of the currently available test results, it could be shown that ferrous slags that were investigated are not hazardous.

#### 4.2 Additional benefits

The use of ferrous slag – crystalline or vitrified – instead of natural rocks such as limestone or granite not only saves the energy that may be required to mine natural aggregates, but also eliminates the negative impacts associated with mining such as effects on biodiversity or disruption of the landscape. In the case of cement manufacture, the use of granulated blast furnace slag instead of clinker reduces the overall process CO<sub>2</sub>-emissions as a result of fuel savings and avoidance of sintering limestone or other calcareous materials. Calculations made by the German FEhS – Institute for Building Materials Research and based on the method given in [15] have shown that CO<sub>2</sub>-emissions were reduced by about 22 million tonnes in the cement industry (hence in the industry as a whole) in Europe in 2008 because of the use of 24 million tonnes of granulated blast furnace slag [16]. The reduction is equivalent to the Kyoto objective of countries like Belgium and The Netherlands together. Hence, blast furnace slag contributes positively to the sustainability of the whole European industry and in the fight against climate change.

### 5. Slag in the light of the WFD requirements

#### 5.1 The relevance of the criteria of Article 5 regarding slag

The criteria of Article 5 WFD will be checked based on the relevance to ferrous slag.

- **Further use of the substance or object is certain**

As stressed in paragraph 3.3, today 90-100 % of the blast furnace slag produced in Europe is used mainly for the production of cement or as addition for concrete. With regard to steel slag, a small quantity (about 13 % in 2010 and less in former years) has to be dumped due to its fine grained properties or due to environmentally related leaching behaviour. However, about 76 % is used for building purposes or as fertilizer.

Furthermore, the specific mention of the condition of use of iron and steel slags in all the aforementioned European and national standards is also the proof of the existence of a permanent and recurrent market that guarantees the use of slag.

Thus, the first criterion of Article 5 is totally fulfilled by blast furnace slag and to a great extent also fulfilled by steel slag, although the use is currently limited due to the waste “label” of steel slags.

Due to the upcoming new environmental friendly fields of applications (see chapter 3.5), the demand for steel slag is expected to increase in the near future.



- **The substance or object can be used directly without any further processing other than normal industrial practice**

In order to regulate the slag quality or to adjust the properties to requirements for a specific use, different measures are usually applied during the generation of slag. Such measures are:

- Treatments in the molten state like addition of aluminates to increase the basicity and the glass content of granulated blast furnace slag or the addition of  $O_2$  and  $SiO_2$  as well as other stabilisation substances (e.g., Borax) to influence the properties of steel slag due to the relevant requirements given by European or national product standards such as volume stability
- Specific treatment processes like moderate or rapid cooling
- Separation of the iron content by a magnetic process
- Weathering in order to achieve volume stability
- Modification of the slag *physical* properties by crushing, sieving and milling to achieve special grain sizes and mixtures in installations similar to the ones used for natural aggregates, to comply with European product standards

The choice of a measure is made at the beginning of the production process in order to ensure that the slag has the required technical and environmental qualities at the end of its production process.

In summary, it can be stated that slag has a controlled chemistry and that all the aforementioned treatments are done in order to improve the slag quality with the objective to fulfil a specific function. Moreover, all these treatments can definitely be considered as normal industrial practice.

Subsequently, blast furnace slag, as well as steel slag, complies with the second criterion of article 5.

However, steel slag that is discarded is an exception and is not conform to this criterion. But it is not only the case for steel slag, but also for all industrial products which do not meet certain technical specifications (standards) at the end of the production line and are rejected as improper for the intended use.

- **The substance or object is produced as an integral part of a production process**

Slag formation is part of the intrinsic process of steel production. It facilitates the reactions needed for the production of steel. Blast furnace slag is generated simultaneously with the production of liquid iron (hot metal) and steel slag is formed during the steel making process e.g. in the converter or the electric arc furnace. Thus, slag generation is definitely an integral part of the iron/steel production processes. Process conditions and raw materials for hot metal/steel making and slag generation are chosen with regard to all of the products/by-products.

Thus, both blast furnace slag as well as steel slag are consistent with the third given criterion of article 5.

- **Further use is lawful, i.e. the substance or object fulfils all relevant product, environmental and health protection requirements for the specific use and will not lead to overall adverse environmental or human health impacts**

Ferrous slags meet the requirements of national and European technical standards in relation with the intended use. The environmental and health requirements which are covered by national standards and directives [10, 11, 12 and 13] are generally fulfilled (see chapter 3.4). Furthermore, the results of the performed tests in relation to the REACH registration dossier support the conclusion that the use of slag will not lead to overall adverse environmental or human health impacts (see chapter 4.1).

Most of the European standards contain conformity criteria mainly based on factory production control (FPC). After the certification of FPC by a third party control, slag products will be labelled and traded with a CE-mark.

## **5.2 The relevance of the criteria of Article 6 regarding ferrous slag**

Article 6 will only be relevant if a slag is generated as waste. Due to the lack of harmonisation concerning the legal status of slag in Europe, some slag types are regarded as by-product in one country and as waste in others. This leads to unfair competition among the member states. As the EU Commission has already recognized the fact that blast furnace slag should be recognized as a by-product, the following criteria as given in Article 6 will only be reviewed in relation with steel slag.

If slag is initially produced as waste it can – after applying some specific measures e.g. processing to single sizes or mixtures – cease to be regarded as waste and can be brought onto the market as a product/secondary raw material.

Thus, the opportunity to overcome the waste status on a European level using the criteria of Article 6 is helpful and reasonable.

- **The substance or object is commonly used for specific purposes**

Only a small amount of steel slag (about 13 % in 2010 and less in former years) is being discarded which is normal in all production processes due to production accident or non compliance with intended specifications. In general, steel slag is used for specific purposes such as aggregate for road construction (see chapter 3.3.2). The common applications for steel slags are listed in Table 4.

- **A market or demand exists for such a substance**

As shown in Figure 4, the produced steel slag (76 %) is used on qualified fields of application and thus is brought onto the market. Subsequently, it can be stated that a market definitely exists for steel slag. Most of the producers service this market continuously within commercial contracts.

Furthermore, the fact that relevant European or national product standards exist is proof enough of the existence of numerous markets.

- **The substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to products**

As explained in chapter 3.4, steel slag that is used for specific purposes, meets the requirements of national and European regulations, directives and product standards relating to technical aspects with regard to the intended use.

- **The use of the substance or object will not lead to overall adverse environmental or human health impacts**

Steel slag that is not discarded but used for a specific application, meets all requirements of national standards concerning environmental aspects (see chapter 3.4). The results of the tests performed in relation to the REACH registration, support the conclusion that the use of steel slag will not lead to overall adverse environmental or human health impacts (see chapter 4.1).

In summary, it can be stated that steel slag can fulfil all end of waste criteria of article 6 leading to a product/secondary raw material classification.

## 6. Conclusion

The legal status determination of ferrous slags in relation with the respective criteria set out in articles 5 and 6 of the WFD is summarized in a flow sheet given in Annex 1.

In most cases ferrous slags shall be considered as by-products with regard to article 5 of the Waste Framework Directive.

In cases where a slag is initially generated as waste and is then processed in such a way that it can be used for specific purposes, it shall cease to be regarded as waste. As stressed in chapter 2.4, the EU Commission already agreed that treatments such as granulation, pelletisation, foaming, controlled solidification, separation, crushing, sieving, and milling are appropriate industrial processing steps which allow such processed slag to lose the waste status. Additionally, such processed slag

- is **commonly** used for specific purposes,
- has an identified market,
- fulfils the respective technical and environmental requirements for the intended purposes
- does not lead to environmental or human health impacts;

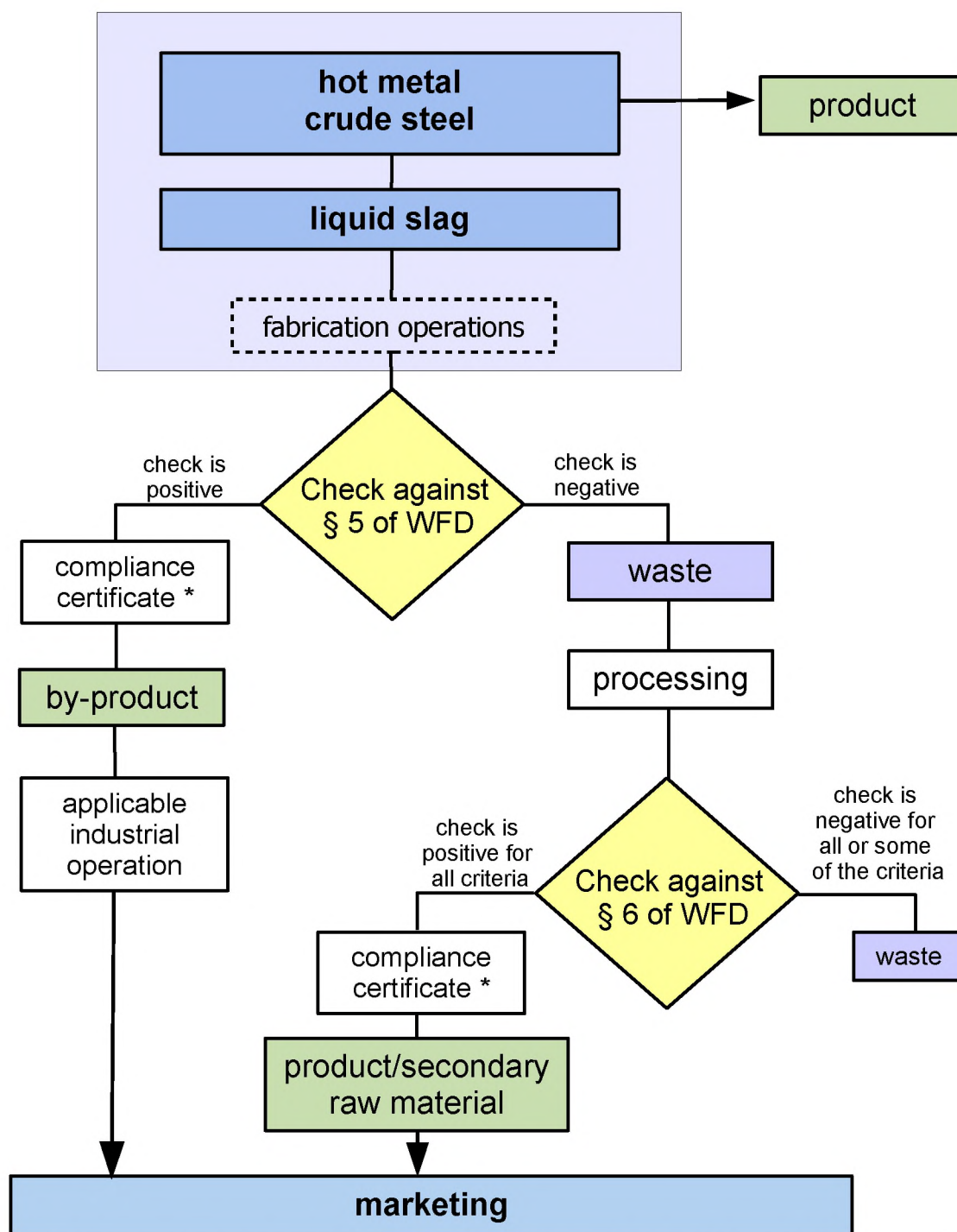
Therefore it fulfils all the criteria set out in article 6 of WFD.

Furthermore, the quality of ferrous slag is guaranteed by the relevant factory production control (FPC). Consequently, EUROSLAG and EUROFER suggest that no further end-of-waste criteria are needed.

## References

- [1] Directive [2008/98/EC] of the European Parliament and of the Council on waste
- [2] EUROSLAG (2006) "Legal Status of Slags", Position Paper
- [3] Joint Research Centre, JRC (2009) "End of Waste Criteria", final report, Chapter: Aggregates. Scientific and technical reports, Sevilla 2009
- [4] Joint Research Centre, JRC (2009) "Study on the selection of waste streams for End of Waste assessment", final report. Scientific and technical reports, Sevilla 2009
- [5] European Council (1999) Directive 1999/31/EC of 26 April 1999 on the landfill of waste

- [5a] Commission of the European communities, Brussels, 20.9.2002, COM(2002) 512 final Council Decision establishing criteria and procedures for the acceptance of waste at landfills pursuant to Article 16 and Annex II of Directive 1999/31/EC on the landfill of waste
- [6] Commission of the European Communities (2007) "Communication from the Commission to the Council and the European Parliament on the Interpretative Communication on waste and by-products" (COM(2007) 59 final, Brussels 21.02.2007
- [7] European Commission (2000) "European waste catalogue"
- [8] Letter from the European Commission to the Steel Trade Association, Düsseldorf, February 2002
- [9] Commission of the European Communities (2006) Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency, amending Directive 1999/45/EC and repealing Council Regulation (EEC) No 793/93 and Commission Regulation (EC) No 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/E
- [10] Dutch Ministry of Environment (VROM) "The Dutch Soil Quality Decree (in Dutch: Besluit bodemkwaliteit)", The Hague, 2007
- [11] Zweiter Arbeitsentwurf der Bundesregierung (2011); Verordnung zur Festlegung von Anforderungen für das Einbringen und das Einleiten von Stoffen in das Grundwasser, an den Einbau von Ersatzbaustoffen und für die Verwendung von Boden und bodenähnlichem Material, Januar 2011
- [12] Guide méthodologique - Acceptabilité de matériaux alternatifs en technique routière Evaluation environnementale; SETRA (Service d'Etudes sur les Transports, les Routes et leurs Aménagements), to be published in April 2011
- [13] Decree 34/2003 Basque Country Autonomous Region, Decree 104/2006 Cantabria Autonomous Region, y Decree 32/2009, Catalonia Autonomous Region
- [14] Regulation No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC
- [15] Ehrenberg, A.: Zur Optimierung der Korngrößenverteilung von hüttensandhaltigen Zementen. Dissertation TU Clausthal, Schriftenreihe der FEhS 8 (2001) Heft 10
- [16] FEhS – Institut für Baustoff-Forschung, internal information, February 2011



\* third party certificate concerning the classification according to § 5 and § 6 of the WFD.

Flow sheet for status determination of ferrous slags considering articles 5 and 6 of the Waste Framework Directive 2008/98/CE.