Legal Status of Slags

Position Paper

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The European Slag Association

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0 Preamble

This paper has been developed by EUROSLAG. It represents the view of the European steel industry as represented by the members of EUROSLAG and sets out the current situation concerning generation and use of slags from iron and steel production referring especially to their legal status in terms of the question: Slag – waste or non waste? This paper deals only with blast furnace and steel slags and no other types of slags e.g. non ferrous slags.

The European court of justice has published a lot of judgements dealing with the question whether substances or materials are wastes or when waste ceases to be a waste. The interpretation of these judgements shows that the European court has expanded the term waste during the past years dramatically. But meanwhile most of the experts discussing this matter came to realise that a substance may not always be described as waste or non waste. It depends not only on the nature of the relevant substance but especially on the intention of the producer before generation and subsequent handling. Therefore, the problem is how could we ascertain whether or not a material or substance being produced is intended to be discarded or not.

Slags generated by the iron and steel industry have a history as by-products going back more than 100 years. Since that time slags have been part of the market economy meeting national and European product standards. Despite all these well known and documented experiences, successes and advantages for the environment and society in general, administrations sometimes still classify slags as waste. Such a generalisation completely disregarding their actual handling by the steel works, as well as by processors, or producers of building and fertilising materials and by the market at large cannot be accepted. The decision as to whether something is waste or not must be made on a case to case basis with respect to the specific circumstances regarding the relevant material and its proposed use.

Therefore EUROSLAG welcomes the intention of the Commission to revise the Waste Framework Directive. By the following contribution EUROSLAG wants to support the debate to clarify a distinction between waste and non waste by-products taking blast furnace and steel slags as an example.

For that reason EUROSLAG proposes that the status of iron and steel slags should be examined taking in account not only current legislation, but also actual generation, processing and marketing in order to help to clarify whether steel producers generate slags with an indisputable intention to be used (e.g. as standardised building materials) or to discard them.

1. Introduction

1.1 Historical development of slag use

The history of the use of iron and steel industry's co-products dates back a long way. The earliest reports on the use of slags refer to Aristotle who used slag as a medicament as early as 350 B.C. During the following centuries slag has mainly been used as construction material. The discovery of the latent-hydraulic properties of the quenched (granulated) blast furnace slag started a new era for using slags. World wide, blast furnace slag production amounts to nearly 190 million tonnes per annum while the share of granulated blast furnace

slag has increased steadily, leading to 130 million tonnes in 2002. Virtually the entire production of granulated blast furnace slag is used as binding agent and/or addition for concrete. The proportion of cements containing granulated blast furnace slag is as high as 80 % in some countries.

Another very important development has been the use of steel slag as fertiliser. Since the 1880s about 140 million tonnes of steel slag have been used as phosphating and/or liming agent. Through awareness of environmental considerations, and more recently the concept of sustainable development, extensive R & D has transformed slags into modern industrial products which are effectively and profitably used.

1.2 Today's production and use of blast furnace and steel slags

With regard to an inquiry in 2004 the European steel industry (associated with EUROSLAG) generated about 40 million tonnes of slags resulting from iron and steel making.

1.2.1 Blast Furnace Slag

The generated blast furnace slag amounted to about 25 million tonnes in 2004, Figure 1. About 23 % of this tonnage was processed as air-cooled crystalline slag, 77 % as vitrified slag, whether granulated or pelletised.

With regard to the relation between crystalline and granulated slag, there are countries where only granulated slag is produced like Belgium, Italy, The Netherlands, etc. and there are others where very little slag is granulated, like Sweden and Spain. But most European countries produce both granulated and crystalline blastfurnace slag.

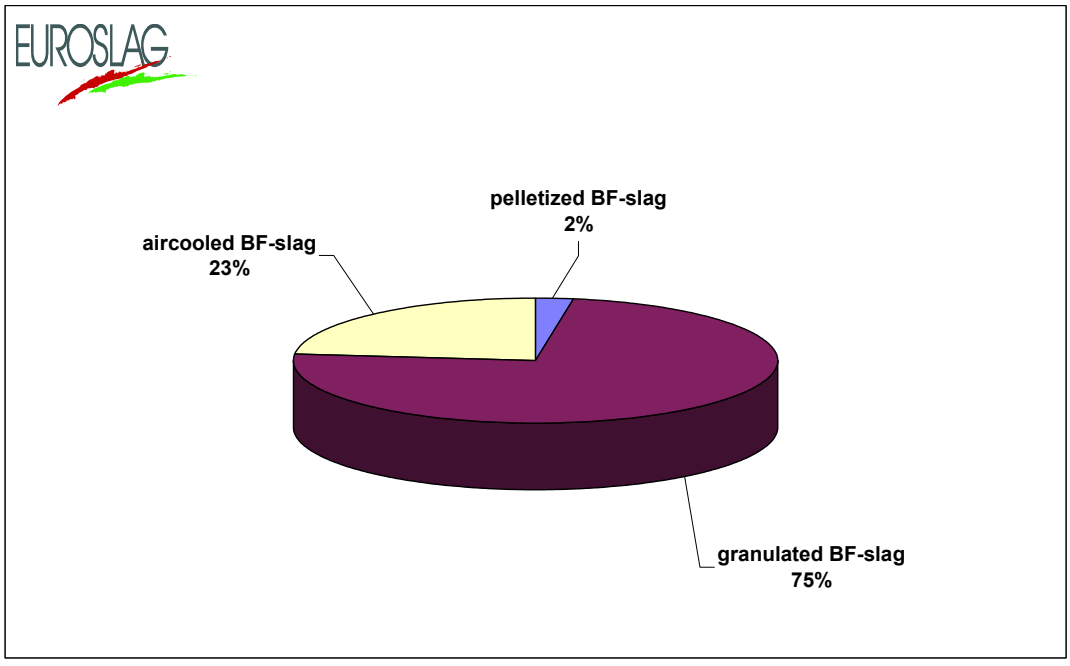


Figure 1: Production of Blast Furnace Slag in 2004: 24.6 Mio tonnes

Today 32.6 % of the generated blastfurnace slag – this is mainly the crystalline blastfurnace slag – is used for road construction purposes, Figure 2. Dominant is the production of slag aggregates or slag mixtures for unbound or self-binding layers. Due to their porosity, blastfurnace slag aggregates are today only used for asphalt road bases or subbases, but not for surface layers. Furthermore, 64 % of the generated blastfurnace slags – most of them granulated or pelletised – are used for cement production.

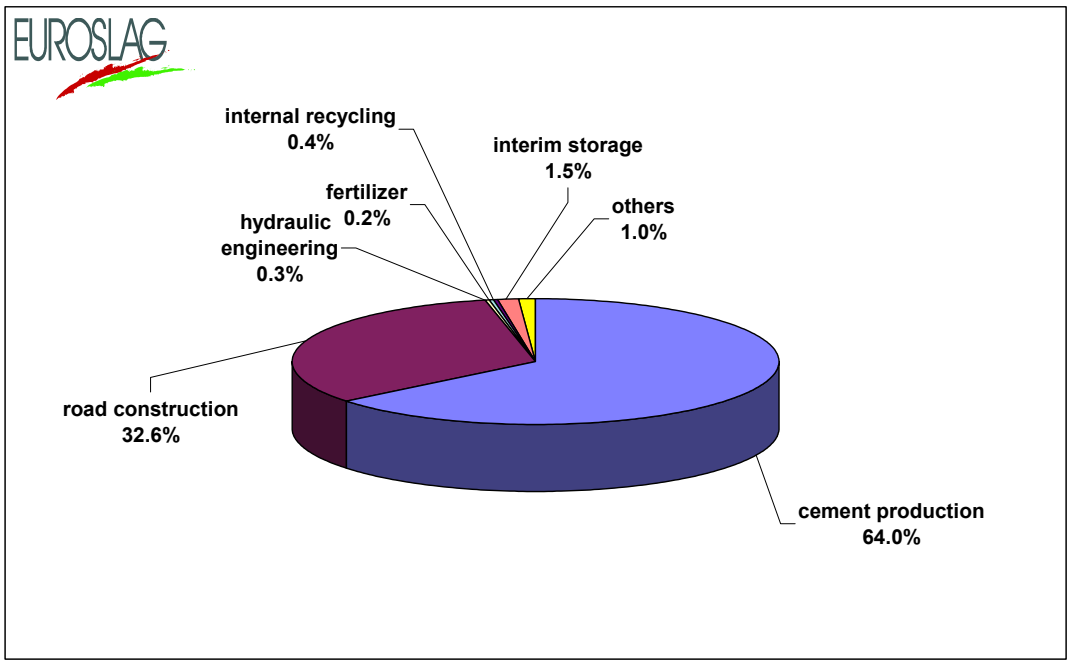


Figure 2: Use of Blast Furnace Slag in 2004: 27.2 Mio tonnes

1.2.2 Steel Slag

The total amount of steel slags generated in 2004 was about 15 million tonnes, Figure 3. About 62 % of this tonnage was produced as basic oxygen furnace-slags, 29 % as electric arc furnace-slags and 9 % as secondary metallurgical slags.

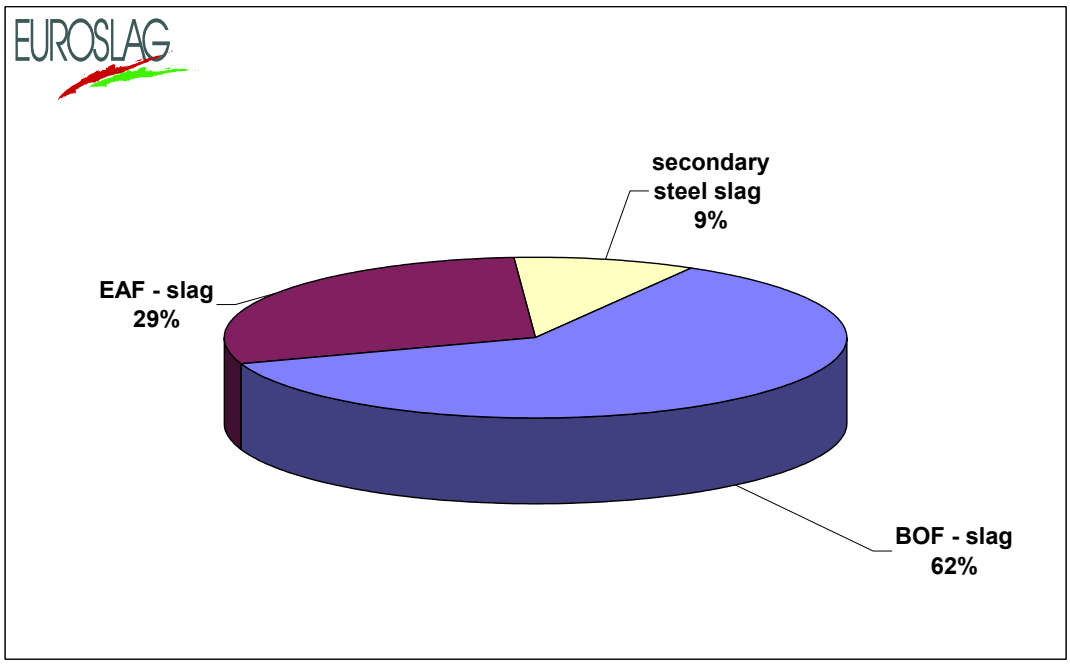


Figure 3: Production of Steel Slags in Europe 2004: 15.2 Mio tonnes

Concerning the use of steel slags, Figure 4, 72 % of the produced slags are used on qualified fields of application owing to the intensive research work over the past 35 years.

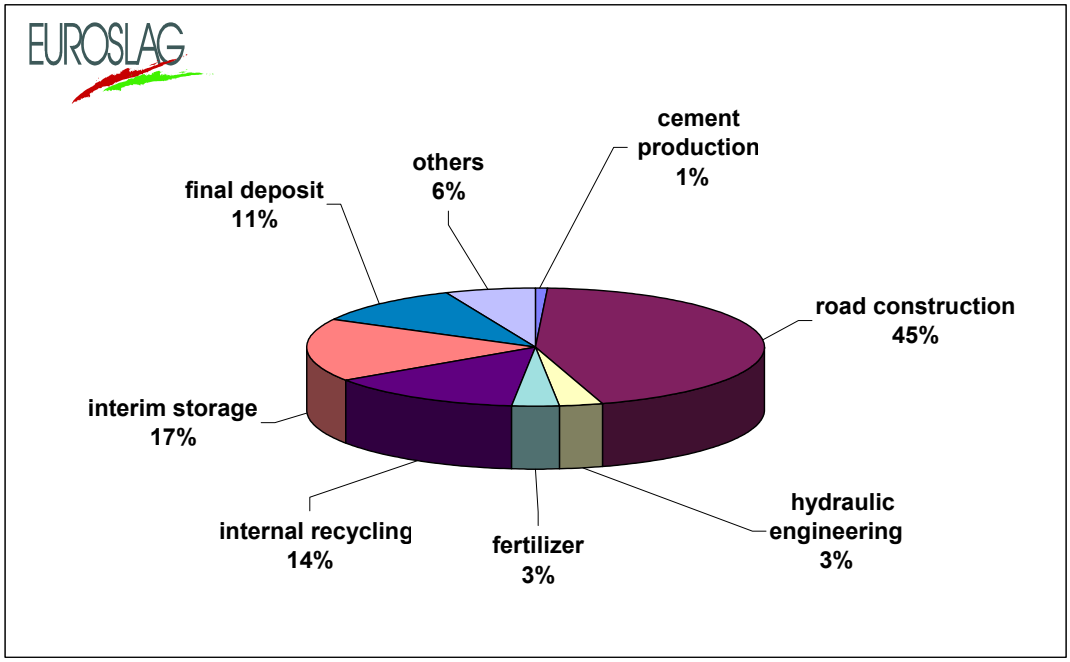


Figure 4: Use of Steel Slags in Europe 2004: 15.0 Mio tonnes

But it is evident that the utilisation rate is lower than that for blast furnace slags. Approximately 11 % of the produced steel slags are still dumped in Europe today. But of course this figure varies from country to country depending upon the quality of these slags as well as the prevailing natural aggregates market conditions. Some countries have utilisation rates higher than 90 %. Main fields of application for steel slags are the production of aggregates for road construction purposes e.g. asphalt layers as well as, the *in-situ* treatment of unsuitable soils for road construction, the production of fertiliser, the use of armourstones in hydraulic engineering and internal recycling in steel works.

2. Current legal status regarding slags

2.1 Waste Framework Directive – WFD and accessory Directives

Presently waste is defined by the Waste Framework Directive and accessory directives as being any substance or object that the holder discards or intends to discard or is required to discard, see Article 1(a) of Directive 75/442/EEC. This definition is completed by a harmonised list of wastes (Annex 1 of the Directive), where residues of industrial processes (e.g. slags, etc.) are listed as Q8. But the directive specifies that the inclusion of a material in this list does not mean that the material is a waste in all circumstances. Materials are considered to be waste only where the definition of waste in Article 1(a) of Directive 75/442/EEC is met.

The inclusion of a substance in one of the categories set out in Part II of Annex I does not per se mean that it is a waste. This listing is only relevant for substances when they are discarded. But the intention to discard, the requirement to discard are not defined by the Waste Framework Directive. The distinction has to be made case by case because the criteria for waste/non waste is complex. European case law provides that whether a substance or object is waste must be determined in light of all the circumstances and without undermining the aims of the WFD.

With respect to blast furnace and steel slags this definition will be used additionally to investigate whether the holder discards or intends to discard or is required to discard the respective material. This question can be investigated from different points of view:

– For the intention to discard: The producer does not intend to discard slags because he performs a variety of measures in order to fulfil the requirements of standards (see chapter 4) and the market.

– For the requirement to discard: There are no regulations requiring slag to be discarded. In fact, conformance with BAT requires that the producer should make products from slag.

– Does the holder discard slag?

  The holder (steel works, processors) generates slag products which fulfil the requirements of European or national product standards. These products are sold at competitive market prices with sales volumes fluctuating over time in line with market demand. The sale of slags is usually based on commercial contracts. (see supra chapter 4). All these activities are characteristic of products and not of the discard of wastes. Slags do not fall out of the commercial cycle or out of the chain of utility.

2.2 European Waste Catalogue

In general it is important to emphasise that the inclusion of a material in the European Waste Catalogue – EWC does not mean that the material is a waste in all circumstances. Only those materials which meet the definition of the Council Directive 75/442/EEC (15.7.75) amended by the Council Directive 91/156/EEC (18.3.91) are considered to be waste.

The EWC established by the Commission Decision 2000/532/ECC of 3rd May 2000 contains two entries regarding slag:

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

With regard to unprocessed slag it is important to stress that on request of Germany the EU-Commission agreed that

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

are examples of slag processing. This means that a slag which has undergone one or more of these processes is not covered by the EWC. These slags have no EWC number. Thus these slags should not be classified as wastes. It should be stressed that the processes explained above represent no change to the inherent composition of the slags but merely improve their properties as a continuation of the production process without any interruption.

2.3 European Waste Shipment Regulation

Like a summary of all these considerations and experiences with slags the European Waste Shipment Regulation (EEC) No 259/93 – with the amendment from 21.9.1995 – defines in the Green List, GC 070: "Slags arising from the manufacture of iron and steel (including low alloy steel) excluding those slags which have been specifically produced to meet both national and relevant international requirements and standards".

It is very important to stress that the shipments of waste for recovery listed on the green list shall be generally excluded from the control procedures of the regulation since such waste should not normally present a risk to the environment if properly recovered in the country of

destination. But most important is that slags which have been specifically produced to meet both national and relevant international requirements and standards are excluded from the green list because they are not classified as waste.

This discussion of European directives and regulations leads to the result that slags are not wastes, but products which are specifically produced to meet the requirements of many standards and regulations.

During the revision of the WSR the entry GC070 has been deleted. The European Commission rejected this modification with the following arguments:

"Amendments 78, 106 ... cannot be accepted. Not because the Commission disagrees on substance, but rather because it is not the right context. Changes to the lists of wastes should be done in the legislation where they originate from (The Basel Convention, the OECD Decision and the EU waste list). Further it will go against one of the main objectives of the proposal, namely international harmonisation in the field of lists of waste".

But as a consequence resulting from the explanation of the Commission this entry will not be deleted because the Commission disagrees with the content, only with regard to formal issues. So this statement is not a deprivation of the possibility to generate slags as products respecting national or international standards.

3. Recent law cases

Considering the large definition of waste in Waste Framework Legislation, the European Court of Justice (ECJ) has specified different relevant criteria to qualify a substance or material as waste. Certain ECJ decisions are of great interest for by-products and so slag. Two ECJ decisions are worth noting.

3.1 Palin Granit case law (11 September 2003)

In the Palin Granit case law or AvestaPolarit Chrome Oy case law, the Supreme Court in Finland asked the ECJ for guidance as to which criteria are relevant for determining whether, in a series of defined circumstances, leftover stone resulting from granite quarrying is to be regarded as waste within the meaning of Waste Framework Directive 75/442.

In this case, the ECJ underlines that "there is no reason to hold that the provisions of Directive 75/442 which are intended to regulate the disposal or recovery of waste apply to goods, materials or raw materials which have an economic value as products regardless of any form of processing and which, as such, are subject to the legislation applicable to those products" (point 33/35 of the judgement).

And the Court brings two additional criteria in order to determine whether or not a substance or material is qualified as a waste.

– The material should not be a production residue but a by-product (point 33/34 of the judgement)

  The Court states clearly that "goods, materials or raw materials resulting from a manufacturing or extraction process, the primary aim of which is not the production of that item, may be regarded not as a residue but as a by-product which the undertaking does not wish to discard, within the meaning of the first paragraph of Article 1 (a) of Directive 75/442, but intends to exploit or market on terms which are advantageous to it, in a subsequent process, without any further processing prior to reuse".

– The material must have a certain reuse with a strong degree of likelihood and must no longer be regarded as a burden which its holder seeks to discard (points 33/37 & 33/38 of the judgement)

  The Court specified "in addition to the criterion of whether a substance constitutes a production residue, a second relevant criterion for determining whether or not that substance is waste for the purpose of Directive 75/442 is the degree of likelihood that that substance will be reused, without any further processing prior to its reuse. If, in addition to the mere possibility of reusing the substance, there is also a financial advantage to the holder in so doing, the likelihood of reuse is high. In such circumstances, the substance in question must no longer be regarded as a burden which its holder seeks to discard, but as a genuine product".

This case law is a significant step forward by bringing the Thematic Waste / by-product issue to the courts attention and opens the door to possible change of status for some slags that meet the criteria from Palin case law.

The Palin Granit judgement assumes that the material will be certain to be reused without any further processing. With regard to slags this prerequisite will be fulfilled. The treatment of the slag as liquid or mineral represents no major changes but only an improvement of their properties as a continuation of the production process without any interruption.

Therefore there is a substantial distinction between the Palin Granit case and the generation of slags. With regard to Palin Granit the enterprise generated lump aggregate pieces as left over stones without taking any measures to influence the quality and the use of that material. However blast furnace and steel slags do not represent unchangeable residues. They are generated due to their nature and used for different fields of application. At any time the steel producers take appropriate measures to modify the slag quality during the hot metal or steel production process as a continuation of the slag production process. Taking in account that slags are used in many fields of application waste characteristics have to be negated.

3.2 Saetti and Frediani Order (15 January 2004)

In the course of criminal proceedings against Mr Saetti and Mr Frediani, the director and former director respectively of the Gela Oil refinery by AGIP Petroli SpA, the judge responsible for preliminary inquiries of the Tribunale di Gela referred to the Court of Justice different questions on the interpretation of the Waste Framework Directive 75/442 and the qualification of Petroleum coke as waste.

The Court decided that "Petroleum coke which is produced intentionally or in the course of producing other petroleum fuels in an oil refinery and is certain to be used as fuel to meet the energy needs of the refinery and those of other industries does not constitute waste within the meaning of Council Directive 75/442/ECC of 15 July 1975 on waste, as amended by Council Directive 91/156/ECC of 18 March 1991".

The Court founded this argument on the distinction between waste and by-product, in accordance with Palin case law. The Court considers that "where the substance used is a production residue, that is to say a product not intended as such" (point 34 of the order). It coincides with the idea of fatal product. "However, one possible analysis which could be accepted is that goods, materials or raw materials resulting from a manufacturing or extraction process which are not primarily intended to produce that item may be regarded not as a residue but as a by-product which the undertaking does not wish to discard, within the meaning of the first paragraph of Article 1 (a) of Directive 75/442, but intends to exploit or market on terms which are advantageous to it, in a subsequent process, without prior processing" (point 35 of the order). And it’s necessary that there is a strong degree of

likelihood of use and that the use is certain, without any prior processing and is an integral part of the production process (point 36 & 37 of the order).

Concerning especially the Petroleum coke, the Court take into account the BREF (BAT reference document) considering that Petroleum coke is one of the numerous substances resulting from the refining of petroleum and is widely used as fuel in the cement and steel industry. Moreover, the Court underlines that the petroleum coke is used in Gela as the main component in the fuel used to power the integrated combined heat and power station which supplies the refinery's steam and electricity needs. The Court concludes "if these conditions of production and use are established, the classification as waste within the meaning of Article 1(a) of Directive 75/442 can be excluded" (point 44 of the order).

This decision and Palin case law are very important in the determination of the scope waste/non waste.

Moreover, the Court has ruled in special form, an Order of the Court. The Article 104 § 3 of the Rules of Procedure of the Court of Justice specifies that "where a question referred to the Court is identical to a question on which the Court has already ruled, where the answer to such a question admits of no reasonable doubt, the Court may (…) give its decision by reasonable order in which, if appropriated, reference is made to its previous judgement or to the relevant case-law". In consequence, this order confirms the criteria of Palin case law and the relevance to distinguish by-products to waste and production residue.

Taking in account the Saetti and Frediani judgement it is important to say that it is not relevant that the generation of slags will be inevitable and the steel production will not be possible without any generation of slags. The key factor is first that the steel producers have a strong intention to generate a slag with defined properties and second that they incorporate the production of slags into their business achievements.

As it is explained above the steel producers take appropriate measures to modify the slag quality already during the hot metal or steel production process as a continuation of the slag production process. Therefore the generation and the use of blast furnace and steel slags will neither be a recovery process nor a recycling process.

4. Generation of blastfurnace and steel slag

The production of steel today is a process consisting of two or three stages.

Starting with ores, hot metal (molten iron) is produced in blast furnaces in the first stage. The hot metal is treated in an oxygen blowing process to remove carbon and other elements that have a high affinity to oxygen. The resulting raw steel undergoes a secondary steelmaking process during which steel gets its final composition and cleanness.

Another route is based on scrap recycling. The scrap-based steel production is usually performed in electric arc furnaces. The resulting raw steel again undergoes a secondary steelmaking process.

In all stages of steel production, slags are generated. These slags are: Blast furnace slag (BF slag), basic oxygen steelmaking slag (BOF slag), electric arc furnace slag (EAF slag) and secondary metallurgy processes slag as vitrified respectively mineral materials. Due to high temperatures of about 1500 °C during generation iron and steel slags do not contain any organic substances.

In earlier times the steel production was only designed to produce iron and steel. The slag generated had to be used as they arose from the process. Today the production of steel is also aimed at the generation of high quality slag to be market e.g. as building material or as

fertiliser. It is an integral part of the primary steel process and a recognized major economical contributor to the competitiveness of European steel industry. Slag is generated in a parallel route to the main hot metal production process. This is confirmed by the BAT reference document on iron and steel elaborated by the European IPPC Bureau which describes the slag generation process as an integral part of the steelmaking process. So the interest and intention of the steel producer is to control and regulate the slag quality by several measures during production and processing as it is given by enclosure 1 to 3. These measures are:

- Selection of raw materials not only with regard to iron and steel quality but also with regard to the final chemical composition of slags

- Both metallic and non metallic products are influenced during the process stages to achieve special chemical compositions with regard to their intended use e.g. addition of aluminates to increase the basicity of blastfurnace slag and its value in cement manufacture

- Specific treatment processes like soft or rapid cooling, addition of sand and oxygen etc. are performed to influence the properties of slags due to the relevant requirements given by European or national products standards e.g. volume stability, glassy content

- Modification of the slag physical properties by crushing, sieving and milling to achieve special grain sizes and mixtures in similar installations as they are used for natural aggregates to comply with European products standards

Thus a great variety of materials e.g. for building and fertilising applications are generated, each of which fulfilling special characteristics.

- Slags are continuously investigated and developed with respect to new fields of application

  The European steel industry has founded its own investigation institutes which are responsible for slag research or co-operate closely with universities in this field. For example, using this knowledge it has been possible to develop new granulation processes to increase the glassy content of blast furnace slag or treatment processes to improve the volume stability of steel slags.

- Slags meet the requirements of national and European standards (EN's) due to technical and environmental aspects with regard to the intended use.

  During the past years most of the national standards relevant for the building industry have been harmonised. Most important for slags are the following European standards:

  EN 197: Cement

  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: Light weight aggregates

  EN 13043: Aggregates for asphalt

  EN 13242: Aggregates for bound and unbound mixtures

  EN 13383: Armourstones

EN 13285: Unbound mixtures – specifications

EN 14227-2: Slag bound mixtures

EN 14227-12: Hydraulic bound mixtures – Specifications – Soil treated by slag

EN 15167: Ground granulated blastfurnace slag for use in concrete, mortar and grout

prEN 13282: Hydraulic road binders – Composition, specifications and conformity criteria

Slags fulfil all chemical, physical, technical and ecological requirements of relevant standards and of the intended fields of application. This requires that they meet high standards of health and environmental protection no more no less than equivalent to standards applicable to primary raw materials and products. Some slag-products even exceed the properties of competitive products by far.

Taking into account the long term experience with slag use it could be confirmed that the use of blast furnace and steel slag – crystalline or vitrified – is as environmentally sound as that of similar natural calcareous primary products and does not present any increased risk to human health or the environment.

– Slags are continuously certified by a relevant factory production control

  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.

– Slags have a permanent market across Europe with a positive economic value

  The holder (steel works, processors) sells slag products and usually gets a market price comparable to alternative materials and the demand of the market, bearing in mind that a "waste" label attached to this production doesn't allow to maximise its sale value.

– Slags are usually sold based on commercial contracts. So a traceability via written contracts is given

– Slags support a sustainable conservation of natural landscape and a reduction of CO_2 emissions

  Products made from slag replace products of natural origin and therefore help to conserve finite natural resources. The use of granulated blast furnace slag for the production of cement and concrete saves energy and reduces the CO_2 emissions by 50 % on average.

It cannot be denied that in some regions of Europe and from time to time, when the consumption of the construction industry is weak, and the competition with natural materials is strong, it gets difficult to sell all the generated slag as co-product from iron and steelmaking. Stock levels increase and decrease in line with market demand, as with primary natural materials, so slag stockpiles should not be mistaken for dumped material.

5. Final statement

Today's steel producing process consists of two or three stages:

– the hot metal production stage in the blastfurnace

– the steel production stage in the basic oxygen furnace process (BOF) and in the electric arc furnace process (EAF)

– the secondary steelmaking process

From these stages result blast furnace slag (BF slag), basic oxygen steelmaking slag (BOF slag), electric arc furnace slag (EAF slag) and secondary metallurgy processes slag as vitrified or mineral material. Due to high temperatures of about 1500 °C during generation iron and steel slags do not contain any organic substances.

In earlier times the steel production was only designed to produce iron and steel. The slag generated had to be used as they arose during the process. But today the production of high quality slag to be sold on the market e.g. as building material or as fertiliser is an integral part of the steel production process. Without the economical contribution of these sales, the European steel cost would not be as competitive as it is. So the intention of the steel producer is to regulate and control the various slag qualities by several measures during production and processing to ensure that it will comply with the market needs given in national or European standards.

In Europe blast furnace and steel slags products are used in huge quantities of about 25 million tonnes and 17 million tonnes respectively per year as crystalline or granulated slag. Both slag types are utilised by society mainly in the development of infrastructure such as roads (aggregates/asphalt), buildings (cement/concrete) and fertiliser.

Blast furnace and steel slags are generated in a parallel route to the main hot metal production process. This is confirmed by the BAT reference document on iron and steel elaborated by the European IPPC Bureau which describes the slag generation process as an integral part of the steelmaking process.

Both chemical and physical characteristics are quality controlled as a result of voluntary operations and/or treatments both prior to and during the production of slags (choice of primary raw materials, chemical additions e.g. aluminates in the furnace, controlled cooling, vitrification, etc.) in order to fulfil requirements of nationally and internationally recognized specifications/standards which can include environmental and technical aspects.

As such, EUROSLAG considers blast furnace and steel slags as typical by-products as, even if it is not a primary production, its actual generation, both in terms of volumes and quality, is fully controlled.

There is a long history of consistent market demands for blast furnace and steel slags and their use as construction aggregates, hydraulic binders and fertilizer over more than 100 years, hence blast furnace and steel slags have positive economic value. Because there is market certainty companies are prepared to make the considerable capital investments necessary to ensure blast furnace and steel slags are processed to meet the requirements of national and European product standards. The production of blast furnace and steel slags is controlled within Steelworks IPPC permits. As with all supplies of bulk building materials, blast furnace and steel slags are stored on a temporary basis in stockpiles to accommodate the cyclic variations associated with market demand. The material is part of the normal commercial cycle or chain of utility and the sale blast furnace and steel slags is based on commercial contracts. The steel makers enter into long term commercial contracts with slag processors (often in excess of thirty years) with the full intention of exploiting the commercial value of blast furnace and steel slags on terms which are advantageous, hence there is never any intention to discard blast furnace and steel slags by the steel makers. Furthermore, at every stage of its processing, it can be used without further recovery operations:

– air cooled blast furnace and steel slags are mainly used as aggregate and fertilizer,

– granulated or pelletised blast furnace slags are mainly used as a cement component and as a road binder.

Furthermore, and taking the possible environmental impact into account, the use of blast furnace and steel slag – crystalline or vitrified – is as environmentally sound as that of similar natural calcareous primary products and does not present any increased risk to human health or the environment. It contributes to the preservation of natural minerals such as limestone, granite or chalk. In the case of cement manufacture, the use of BF slag instead of limestone clinker reduces the overall process CO_2-emissions. Calculations made by the German FEhS – Institute for Building Materials Research have shown that CO_2-emissions were reduced by about 12 million tonnes in the cement industry (hence in the industry as a whole) in Europe in 2002 because of the use of 12.7 million tonnes of BF slag. This is equivalent to the Kyoto objective of a country like Belgium hence blast furnace slag contributes in a decisive way to the sustainability of the whole European industry and in the fight against climate change.

Taking into account the considerations given above blast furnace and steel slags cannot be considered as "waste". They are intentionally generated by-products.

enclosure 1 to 3

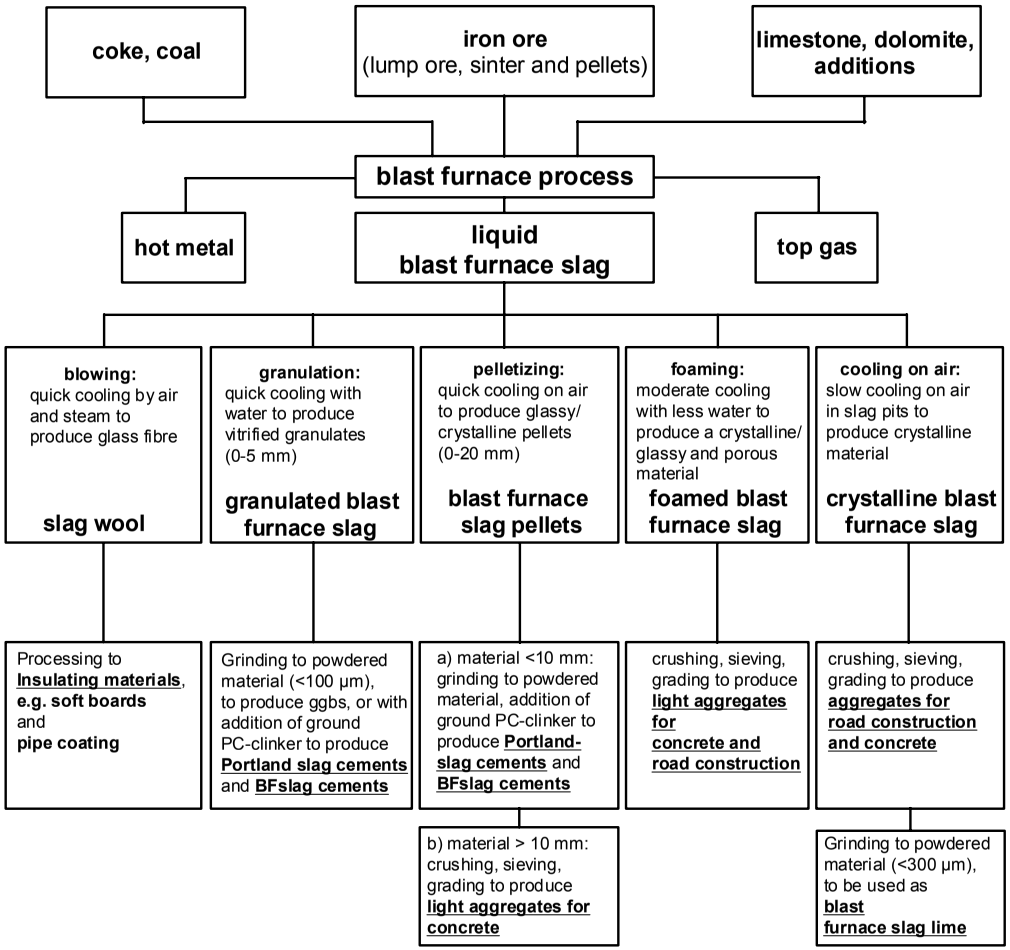
Blast Furnace Slags

Measures to influence the quality of slags

Process-Stage [1]	Measures to influence the quality	influenced properties	
Raw material preparing	selection, arrangement and pre-treatment of raw materials relating to the chemical composition of the blast furnace slag	chemical composition e.g. CaO, SiO_2, Al_2O_3, MgO, alkalis	=>
Melting process	selection of suitable process conditions (blast temperature, -rate, reduction carbon rate, gas flow)	temperature, composition of the products	=>
Heat treatment	different cooling rates:		
	a) quick: - blowing - granulation - pelletising	glassy content structure porosity	=>
	b) moderate: - foaming	bulk density strength porosity	
	c) slow: - air cooling	strength, porosity resistance to polishing grain size	
Processing	crushing, sieving, grading, milling	grain size shape grain size distribution	=>

[1] All process stages are subjected to a continuous production control like sampling, physical/chemical analysis and testing

Flow sheet



Enclosure 1: **Production processes and measures to influence the quality of blast furnace slag**

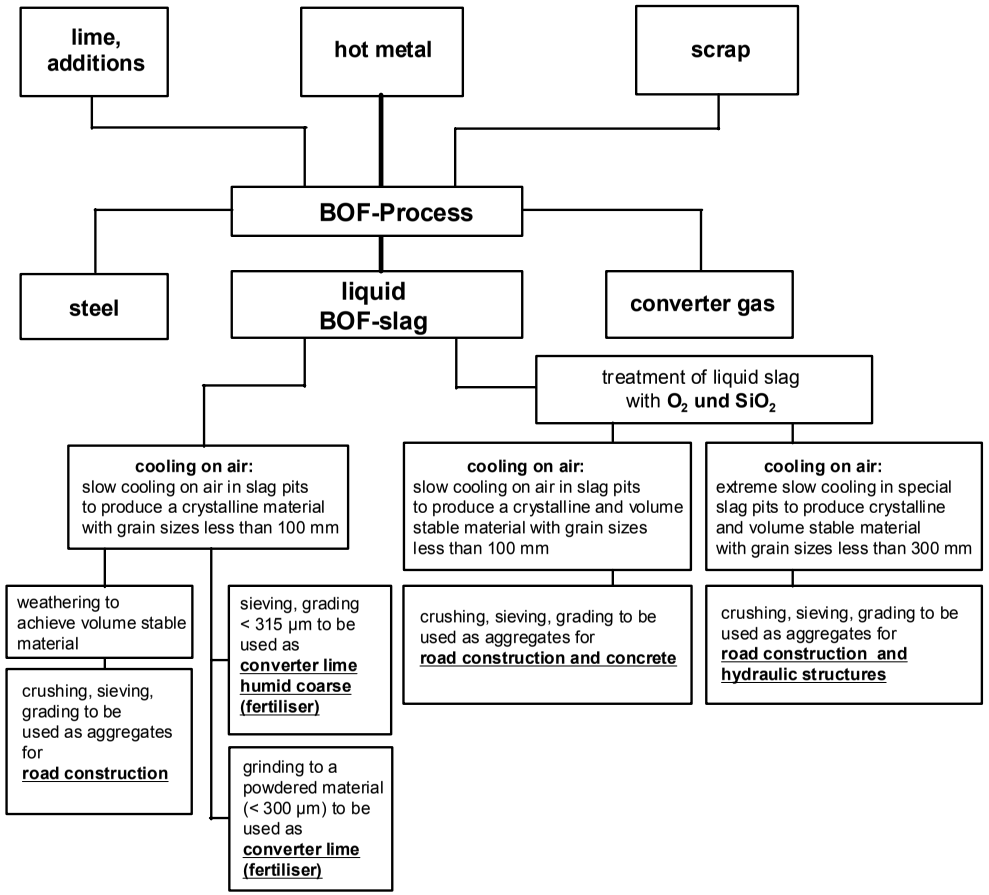
Steel Slag - BOF-slag

Measures to influence the quality of slags

Process-Stage [1]	Measures to influence the quality	influenced properties
Raw material preparation	selection, arrangement and pre-treatment of raw materials relating to the chemical composition of the BOF-slag	chemical composition e.g. CaO, SiO_2, P_2O_5, FeO_x, MgO, tracer elements
Melting process	selection of appropriate process conditions (O_2 rate, lime and scrap rate)	temperature, composition of products (e.g. FeO, CaO_{free}), volume stability
Heat treatment	controlled cooling	structure, porosity, strength, grain size distribution
Processing	crushing, sieving, grading, grinding	grain size, shape, grain size distribution

[1] All process stages are subjected to a continuous production control like sampling, physical/chemical analysis and testing

Flow sheet



Enclosure 2: **Production processes and measures to influence the quality of BOF-slag**

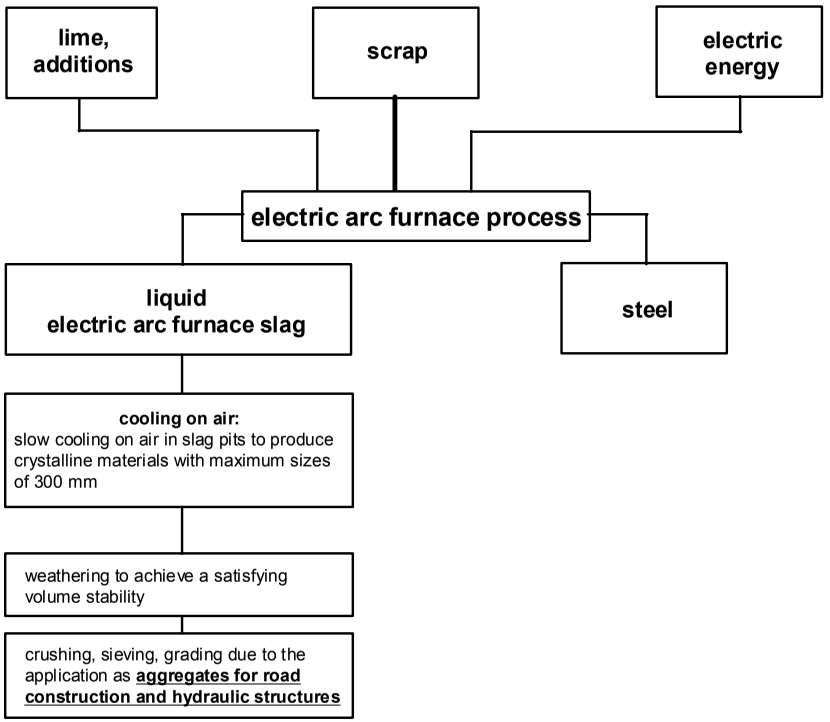
Steel Slag - Electric arc furnace slag

Measures to influence the quality of slags

Process-Stage [1]	Measures to influence the quality	influenced properties	
raw material preparing	selection, arrangement and pre-treatment of the raw materials relating to the chemical composition of the electric arc furnace slag	chem. composition e.g. CaO, SiO_2, P_2O_5, FeO_x, MgO, tracer elements	=>
Melting process	selection of appropriate process conditions (O_2, lime addition and quality of scrap)	temperature, composition of products (e.g. FeO, MgO_{free}), volume stability	=>
Heat treatment	slow cooling	structure, porosity, strength, grain size distribution	=>
Processing	crushing, sieving, grading	grain size, shape, grain size distribution	=>

[1] All process stages are subjected to a continuous production control like sampling, physical/chemical analysis and testing

Flow sheet



Enclosure 3: **Production processes and measures to influence the quality of electric arc furnace slag**