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European environmental policy and its influence on the use of slag products

Ruth BIALUCHA, Thomas MERKEL, Heribert MOTZ

FEhS – Institut für Baustoff-Forschung e.V. - Building Materials Institute -Duisburg, Germany

r.bialucha@fehs.de, th.merkel@fehs.de, h.motz@fehs.de

Abstract

About 87 wt% of ferrous slag produced in Europe is used for building purposes. A prerequisite for the use of this slag is that it meets the requirements for technical aspects given in the standards. This is one reason why they are marketed as products and not as wastes. With the first generation of building materials standards, environmental issues were not covered adequately. This shall be corrected now by drafting the second generation of European standards. But also other fields of environmental affairs are covered by EU Community law which have to be implemented into national legislation. So, for the future use of ferrous slag, targets such as preservation and protection of the environment, protection of human health as well as sustainable use of natural resources have to be taken into account.

Introduction

"Ferrous slag" is the overall term for many different slags coming from several stages of steel production. It comprises blast furnace slag, basic oxygen slag, electric arc furnace slag and secondary metallurgical slag. Based on a questionnaire of the European Slag Association (EUROSLAG) it is found that in Europe a large amount of more than 45 million tonnes of ferrous slag is produced every year. By far the largest proportion (87 wt%) is used for building purposes corresponding to about 40 million tonnes/year. A prerequisite for the use of ferrous slag in this field of application is that it meets the requirements for technical aspects given in harmonised European or national standards. This is one reason why slag is marketed as a product and not as a waste. A further requirement is that ferrous slag behaves in an environmentally sound manner, taking into account targets like preservation and protection of the environment (*i.e.* water, soil and air), protection of human health as well as sustainable use of natural resources. With the first generation of building materials standards, environmental issues were not covered adequately. This shall be corrected now within the scope of the Construction Products Directive, which is currently being revised. But also other fields of environmental affairs are covered by EU Community law and during the last 10 years the number of EU regulations concerning environmental issues has nearly doubled. Of course this already had an

effect on the use of ferrous slag in the recent past and this effect will even increase in future.

Ferrous slag in Europe

To assess the importance of the different slag types and the products manufactured from them, the European Slag Association EUROSLAG conducts surveys among its members (European steelworks and processing companies) every two years since 2000. From this it is known that in 2008, 45.6 million tonnes of ferrous slag have been produced. The rate of utilization of this slag was somewhat higher (46.9 million tonnes) because slag from deposits has been used too. About 38 wt% of this tonnage was used as crystalline air cooled blast furnace slag and steel slag mainly for road construction and other building purposes. 48 wt% of the slag – *i.e.* solely blast furnace slag – was granulated to vitrified slag and was mainly used as constituent for the cement production or as addition to concrete. In general the utilization rate of ferrous slag in Europe is high. Most European countries have a utilization rate of about 100 wt% with regard to blast furnace slag. Concerning steel slag about 79 wt% is used in Europe. Besides the main field of application, road construction and earth work (62 wt%), a amount of about 17 wt% is used for other purposes like fertiliser, hydraulic engineering and internal use for metallurgical purposes. 15 wt% is brought to interim storage due to economic reasons and 6 wt% is brought to a final deposit, mostly due to its fine grain size and/or to leachable concentrations not meeting specific limit values.

Ferrous slag – waste or product?

Slag generated by the iron and steel industry has a history as by-product going back more than 100 years. Since that time slag has been part of the market economy meeting national and European product standards. A main issue in connection with the use of ferrous slag is the question whether it is waste or a (by-)product. For marketing purposes it is better in any case to have products because the term “waste” implies that the material should not be used but deposited. This applies especially to the German expression “*Abfall*” which causes even more negative associations than the English term “waste” which has a somewhat broader meaning. On the other side there is a significant difference between waste which is often unknown with respect to its origin and which might be very inhomogeneous and ferrous slag which is produced target-oriented. That was the reason why the FEhS-Institute together with the German steel industry tried to get an agreement with environmental authorities concerning the product status of ferrous slag. In some cases we were successful in achieving consensus with some Ministries of Environment that steel slag and blast furnace slag can be regarded as by-products if

they meet specific requirements. This success was based to a great extent on expertises made by a German lawyer, Prof. Dr. L.-A. Versteyl, in 1998 and 2005. Similar agreements could be reached in other European countries with the national authorities *e.g*. in UK, Belgium and Finland. That was why the European steel industry took a lot of initiatives to get an acceptance of slag as (by-)product confirmed by EU Community law in regulations and directives.

European regulations and directives

Examples of environmental regulations and directives in Europe [in brackets: year of publication], which concern the use of slag are:

- EU-Construction Products Directive [1988]
- EU-Waste catalogue [2000]
- EU-Council Decision on the Landfill of Waste [2002]
- EU-Waste Shipment Regulation [2006]
- EU-REACH Regulation [2006]
- EU-Waste Framework Directive [2008]
- EU-Water Framework Directive [2008]

In the following a short summary is given regarding the above mentioned regulations and directives in the order of their date of publication. Although the Construction products Directive is the oldest one, it will be considered at the end of this section because the inclusion of environmental aspects, which are considered here, has started only in 2006 and will go on the next years.

In 1994 a comprehensive list of all wastes, hazardous or otherwise (the so-called European Waste Catalogue - EWC) was produced pursuant to Council Directive 75/442/EEC. Council Decision 94/904/EC then identified which of the wastes are considered as being hazardous, resulting in a list called “Hazardous Waste List – HWL”. After several years of debate among the EC countries the EWC 1994 and the HWL were updated and combined. This resulted in a revised European Waste Catalogue (Commission Decision 2000/532/ECC of 3 May 2000)[1] containing two entries regarding ferrous slag:

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

As a reversed conclusion, processed slag could be regarded as product or by-product. Only the question had to be clarified what is meant by “processing”. In 2002 the EU Commission agreed that granulation, pelletisation, foaming, proper solidification

connected with a specified heat treatment as well as separation, crushing, sieving and milling are examples of processing of slag. This means that a slag which has undergone one or more of these processes is not covered by the EWC. Such a slag has no EWC number and should not be classified as waste. It should be stressed that the processes explained above represent no change to the inherent composition of the slag but merely improve its properties as a continuation of the production process without any interruption.

Although the rate of use of ferrous slag increases steadily, some slag still has to be landfilled due to market conditions. 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 strong, it gets difficult to sell all the generated slag as by-product from iron and steelmaking. Therefore the Council Directive on the Landfill of Waste,[2] which was published in 1999 is of importance also for ferrous slag. In case of sales difficulties, the slag which has to be dumped has the same technical and environmental properties like the slag which is used. Therefore, it can be concluded that slag does not pose environmental risks. By careful hydrogeological investigation, it could be shown that the leaching from slag has not endangered the groundwater below a landfill, which was in operation for some 100 years. One of the reasons is that slag naturally hardens during storage and thus prevents the permeation of water. The FEhS-Institute together with EUROSLAG and EUROFER (European Confederation of Iron and Steel Industries) requested to introduce into the list of "wastes acceptable at landfills for inert wastes without testing" those slags from the manufacture of iron and steel, which always fulfil the requirements for this waste category according to Ref.[3], being blast furnace slag, basic oxygen furnace slag and electric arc furnace slag. But unfortunately the steel industry was not successful and therefore slag which has to be deposited has to be investigated with regard to its leachability. In accordance with the EU Council Directive the national regulations had to be adjusted. For Germany, this meant an increasing number of parameters to be tested, *e.g.* Ba, Mo, Sb and Se had to be added to the former state of the German landfill Ordinance.

The green list of Council Regulation (EEC) No 259/93 of 1 February 1993 on the supervision and control of shipments of waste within, into and out of the European Community (Waste Shipment Regulation) included the specific item GC 070 "slag arising from the manufacture of iron or steel excluding those slags which have been specifically produced to meet both national and relevant international requirements and standards". So under the current OECD- and EU regime, slag which is produced target-oriented and meets the specific requirements was explicitly excluded from the waste lists. But as a result of the OECD Decision C(2001)107 OECD Council and the proposed EU amendment, slag arising from the manufacture of iron or steel instead

falls under another item on the green list (B 1200 and B 1210) but without the specific exclusion in question. The reason for this decision was that slag could also be considered as waste under Community legislation and it then would not only have to follow requirements for information, but even more far-reaching obligations of notification and consent. In the revised Waste Shipment Regulation of 2006[4] amendments have now been made so that the slag in question would, if shipped for recovery only, have to be accompanied by certain information, *e.g.* who arranges the shipment and a description of the waste. It has been considered necessary that such information is provided to the competent authorities with regard to all green-listed waste so that waste can be tracked if necessary.

The current Waste Shipment Regulation now includes two entries in the green list relevant for the ferrous industry:

- B1200: "Granulated slag arising from the manufacture of iron and steel";
- B1210: "Slag arising from the manufacture of iron and steel including slags as a source of TiO_2 and Vanadium"

Furthermore the yellow list, which has stricter requirements with regards to cross border transports, includes the entry:

- AA010[a]: "Dross, scalings and other wastes from the manufacture of iron and steel"

As a consequence of listing slag both in the green list and the yellow list, th§e question arises which status should be given to slag from the manufacture of iron and steel. It has been discussed with European and national regulators very often but a compromise has not yet been reached. However, the cross-border shipment practice of slag in Europe has shown that in most cases slag has to fulfil the green list requirements if it is regarded as waste.

The new European Regulation No 1907/2006 for Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) was adopted by the European Parliament and the European Council in December 2006 and came into force on 1 June 2007.[5] The REACH regulation replaces a number of national regulations and directives with a single system. It applies to manufacturing, import, placing on the market and use of substances, while preparations and articles do not have to be registered. Only products (or by-products) have to be registered while wastes are

[a] "This listing includes wastes in the form of ash, residue, slag, dross, skimming, scaling, dust, powder, sludge and cake, unless a material is expressly listed elsewhere."

excluded from the obligation to register. The REACH Regulation applies to "new substances" that are brought to the market since 18 September 1981 and to "phase-in-substances" which have been put on the market before this date. Ferrous slag has been marketed long before 1981 and therefore is already listed as "phase-in-substances" for many years labelled by relevant CAS- and EINECS-numbers. As mentioned before, the steel industry has made serious efforts to clarify that iron and steel slag is produced and sold as (by-)product but not as waste. Therefore it was clear from the beginning that ferrous slag had to be registered under REACH as a substance before 1 December 2010.

Because it was possible to make a joint registration, the FEhS-Institute initiated the formation of a Consortium "Ferrous Slag", open to all European producers of iron and steel slag. Shortly before expiration of the registration deadline, 154 consortium members represented about 95% of the EU 27 crude steel production. Due to the fact that most of the resulting slag is registered, it is emphasised that a very large amount of ferrous slag is marketed as products today. Registration dossiers have been sent to the European Chemicals Agency (ECHA) for the following 5 slag types: blast furnace slag (crystalline and granulated), converter slag, electric arc furnace slag (carbon steel production), electric arc furnace slag (stainless/high alloy steel production) and steelmaking slag (including slag from secondary metallurgical processes). On the basis of the test results that were already available before 1 December 2010, it was shown that the ferrous slags investigated are not hazardous and do not release any dangerous substances in excess of maximum permitted levels specified in relevant European Standards for materials, Directives and/or National Regulations of the Member States. The members of the FEhS-Institute, EUROSLAG and the REACH Working Committee are assured that the registration of iron and steel slag within REACH will be achieved successfully. The outstanding results regarding inhalation tests are assumed to be "positive" in the sense that no harmful effects will occur when ferrous slag is used for its intended purpose fulfilling the recommended requirements. The registration dossiers will be evaluated by ECHA – European Chemicals Agency, Helsinki. To date, there is no information from ECHA when the dossiers will finally have been checked.

As a consequence of the discussion on by-products the EU Commission published guidelines on the Interpretative Communication on waste and by-products at the end of February 2007. In these guidelines blast furnace slag has been chosen as an example for by-products.[6] Furthermore, the steel industry supported the activities of the EU-Commission to establish a definition of by-products in the Directive 2008/98/EC on waste (Waste Framework Directive, WFD[7]) as a separate article. In 2008 the WFD has been published including the articles 5 "By-products" and 6 "End-of-waste status". Concerning the classification of slag there are two possibilities:

either slag is considered being a by-product already in the liquid state directly after manufacture with or without processing steps, or slag is first considered being waste but ceases to be waste after a number of recovery measures. Which substances may be classified by paragraph 5 or 6 and which environmental requirements have to be finally fulfilled, has to be agreed by the Commission via performing the so-called Comitology Procedure.

Concerning the development of the specific End-of-Waste criteria mentioned in point (1) of Article 6, the Commission has already asked the Joint Research Center JRC, Seville, in 2007 to draft two Reports "End of waste criteria, including Part: Aggregates"[8] and "Study on the selection of waste streams for End of Waste assessment".[9] 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 or to develop new European End-of-Waste pollutant limit values for recycled and secondary aggregates to cease to be a waste.

In January 2011 the European Commission began a new study in order to define pollutant leaching values for aggregates under the project 'End-of-Waste criteria'. For aggregates, there are a lot of materials that should be considered, among others blast furnace slag, which was already accepted as being a by-product (see 7). The Institute for Prospective Technological Studies (IPTS, Sevilla), which is one of the seven scientific institutes of the European Joint Research Centres, works on the above mentioned project which includes the following tasks:

- Identify the potential pollutants from aggregates;
- Identify the most suitable testing approaches a methods, including simplified modes of compliance;
- Describe the legislation and regulatory practice for controlling pollution from aggregates;
- Assess the need for including limit values for pollutants in end-of-waste criteria;
- Identify and assess the different methodological approaches for deriving pollutant limit values.

The research project has a duration of 1 year and based on the results of this study it will be decided whether end-of-waste criteria for aggregates based on the pollutant leaching values will be defined.

The European activities especially on behalf of the environmental regulations influence the national legislation of the European countries as most of the laws and directives have to be transferred into national law within a limited time. So the EU Water Framework Directive,[10] which was amended later on,[11] has to be transferred into national law of the Member States at the latest 15 years after the date of entry into force of this Directive, that means in 2015. One of the Daughter Directives of the Water Framework Directive, the Directive "Groundwater protection"[12] should have been transferred into national law already before 16 January 2009. This directive includes a minimum list of pollutants and their indicators for which Member States have to consider establishing threshold values in accordance with Article 3. Concerning the inorganic components As, Cd, Pb, Hg, NH_4, Cl and SO_4 are listed. But according to Article 3 (6) "*Member States shall amend the list of threshold values whenever new information on pollutants, groups of pollutants, or indicators of pollution indicates that a threshold value should be set for an additional substance, that an existing threshold value should be amended, or that a threshold value previously removed from the list should be re-inserted, in order to protect human health and the environment*". In Germany, the Groundwater Directive was brought into force in November 2010 including thresholds for the components listed above. But the Ministry of Environment has already informed the industry that Germany intends not only to tighten up the number of substances to be controlled in groundwater in contrast to the EU Groundwater Directive but also intends to introduce the much stricter German limit values on substances in groundwater (no-adverse-effect-level) by an additional Directive. A first draft of this Directive was presented in January 2011 including 22 inorganic components. The Austrian environmental authorities intend to set limit values for even more components, *e.g.* beryllium, silver and uranium. It has to be feared that this will lead to a distortion of competition in the European market (*e.g.* of building materials).

The introduction of the Groundwater Protection Directive in Germany will have considerable consequences to the future use of ferrous slag and other aggregates. Currently the German Ministry of Environment is drafting a new Directive (Regulation for the utilization of alternative materials as building materials).[13] The Regulation is based on the concept of no-adverse-effect-level for environmentally relevant components which now underlie the Groundwater Protection Directive. Especially for iron and steel slag traditional fields of use will cease to be applicable in future. That may mean prohibition of the use of slag in areas like unbound layers (sub base), unbound use in rural roads and earthworks and unbound use under block-pavement. The activities in Germany and Austria to introduce the Groundwater Protection Directive into national law are examples of consequences resulting from the European legislation on building products. That is why the steel industry reminds the

administration that all these activities should consider the existing experience in slag use and the intention to save natural resources.

When compared to other products, the cross-border trade on construction products within the European market has traditionally not been as commonplace. National markets have often obstacles preventing foreign products from being efficiently commercialised. Therefore, as one of the first efforts of such Community-wide harmonization, the Council adopted in 1988 the Construction Products Directive (CPD)[14] which will be revised as regulation soon. The primary function of the CPD is to ensure the safety of constructions in all countries of the European Economic Area. The CPD lays down certain Essential Requirements (ER) for buildings under six general headings:

- ER 1: Mechanical resistance and stability
- ER 2: Safety in case of fire
- ER 3: Hygiene, health and the environment
- ER 4: Safety in use
- ER 5: Protection against noise
- ER 6: Energy economy and heat retention

Most of these issues have been addressed already, but environmental issues, *e.g.* hygiene, health and emission (ER 3) were not covered adequately by the first generation of building materials standards. For implementing the Essential Requirements ER 3, the EU Commission worked out a Mandate (M/366). Because part of the work programme of CEN Technical Committees consists of standards developed in compliance with the Construction Products Directive following specific mandates, the Mandate was awarded to CEN. As a result of this, a new Technical Committee (CEN/TC 351 "Construction Products - Assessment of release of dangerous substances") was established, which started its work in 2006. Two Working Groups were set up dealing with test methods for assessing the release of dangerous substances into soil and groundwater (WG 1) and with indoor air (WG 2) respectively. Furthermore the following five Task Groups were set up:

- TG 1: Barriers to trade
- TG 2: Horizontal test methods and use
- TG 3: Without testing (WT), Without further testing (WFT), Further testing (FT)
- TG 4: Sampling (compilation of methods)
- TG 5: Contents (compilation of methods)

The first step was to identify regulated dangerous substances (RDS) of relevance for construction products. This work was completed as far as possible in 2010. Now an adjustment of the mandates for all building products will be necessary. Meanwhile, for CEN/TC 154 “Aggregates” a revised Mandate (M/125) has been drafted and discussed. It includes a list of Regulated Dangerous Substances which may be relevant for natural, manufactured and recycled aggregates to be tested in the future. The same procedure is running for CEN/TC 227 “Building Materials” at present. It was agreed within CEN/TC´s 154 and 227 that all Building Material Associations concerned by these TC´s shall prepare dossiers laying down the experience with the relevant building products or product families. The dossier will include statements mainly with regard to the environmental behaviour and suggestions which RDS may be tested if there is a need to be. For ferrous slag EUROSLAG will draft the dossier as basis to propose a classification of slag with regard to testing and RDS.

In Europe, tests have been developed to characterise and assess the constituents which can be leached from construction products. The release of soluble constituents upon contact with water is regarded as one of the main mechanism of release, which results in a potential risk to the environment during the intended use of construction products. The intent of these tests is to identify the leaching properties of construction products that allow conclusions on the suitability of such products for CE marking. The complexity of the leaching process makes simplifications necessary. Not all of the relevant aspects of leaching behaviour can be addressed in one single standard.

Up to now different investigation methods are used by Member States, which have to be harmonised. CEN/TC 351 WG 1 agreed that its objectives are to:

1. enable product TC to select the appropriate test;
2. determine the release performance;
3. ensure methods are scientifically sound;
4. be relevant to CE Marking of the product.

Three technical specifications (TS) are proposed for the above with guidance on choice depending upon material. TS-1 describes the general principles for selection of leaching tests appropriate for a specific product. Test selection will be based on product properties like grain size distribution, hydraulic permeability and release mechanism. TS-2 describes a dynamic surface leaching test (DSLT) for determination of surface dependent release of substances from monolithic, plate-like or sheet-like construction products. Apart from the DSLT, a pH dependence leaching test is needed to assess the long term release from a material that undergoes significant pH

changes (*e.g.* carbonation of cement-based materials) during its exposure to field conditions. TS-3 contains information on a horizontal up-flow percolation test for determination of the release of substances from granular products. The latter will be decisive for the majority of ferrous slag used for road construction. Further details with regard to leaching test developed by CEN/TC 351can be found in the contribution of van der Sloot *et al.* "Harmonisation of leaching test methods in support of EU regulations controlling the beneficial use of industrial slag in construction", elsewhere in these Proceedings.

After having collected as much information as possible concerning historical data on the release of RDS from construction products into soil and water a testing scheme was developed to gain information on the robustness of the methods presented in TS-2 and TS-3. The robustness validation of CEN/TC 351 methods for release to soil, surface and groundwater is to be started in the first half of 2011. It is intended to test about 11 granular products and 13 monolithic products. Concerning ferrous slag, granular steel slag with grain sizes up to 20 mm shall be tested as well as monolithic steel slag to be used as armour stone. Among others, the effect of the liquid to area ratio and of the leachant renewal time on release from monolithic materials shall be tested. The granular steel slag shall be used for studying the effect of pre-equilibration, flow rate and temperature on release. After having finished the ruggedness testing and depending on the results the leaching methods have to be revised. As a next step a round robin has to be organised to validate the methods, which is expected to start in 2013 at the earliest.

The harmonised standards shall support the work in product TC´s on drafting dossiers for WT (without testing), WFT (without further testing) and FT (further testing) classification. All construction products have to be classified into one of the three categories on the basis of the entire knowledge about the environmental behaviour and the field of use. This step is called "Initial Type Assessment" (ITA). Materials which are classified as WT only have to undergo Factory Production Control (FPC) concerning technical properties but no environmental properties have to be tested. All other materials have to pass an Initial Type Testing (ITT) and depending on the results it has to be decided whether or not they have to undergo further testing in regard to the environmental behaviour.

Meanwhile the second generation of building materials standards is nearing completion but the environmental issues relating to ER 3 are still not taken into account. The standards include only a very general reference to environmental requirements at the location of use. The next step in the third generation of building material standards has to be the implementation of concrete requirements concerning harmonised test methods. The EU tries to achieve the environmental

protection through an extensive set of legislative instruments, the implementation of which is frequently supported by standards. According to the original time schedule, the results were expected to be submitted in 2010 but from today's viewpoint they are to be evaluated not earlier than 2015.

While standards are in development, there is no requirement for CE marking for the affected products, and any existing national standards still apply. However, once the harmonised standard has been published, the national standards have to be withdrawn and compliance with the harmonised standard becomes mandatory.

Conclusions

Since 2000 the number of EU Environmental Community laws nearly doubled with consequences for the use of all building products including slag. This trend takes necessary steps *e.g*. related to the evaluation of by-products and waste, the shipment of wastes, landfilling, the classification of all substances under REACH and the assessment of building products with regard to regulated dangerous substances. All producers of building materials, therefore, are increasingly confronted with expanded, respectively, new requirements concerning testing and evaluation of environmental behaviour of their products, which have partly dramatic constraints on the future application. This is why the building industry including the steel industry as building material producer urgently requests the national environmental bodies not to destroy an existing building material market by exaggerated environmental requirements.

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