InSGeP

Investigations of Slags from Next Generation Steel Making Processes

Deliverable 2.3

Compilation of regulatory information about slag use in Europe

The research leading to these results has received funding from the European Union's Research Fund for Coal and Steel research programme under grant agreement number: 101112665

Project information

Project title	Investigations of Slags from Next Generation Steel Making Processes		
Project acronym	InSGeP		
Grant Agreement No.	101112665		
Project start date	01-07-2023	**Project end date**	30-06-2027

Document information

Deliverable title	Compilation of regulatory information about slag use in Europe
Deliverable number	2.3
Related work package	WP2
WP leader	SSSA
Related task	2.3
Task leader	FEhS
Number of pages	27
Author(s)	Agnieszka Morillon, all beneficiaries
Due date	31st December 2023
Submission date	5 January 2024
Dissemination level	Public – fully open

Abstract

Deliverable 2.3 describes regulations in Austria, Belgium, France, Germany, Italy, Spain about slag utilization (EAF slag and LF slag), which are the countries of beneficiaries of the project. As there are no uniform regulations in Europe as to slag utilization it is important to understand the legal framework in each country the slag will be used in. In addition, the report describes current slag utilization routes which are common and taking place in each country. The next generation slag that will be produced will have to meet regulations in the country where it will be used in order to continue circular economy of the steel industry.

List of tables

List of abbreviations and acronyms

DRI	direct reduced iron
EAF	electric arc furnace
HBI	hot briquetted iron
HPSR	hydrogen plasma smelting reduction

Table of contents

1 Introduction

Next generation iron and steelmaking processes to decrease CO_2 by using direct reduced iron (DRI) with varying metallization degrees, hot briquetted iron (HBI) or low-grade fine ores in a hydrogen plasma smelting reduction (HPSR) will result in increase of electric arc furnace (EAF) slag, smelter slag and other slags with different properties. This requires the understanding of the possibility to valorize future slags in the present value chain and define innovative applications to assure smooth transition process without disruption to the steel industry as well as other sectors (such as road construction or cement) who currently rely on slag as raw material for their processes. To understand and move forward the transition of the steel industry, InSGeP project is investigating slags resulting from next generation steelmaking in Europe. The project relies on the limited amount of currently produced slags from next generation steel production in Europe and abroad as well as on laboratory, pilot scale and industrial scale tests that will be performed based on the needs of the involved partners.

Deliverable 2.3 “Compilation of regulatory information about slag use in Europe” describes regulations in Austria, Belgium, France, Germany, Italy, Spain about slag utilization (EAF slag and LF slag), countries of beneficiaries of the project. As there are no uniform regulations in Europe as to slag utilization it is important to understand the legal framework in each country the slag will be used in.

According to Euroslag Association, in 2020 in EU countries about 76 % of iron and steel furnace slags[1] are used in such applications as cement, concrete addition, road construction, hydraulic engineering, fertilizer or metallurgical use. Most of the slag is used as raw materials for other industries, especially cement or construction industries. Understanding the legal environment is crucial to finding technical solutions to the desirable properties of slag in order to continue with the industrial symbiosis which is the current standard.

The results of this deliverable will be used in WP3 in order to understand the environmental behavior of the next generation steelmaking slags as well as in WP4 and WP5 in order to find appropriate applications for the next generation slags that complies with the regulatory environment.

[1] www.euroslag.com

2 Slag regulations based on different countries

In order for industrial symbiosis to function, it is important for steel producers to create a desirable by-product such as slag that answers all physical parameter needs, is environmentally safe as well and fulfils all national regulations where it will be used. Slag utilization is governed by national and sometimes regional regulations. In this chapter Austrian, Belgian, French, German, Italian and Spanish national or regional regulations for slag utilization are summarized.

2.1 Austria

The Recycling-Baustoffverordnung (Recycled Building Materials Ordinance) in its current version from 01.02.2023 provides parameters and limiting values for aggregates from steel slags directly from production, which are used exclusively for the production of asphalt mixes (**Table 1**).

Table 1: Parameters and limiting values for aggregates from steel slags directly from production, which are used exclusively to produce asphalt mixes in Austria (solid:liquid ratio of 1:10, grain size < 10mm)

Parameter	**Unit**	**Limiting value**
pH	mg/kg DM	12.5
Ba	mg/kg DM	20
Cd	mg/kg DM	0.040
Cr total	mg/kg DM	0.30
Co	mg/kg DM	1.0
Mo	mg/kg DM	0.50
Tl	mg/kg DM	0.10
V	mg/kg DM	1.0
W	mg/kg DM	1.50
F^-	mg/kg DM	10.0
total content		
Cd	mg/kg DM	1.10
Cr total	mg/kg DM	2500
Mo	mg/kg DM	50
Tl	mg/kg DM	50
W	mg/kg DM	450

DM = dry matter

Quality classes (A and B) for recycled construction materials are shown in

Table 2 according to “Gesamte Rechtsvorschrift für Recycling-Baustoffverordnung, Fassung vom 20.03.2025” (complete legal regulation for the Recycling Construction Materials Ordinance), version dated March 20, 2025.

Table 2: Parameters and limit values for aggregates for unbound, hydraulically, or bituminous bound use (solid:liquid ratio of 1:10, grain size < 10mm)

Parameters	Unit	Limiting	
		Class A	Class B
pH		7.5-12.5	7.5-12.5
EC	µS/l	≤ 150	≤ 150
Co	mg/kg	≤ 0.60	≤ 2.0
Cr	mg/kg	≤ 0.30	≤ 1.0
Ni	mg/kg	≤ 0.40	≤ 0.60
V	mg/kg	≤ 0.50	≤ 0.50
Cl^-	mg/kg	≤ 800	≤ 800
NO_3^-	mg/kg	≤ 100	≤ 130
SO_4^{-2}	mg/kg	≤ 2,500	≤ 4,000
NH_4^+	mg/kg	≤ 4.0	≤ 8.0
TOC	mg/kg	≤ 100	≤ 200

In Austria substitute raw materials used in plants for the production of cement clinker must comply with the limiting values from July 1, 2018, presented in **Table 3**.

Table 3: Limiting values for substitute raw materials to produce cement clinker in Austria (from July 1, 2018)

Parameter	Unit	Limiting value
Sb	mg/kg DM	30
As	mg/kg DM	30
Pb	mg/kg DM	500
Cd	mg/kg DM	5
Cr	mg/kg DM	500
Co	mg/kg DM	250
Ni	mg/kg DM	500
Hg	mg/kg DM	0.7
Tl	mg/kg DM	3

DM = dry matter

Table 4 presents the physical parameters for EAF slag in road construction in Austria which must comply with EN 13242.

Table 4: Summary of physical parameters for EAF slag in road construction regulated in Austria (EN 13242)

Parameter	Unit	Limiting Value
Los Angeles coefficient		
0-16 mm	wt.-%	≤ 30
16-32 mm	wt.-%	NR
32-63 mm	wt.-%	NR
63-125 mm	wt.-%	NR
0-32 mm	wt.-%	≤ 30
0-63 mm	wt.-%	≤ 30
0-125 mm	wt.-%	≤ 40
Shape Index		
0-16 mm	wt.-%	≤ 40
16-32 mm	wt.-%	NR
32-63 mm	wt.-%	NR
63-125 mm	wt.-%	NR
0-32 mm	wt.-%	≤ 40
0-63 mm	wt.-%	≤ 40
0-125 mm	wt.-%	NR
Frost resistance (loss)	wt.-%	≤ 2
Fines (<0.063 mm)		
0-16 mm	wt.-%	≤ 3
16-32 mm	wt.-%	≤ 2
32-63 mm	wt.-%	≤ 2
63-125 mm	wt.-%	≤ 2
0-32 mm	wt.-%	≤ 3
0-63 mm	wt.-%	≤ 3
0-125 mm	wt.-%	≤ 3
Volume stability	wt.-%	V5

NR = no requirement

The Austrian Fertilizer Ordinance, BGBl. II Nr. 100/2004 (in the current version 2014) provides limiting values for use of slags as fertilizers (**Table 5**).

Table 5: Limiting values for using slags as fertilizer or soil additives in Austria

Parameter	Unit	Limiting value		
		Fertilizer, soil additives, plant additives	Mineral fertilizer with more than 5% P_2O_5	Horticultural growing
As	mg/kg DM	40	40	40
Cd	mg/kg DM	3	75 mg/kg P_2O_5	1

Cr(VI)	mg/kg DM	2	2	2
Hg	mg/kg DM	1	1	0.5
Ni	mg/kg DM	100	100	70
Pb	mg/kg DM	100	100	50
V	mg/kg DM	-	1500	-

DM = dry matter

2.2 Belgium

In Belgium, there are two main layers of regulations regarding to the slag use. The first one is federal/national and targets the technical characteristics of materials including the slags for specific applications. The second layer is regional (Walloon or Flemish) and focus on environmental limitations depending on application.

The slags are defined based on which process had generated them and so it is specified either it is a BF, EAF, BOF, Stainless steel or non-ferrous slag (the cooling rate can be specified for crystallized or fast cooled slags for some applications).

The Slags can be use as granulates according to NBN EN 12620+A1:2008 norm, plus NBN EN 13043, NBN EN 13139 & NBN EN 13242. These norms give the limitations, ranges and protocol to assess the technical characteristics of slags. It includes Polishing coefficient, Micro-Deval, Los Angeles, Water Absorption, flattening coefficient, fines content (NBN EN 933). Besides, that are specific requirement for slag (NBN EN 1744-1) about free lime content (must be <4.5%) and swelling (if D <25 mm) or disintegration (if D > 25mm). The limits vary depending on the application/quality required.

The slags can also be used as a substitute to clinker in cement making following the NBN EN 15167-1:2007, NBN B 15-001:2022 and NBN EN 197-1 norm. The BFS is the main slag concerned by this valorization. The cement could include different grades of BFS in the mix (from 36 to 95% for some categories). The characteristics are a limited Loss on fire, insoluble residues content, SO3 content and chloride content. There are variants for sulfate high resistance cements and limited alkali content cements which for the latter limit the % Na2 Oeq (= % Na2 O + 0,658 x % K2 O) to a maximum value, again depending on the cement type.

For the environmental aspects, in Wallonia, the slags were considered as waste (10 02 02 and 10 02 01). However, since 2022, the stainless steel slags (mainly from EAF) are no longer considered as waste and can be use with different limitations as granulates or fillers for concrete, other solution with binder, road and in general civil engineering. Other sectors are a priori not allowed; therefore agriculture application seems to not be allowed.

The utilization of EAF slag in Belgium is governed by “Arrêté du Gouvernement wallon favorisant la valorisation de certains déchets (M.B. 10.07.2001 - err. 18.07.2001)”. The leaching procedure is EN 12457-4, one stage batch test at a liquid to solid ratio of 10 to l/kg for materials with particle size below 10 mm. **Table 6** shows leaching limiting values in Belgium.

Table 6: Belgian limiting leaching values

Parameter	Unit	Belgium EN 12457-4
solid: liquid ratio		**1:10**

Parameter	Unit	Belgium EN 12457-4
pH		7-12
EC	µS/cm	≤ 6000
Al	mg/l	≤ 2000
As	mg/l	≤ 0.1
Cd	mg/l	≤ 0.1
Co	mg/l	≤ 0.1
Cr VI	mg/l	≤ 0.1
Cu	mg/l	≤ 2
Hg	mg/l	≤ 0.02
Mo	mg/l	≤ 0.15
Ni	mg/l	≤ 0.2
Pb	mg/l	≤ 0.2
Sb	mg/l	≤ 0.2
Ti	mg/l	≤ 2
Zn	mg/l	≤ 0.9
CN^-	mg/l	≤ 500
F^-	mg/l	≤ 5
NO_3^-	mg/l	≤ 3
SO_4^{-2}	mg/l	≤ 1000

2.3 France

The use of slag in France for road construction is regulated according to "Guidelines for acceptability of alternative materials in road construction (SETRA, October 2012)". This document defines the possible use of the slag on the basis of the results of the leaching test. The leaching test procedure is EN 12457-4, overhead rotation for 24 hours with grain size < 10 mm and solid to liquid ratio of 1 to 10. Three different slag quality classes are defined with possible uses when each class is met. **Table 7** shows leaching limiting values in France.

Table 7: French limiting leaching values for applications as road construction

Parameter	Unit	France EN 12457-2		
solid: liquid ratio		1:10		
		Type 1	Type 2	Type 3
As	mg/l	≤ 0.06	≤ 0.06	≤ 0.06
Ba	mg/l	≤ 3.6	≤ 2.5	≤ 2.5
Cd	mg/l	≤ 0.005	≤ 0.005	≤ 0.005
$Cr_{(total)}$	mg/l	≤ 0.4	≤ 0.2	≤ 0.06
Cr IV	mg/l	≤ 0.12	0.06	
Cu	mg/l	≤ 0.3	≤ 0.3	≤ 0.3
Hg	mg/l	≤ 0.001	≤ 0.001	≤ 0.001
Mo	mg/l	≤ 0.56	≤ 0.28	≤ 0.06

Ni	mg/l	≤ 0.05	≤ 0.05	≤ 0.05
Pb	mg/l	≤ 0.06	≤ 0.06	≤ 0.06
Sb	mg/l	≤ 0.008	≤ 0.008	≤ 0.008
Se	mg/l	≤ 0.05	≤ 0.04	≤ 0.01
Zn	mg/l	≤ 0.5	≤ 0.5	≤ 0.5
Cl^-	mg/l	≤ 1000	≤ 500	≤ 100
F^-	mg/l	≤ 6	≤ 3	≤ 1.3
SO_4^{-2}	mg/l	≤ 1000	≤ 500	≤ 130

Other applications:

Concrete aggregate: no regulation on leaching nor heavy metal total content. Only technical standards apply to aggregates (performances and characteristics) according to EN 12620.

Cement: according to 2003-53 CE (limitation for marketing authorization of dangerous substances and preparation for cement, annex), soluble Cr(VI) has to be < 2 mg/kg of total dry mass of cement

Fertilizer: according to NFU 44001, BOF slag is allowed as basic mineral amendments or as part of it, when it contains more than 32 wt.% CaO + MgO. Requirements on maximal composition of minor elements are listed in **Table 8** expressed as total content in the dry amendment. The regulation is planned to be updated in 2024.

Table 8: Maximum content in in slag as fertilizer amendment in France

Parameter	Unit	Maximal content in dry amendment
MgO	wt.%	12
P2O5	wt.%	3
Organic compounds	wt.%	5
As	mg/kg	56
Cd	mg/kg	5.0
Cr VI	mg/kg	4
Cu	mg/kg	63
Hg	mg/kg	0.33
Mo	mg/kg	33
Ni	mg/kg	20
Pb	mg/kg	22
Se	mg/kg	1
Zn	mg/kg	60

2.4 Germany

The current use of steel slag (EAF and LF slags) in Germany in road construction was regulated by each federal state and often according to TL Gestein-StB 04, 2007. Since August 2023, new regulation took effect called *Substitute Building Materials Ordinance* (Ersatzbaustoffverodnung - EBV), which replaces the previous regulation TL Gestein-StB 04, 2007 7.1.1.

If the class SWS-1 of the new regulation is fulfilled, the slag can be declared a product. There are two different leaching procedures that can be used for the frequent analysis: DIN 19528 or DIN 19529. DIN 19528 is an up-flow column percolation test with a solid to liquid ratio of 1:2. DIN 19529 is an overhead rotation test for 24 hours with a solid to liquid ratio of 1:2. Both require a grain size of < 22.4 mm (with ≥ 45 wt.-% < 4 mm) or testing of specific grain size that will be used in specific application. **Table 9** shows leaching limiting values in Germany. Limiting values for both methods, DIN 19528 and DIN 19529, are the same.

Table 9: German limiting leaching values for both methods, DIN 19528 or DIN 19529 (solid to liquid ratio of 1:2)

Parameter	Unit	SWS1	SWS2
pH		9-13	9-13
EC[1)]	µS/cm	≤ 10,000	≤ 10,000
Cr(total)	mg/l	≤ 0.110	≤ 0.190
Mo	mg/l	≤0.055	≤ 0.400
V	mg/l	≤ 0.180	≤ 0.450
F^-	mg/l	≤ 1.1	≤ 4.7

1) EC = electrical conductivity
2) Class SWS-1 = product

Table 10 shows the physical parameters that are required and their limiting values for different applications: bulk density, Los Angeles coefficient, resistance to fragmentation, frost resistance and volume stability. Different parameters or limiting values might be required for different type of applications of the EAF slag. There are no regulations as to the chemical composition of the EAF slag in Germany, except in cement, concrete and fertilizer utilization.

Table 10: Summary of physical parameters regulated in Germany

Parameter	**Unit**	**EAF slag**
Bulk density	g/cm^3	3.20-3.80
Los Angeles coefficient		≤ 18[3)] ≤ 35[3)]
Resistance to fragmentation[1)]		
For chippings (8-12,5 mm)	wt.-%	≤ 26[2)]
For coarse material (35,5-45 mm)	wt.-%	≤ 29
Frost resistance (loss)[3)]		
< 2 mm	wt.-%	≤ 1 F1 ≤ 2 F2
< 0.71 mm	wt.-%	
Volume stability	wt.-%	3.5 or 5[3)]
Size		3.6
Compressive strength	N/m^3	3.7

1) Depending on the application
2) EU regulation (not German)
3) DIN EN 1367-1

Use of slag in concrete in general is allowed in Germany and **Table 11** shows the required leaching and total chemical composition limiting values the slag has to fulfil. The requirements are included in Annex 10 "Requirements on constructions regarding impact on soil and water" (ABuG) of the Model Administrative Provisions-Technical Building Rules (MVV TB 2023/1)[2].

[2] Veröffentlichung der Muster-Verwaltungsvorschrift Technische Baubestimmungen 2023/1 (MVV TB 2023/1) mit Druckfehlerberichtigung vom 10. Mai 2023

Table 11: Limiting values for leaching and total composition of steel slag in concrete, regulated in Germany

	Parameter	Unit	Steel Slag
Leaching	pH		10-13
	EC[1)]	µS/cm	1,500
	Cr(total)	mg/l	≤ 0.100
	V	mg/l	≤ 0.250
	F^-	mg/l	≤ 5
Total composition	As	mg/kg	150
	Cd	mg/kg	10
	CN^-	mg/kg	10
	Cr(total)	mg/kg	600
	Hg	mg/kg	5
	Cu	mg/kg	400
	Ni	mg/kg	500
	Pb	mg/kg	700
	Tl	mg/kg	7
	Zn	mg/kg	1,500
	Benzo(a)pyrene	mg/kg	3
	BTX[2)]	mg/kg	1
	EOX[3)]	mg/kg	10
	Hydrocarb on	mg/kg	1000
	LHKW[4)]	mg/kg	1
	PAH16[5)]	mg/kg	20
	PCB6[6)]	mg/kg	0.5
	TOC[7)]	wt.-%	5

1) EC= electrical conductivity
2) BTX = Benzene, Toluene, Xylene
3) EOX = Extractable Organic Halides compounds
4) LHKW = Volatile halogenated hydrocarbon compounds
5) PAH16 = EPA designated high pollutant Polycyclic Aromatic Hydrocarbon
6) PCB = Polychlorinated biphenyl
7) TOC = Total Organic Carbon

There are also additional requirements (ABuG) for leaching of the final concrete, produced with steel slag, determined by the tank test over 64 days (CEN/TS 16637-2) and cumulated by different fractions, where following limiting values must be met, **Table 12**.

.

Table 12: Limiting values for leaching and total composition of steel slag in concrete, regulated in Germany

Parameter	Unit	Limit
As	mg/m^2	11
Ba	mg/m^2	375
Cd	mg/m^2	0.56
Co	mg/m^2	8.8
Cr	mg/m^2	7.7
Cr^{6+}	mg/m^2	6.6
Cu	mg/m^2	15.4
Hg	mg/m^2	0.22
Mo	mg/m^2	38.6
Ni	mg/m^2	15.4
Pb	mg/m^2	7.7
Sb	mg/m^2	5.5
Tl	mg/m^2	0.88
V	mg/m^2	4.4
Zn	mg/m^2	63.9
Cl^-	mg/m^2	275,515
F^-	mg/m^2	826
SO_4^{2-}	mg/m^2	264,495

Fine slag can be used as a liming/fertilizer material, if its properties fulfil national regulations (Düngemittelverordnung (DüMV) 2012) and if the material is REACH registered for fertilizer use. In Germany the national fertilizer regulation specifies criteria for slags to be used as liming material that can be met by BF, BOF or LF slags only. According to the German Fertiliser Regulation the Cr(VI) concentration needs to be below 2 ppm. EAF slag could be used as fertilizer material only if it would meet the new European Fertilizer Regulation, which requires amongst others, the concentrations of total Cr to be below 400 ppm and Cr(VI) to be less than 2 ppm.

Reactivity for self-disintegrating slag and sieved BOF slag has to have 30% soluble Ca and Mg after treatment with diluted HCl. **Table 13** shows German regulations for using BF, BOF or LF slag as fertilizer.

Table 13: German regulations for using BF, BOF or LF slag as fertilizer

Parameter	**Unit**	**Regulation**	**Analysis of any given sample must fall within the specified deviation5)**	
			Lower deviation	**Higher deviation**
Al	wt.-%	-	-	-
CaO	wt.-%	> 40[1)]	3 %	3%
Co	wt.-%	> 0.004[1)]	50 %; max 0.4 pt.	
Fe_{total}	wt.-%	>1.0[1)]	2 %	2 %
MgO	wt.-%	> 5[1)]	2.1 %	1.5 %
CaO+MgO[2)]	wt.-%	> 42/40[1)2)3)]	3 %	3 %
Mn	wt.-%	> 0.2[1)]	50 %; max 0.4 pt.	
Na	wt.-%	> 0.2[1)]	50 %; max 0.4 pt.	
P_2O_5	wt.-%	> 0.5[1)]	25 %; max 1 pt.	
S	wt.-%	> 1.3[1)]	50 %; max 1.5 pt.	
As	mg/kg	20/40[1)4)]	50 %[5)]	
Cd	mg/kg	1.0/1.5[1)4)]	50 %[5)]	
Cr	mg/kg	300/-[1)4)]	50 %[5)]	
Cr(IV)	mg/kg	1.2/2.0	50 %[5)]	
Cu	mg/kg	200/900[1)4)]	50 %; max 0.4 pt	
Hg	mg/kg	0.5/1.0[1)4)]	50 %[5)]	
Ni	mg/kg	40/80[1)4)]	50 %[5)]	
Pb	mg/kg	100/150[1)4)]	50 %[5)]	
Tl	mg/kg	0.5/1.0[1)4)]	50 %[5)]	
Zn	mg/kg	200/5000[1)4)]	50 %; max 0.4 pt.	
Percent of slag that passes through given grain size				
0-0.315 mm	%	>40[5)] / > 80[6)]	-	-
> 3.15 mm	%	< 3[5)]	-	-

1) German slag fertilizer regulations – value at which declaration is necessary, needs to be labeled
2) Declaration of the lime content is the sum of CaO and MgO
3) 42 % for BF slag and 40 % for BOF slag
4) First is value at which declaration is necessary and second is limiting value
5) Lower and higher deviation refers to the declared value, but tolerance does not allow deviations below minimum content or above maximum content
5) Value for slag that was naturally disintegrated
6) Value for slag that was milled

2.5 Italy

Italian law, Law n.257 of 2nd Nov.2019, modification of art. 184-ter D. Lgs 152/2006, gives criteria to define residue as a by-product. The material has to have the environmental and merchandise quality necessary to be used as a raw material and the final use of this material should be defined. The leaching procedure is EN 12457-2, overhead rotation with grain size < 4 mm and solid to liquid ratio of 1 to 10 is used to assess the environmental behavior of the by-product. **Table 14** Italian limiting values for reuse and for inert landfill. **Table 15** shows the physical parameters that are required and their limiting values for different applications.

Table 14: Italian limiting leaching values for reuse and inert landfill

Parameter	Unit	Italy EN 12457-2	
solid: liquid ratio		1:10	
		for reuse	for inert landfill
pH		5.5-12	-
COD	mg/l	< 30	-
As	mg/l	< 0.05	< 0.05
Ba	mg/l	< 1	< 2
Be	mg/l	< 0.01	-
Cd	mg/l	< 0.005	< 0.004
Co	mg/l	< 0.25	-
Cr(total)	mg/l	< 0.05	< 0.05
Cu	mg/l	< 0.05	< 0.2
Hg	mg/l	< 0.001	< 0.001
Mo	mg/l	-	< 0.05
Ni	mg/l	< 0.01	< 0.04
Pb	mg/l	< 0.05	< 0.05
Sb	mg/l	-	< 0.006
Se	mg/l	< 0.01	< 0.01
V	mg/l	< 0.25	-
Zn	mg/l	< 3	< 0.4
Cl^-	mg/l	< 100	< 80
CN^-	mg/l	< 0.05	-
F^-	mg/l	< 1.5	< 1
NO^{3-}	mg/l	< 50	-
SO_4^{-2}	mg/l	< 250	<100

Table 15: Summary of physical parameters regulating EAF slag use in Italy

Parameters	Units	EAF slag
Los Angeles coefficient		< 30[1]; < 20[2]; < 40[3]
Size	mm	> 4[1)2)3)]

1) Highway and extra urban way – substrate; 2) Highway and extra urban way – wear layer; 3) Local way – substrate

In Italy at this time slag is not allowed to be used as a fertilizer, unless it fulfills the European Fertilizer regulation. However, in July 2023 the Italian fertilizer legislation was updated through the Italian decree of 6 July 2023 of the Ministry of Agriculture, Food Sovereignty and Forests containing the update of annexes 1, 2, 3, 7 and 13 to the legislative decree of 29 April 2010, n. 75, containing: "Reorganization and revision of the regulations regarding fertilizers, in accordance with the article 13 of law 7 July 2009, n. 88"[3]. In particular, in Annex 3 "Correctives", Point 2.1. Calcium and magnesium correctives, of the Legislative Decree of 29 April 2010, n. 75, the product no. 24 was added: "White slag (LF slag) from electric steelworks for the production of flat rolled steels with low phosphorus and sulfur content".

This means that LF slag can be used as a fertilizer in Italy if it fulfills the calcium and magnesium corrective criteria listed in Annex 3 (summarized in **Table 16**).

Table 16: Calcium and magnesium correctives (translated from Annex 3, Italian decree of 6 July 2023)

Type designation	Type designation	Minimum content in useful elements and/or substances. Evaluation criteria. Other required requirements.	Elements whose content must be declared	Notes
White slag from electric steelworks for the production of flat rolled steels with low phosphorus and sulfur content	Product recovered from white slag from electric steelworks for the production of flat rolled steels with low phosphorus and sulfur content, essentially consisting of calcium and magnesium oxides	50 % CaO 6.5 % MgO	Total CaO Total MgO Grain size classification	Ground product (at least 80% grain size less than 5 mm)

2.6 Spain

The use of residues and contaminated soil in Spain is regulated according to the Regulation 7/2022 of April 8. Furthermore, some regions, including the Basque Country, have more specific decrees for slags.

In the case of the Basque Country, only the EAF slag is considered a product after its valorization process (slag aggregate) and has a specific decree, whilst the LF slag is considered as a residue and its valorization process and future use is regulated as such.

The Basque Country recently revised EAF slag valorization activities according to D64/2019, of 9th April, which replaces the previous regulation RD 34/2003 of Feb. 2003. To comply with environmental regulation, there are both slag metal content and leaching content limiting values (**Table 17**). The leaching procedure is EN 12457-4 (previously EN 12457-3), one stage batch test at a liquid to solid ratio of 10 to l/kg for materials with particle size below 10 mm. The results are calculated in mg/kg and not mg/l like in the other leaching tests. Limiting values only apply for unbound applications, divided into type 2 and 3 depending on permeability level.

[3] www.gazzettaufficiale.it/eli/id/2023/09/16/23A05090/sg

Table 17: Basque Country (Spain) limiting leaching values for EAF slag

Parameters	Units	Basque Country (Spain)		
		EN 12457-4 (solid:liquid = 1:10)		
		Type 1: Bound applications	Type 2: Unbound applications without complete impermeability coverage	Type 3: Unbound applications with complete impermeability coverage
As	mg/kg	NA	0.5	0.6
Ba	mg/kg		20	25
Cd	mg/kg		0.04	0.05
Cr	mg/kg		0.5	2
Cr (VI)	mg/kg		0.1	0.4
Cu	mg/kg		2	3
Hg	mg/kg		0.01	0.01
Mo	mg/kg		0.5	2.8
Ni	mg/kg		0.4	0.5
Pb	mg/kg		0.5	0.6
Sb	mg/kg		0.06	0.08
Se	mg/kg		0.1	0.4
V	mg/kg		1.5	4
Zn	mg/kg		4	5
Cl^-	mg/kg		800	5 000
F^-	mg/kg		18	30
SO_4^{-2}	mg/kg		1 000	5 000

NA= not applicable

Total metal composition limits (**Table 18**) on the EAF slag aggregate itself applies only for unbound applications (type 2 and 3).

Table 18: Summary of limiting metal values in the Basque Country (Spain) (D 64/2019)

Parameters	Units	Metal content limits
As	mg/kg	30
Cd	mg/kg	5
Cu	mg/kg	10 000
Cr (VI)	mg/kg	8
Cr	mg/kg	10 000
Hg	mg/kg	4
Mo	mg/kg	75
Ni	mg/kg	110
Pb	mg/kg	120
Zn	mg/kg	10 000
V	mg/kg	1 000

Depending on the final use of the slag aggregate, there are several physical properties to be fulfilled. In the case of Sidenor, the most common usage is on base layers for road pavement construction, for which, both Basque Country's and Spanish regulation (PG-3) for pavement construction must be followed. A summary of those requirements is shown in **Table 19**.

Table 19: Summary of physical parameters regulated in Spain

Parameters	Units	EAF slag
Bulk density	g/cm^3	~3.5
Los Angeles coefficient		$< 20^{1)}$; $< 30^{2)}$
Volume stability	wt.-%	≤ 3.5
Compressive strength$^{3)}$	MPa	≤ 120; ≤ 200; ≤ 300

1) Road wear layer and concrete pavements
2) Road base layer
3) Depending on pavement category

3 European regulations

There are different European regulations governing slag utilization. In some cases European regulations can be used, meaning either national or European regulations can be used. In some cases the regulations are not translated/interpreted in the same way. If

3.1 Waste

Different slag types are defined as a product, by-product or waste in different countries.

The definition of what constitutes waste in EU is designated in Directive 2006/12/EC (the Waste Framework Directive). Article 6 defines the end-of-waste (EoW) criteria. Article 5 classifies materials as by-product which exempts it from the waste directive. While there is generally clarity on what qualifies as waste and what does not, challenges have emerged in interpreting this definition. The Communication from the Commission to the Council and the European Parliament on the Interpretative Communication on waste and by-products Brussels, 21.2.2007 (COM(2007) 59 final), clarified specifically iron and steel slags as waste; "In contrast, 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."

3.2 Construction products

The Construction Products Regulation (CPR, 305/2011/EU) [4] defines the harmonized test methods. However, the actual criteria to be met by products to be used in construction will be regulated by Member States, who might refer to the EU regulation.

3.2.1 Road and waterway construction

There are no road and water construction regulations in reference to slag in EU, national regulations apply.

3.2.2 Cement

There are no cement regulations in reference to slag in EU, national regulations apply.

3.2.3 Concrete

There are no concrete regulations in reference to slag in EU, national regulations apply.

3.3 Fertilizer

Since July 2022 there is a new EU regulation regarding fertilizers (Fertilizer Product regulation 2019/1009[5]). The EU regulation does not affect national regulations and fertilizers can be marketed as "national fertilizer" if they comply with national regulations or "CE marked fertilizing product" if they comply with EU fertilizer regulation. EU parliament and council regulation 2019/1009, including slag explicitly, with limiting values for heavy metals (400 ppm total Cr and 600 ppm V).

3.4 REACH

The REACH regulation[6] requires that all substances above 1 ton per year to be registered with the European chemicals Agency (ECHA) if a product is to be placed on the market. EUROSLAG was in charge of the initiative to register ferrous slags, grouped in five types, as substances. Ferrous slags are registered as Unknown or Variable Composition, Complex reaction or Biological materials (UVCB). Depending on the application slags should be considered as a substance (e.g. cement or concrete products) or recycled aggregates (e.g. construction).

---

[4] Regulation (EU) 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

[5] Regulation (EU) 2019/1009 of the European Parliament and of the Council of 5 June 2019 laying down rules on the making available on the market of EU fertilising products and amending Regulations (EC) No 1069/2009 and (EC) No 1107/2009 and repealing Regulation (EC) No 2003/2003

[6] (EC) No 1907/2006 of the European Parliament and the Council

4 Actual slag applications in different partner countries

Slag utilization practices vary among different countries based on factors such as industrial processes, environmental regulations, and local needs. While the regulatory environment determines how developed and in what application the slag is used, historical experience as well as geography and access to natural materials which slag replaces creates additional incentives or disincentives.

4.1 Austria

In Austria EAF and LF slags are used in applications such as road construction, concrete or cement. **Table 20** summarizes the current slag utilization in Austria.

Table 20: Current use of EAF and LF slag in Austria

Carbon EAF (EAF-C) slag	Stainless EAF (EAF-S) slag	LF slag
Road construction	Usage in special concretes in rock filling (filling material or support material in mining areas)	Cement

4.2 Belgium

In Belgium EAF and LF slags are used in applications such as road applications, road building, cement or civil engineering. **Table 21** summarizes the current slag utilization in Belgium.

Table 21: Current use of EAF and LF slag in Belgium

Carbon EAF (EAF-C) slag	Stainless EAF (EAF-S) slag	LF slag
Road applications	**Road building**	**cement**
	concrete	
	Products mixed with binder	
	Civil engineering	

4.3 France

In France EAF and LF slags are used in multiple applications such as public works, internal recycling, construction and production of hydraulic binders, according to CTPL. **Table 22** summarizes the current slag utilization in France.

Table 22: Current use of EAF and LF slag in France

Carbon EAF (EAF-C) slag	Stainless EAF (EAF-S) slag	LF slag
Public works	Public works	Public works
Internal recycling	Internal recycling	Hydraulic binder production
Construction	Construction	Construction
		Internal recycling

4.4 Germany

In Germany EAF and LF slags are used in multiple applications such as in landfill replacement or landfill building material, aggregate, slag sand, fertilizer, as well as for internal recycling or metal extraction. **Table 23** summarizes the current slag utilization.

Table 23: Current use of EAF and LF slag in Germany

Carbon EAF (EAF-C) slag	Stainless EAF (EAF-S) slag	LF slag
Landfilling	**Landfilling**	**Landfilling**
Landfill replacement	Landfill replacement	Landfill replacement
Building material	Building material	Building material
Aggregate	**Metal extraction**	**Aggregate/Sand**
Unbound and hydraulically bound mixtures		Unbound mixtures
Bituminous mixtures		Cement
Armourstone		**Fertilizer**
Gabions		**Internal recycling**
Railway ballast		
Embankments and fill		
Slag Sand		
Blasting		

4.5 Italy

In Italy EAF and LF slags are used in multiple applications such as in landfill replacement or landfill building material, aggregate, slag sand, cement, liming material, as well as for internal recycling or metal extraction. **Table 24** summarizes the current slag utilization.

Table 24: Current use of EAF and LF slag in Italy

Carbon EAF (EAF-C) slag	Stainless EAF (EAF-S) slag	EAF slag as “slag sand”	LF slag	LF slag as “slag sand”
Landfilling	**Landfilling**	Acid mine drainage prevention, treatment and remediation	**Landfilling**	Acid mine drainage prevention, treatment and remediation
Landfill replacement	Landfill replacement	Soil stabilization and road base reclamation	Landfill replacement	Soil stabilization and road base reclamation
Building material	Building material	Road base and sub-base	Building material	Sludge solidification and stabilization
Aggregate	**Metal extraction**	General construction engineered fill,	**Liming material**	Hazardous waste stabilization

Carbon EAF (EAF-C) slag	Stainless EAF (EAF-S) slag	EAF slag as "slag sand"	LF slag	LF slag as "slag sand"
		embankment, and backfill		
Unbound and hydraulically bound mixtures		Sludge solidification and stabilization	Agriculture – pH adjustment and plant available silicon	Flowable fill and excavatable backfill
Bituminous mixtures		Hazardous waste stabilization	**Replacement of lime in EAF**	
Concrete		Flowable fill and excavatable backfill	**Cement**	
Mortar		Cement and concrete		
Armourstone		Asphalt		
Gabions		Blasting material		
Railway ballast				
Roofing				
Embankments and fill				
Sealants				
Waste-water treatment				
Air quality control				

4.6 Spain

In Spain EAF and LF slags are used in multiple applications such as in landfill replacement or landfill building material, aggregate. **Table 25** summarizes the current slag utilization.

Table 25: Current use of EAF and LF slag in Spain

Carbon EAF (EAF-C) slag	LF slag
Landfilling	**Landfilling**
Landfill replacement	**Aggregate**
Building material	Cement
Aggregate	
Concrete (many types)	
Bituminous mixtures	
Surface treatment of roads, airports and other paved areas	
Granular layers	
Layers treated with hydraulically bond mixtures	
Mortars	
Embankments	
Backfill	
Railway sub-ballast	
Sonic shield for road structures	
Road base and sub-base	

5 Conclusion

The regulations that pertain to EAF and LF slag were collected for each country (Austria, Belgium, France, Germany, Italy and Spain) as well as European Union. Regulations apply to the area where the slag will be used, but also specifications must be met which might be required by the user. Often local regulations apply (e.g. in Germany or Spain). Not all applications are regulated in the same way in each country, in some cases there are no regulations as to slag use, in other case there are regulations to a particular slag, but not necessarily EAF and LF. In order to assess slags from next generation steelmaking it is crucial to understand what applications they are being used in currently and if the new application that is being investigated is allowed (if not if there are steps that can be taken to obtain permission).

InSGeP

Investigations of Slag from Next Generation Steel Making Processes

START DATE | 01-07-2023
PROJECT DURATION | 48 months
TOPIC | RFCS-02-2022-RPJ
BUDGET | 4.5 M€
COORDINATOR | FEhS
CONTACT | info@insgep.eu