



GTOG: From production to recycling: a circular economy for the European gypsum Industry with the demolition and recycling Industry



GYPSUM TO GYPSUM

Protocol of action B2.2: Quality criteria for recycled gypsum, technical and toxicological parameters

Executive Summary

Start date of the project: 2013/01/01 Duration: 36 months

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Introduction

In the Grant agreement, it was foreseen to establish the quality properties of the recycled gypsum and in parallel to assess the opportunity to establish the end-of-waste criteria for the recycled gypsum at EU level. The partners were aware about the necessary steps to obtain the end-of-waste status for recycled gypsum at EU level.

The end-of-waste status is appealing but in practice is today challenging to achieve at EU level for the recycled gypsum. Indeed, the GtoG project gave the recyclers and producers the opportunity to have together a round robin test on 20 recycled gypsum samples testing by a third party laboratory, partner to the project.

It is the first time that recyclers and producers have a collaborative approach for the establishment of quality criteria for the recycled gypsum on a scientific basis.

The gypsum recycling business is growing in France, the UK, Germany, Scandinavia, Belgium and the Netherlands. New recyclers businesses are emerging.

This will give the Gypsum sector the opportunity to establish further collaborations, also with other recyclers across Europe, taking advantage of the lessons learnt from the GtoG pilot tests.

In view of the above-mentioned, the partners decided to agree on guidelines for quality criteria for recycled gypsum, covering technical and toxicological parameters. These guidelines should be further optimized after the project, taking into account scientific developments mainly regarding the toxicological parameters.

Methodology

Quality criteria for recycled gypsum were evaluated in practice during the GtoG Pilot phase. The work methodology was as follows:

1. Recyclers:
 - Processed¹ the plasterboard waste received from the producers (business as usual)-Trial 1
 - Processed plasterboard waste from production, construction and demolition waste, including the plasterboard waste stemming from the demolishers partners to the project-Trial 2.
2. Producers:
 - Standard production as implemented by each manufacturer – including different raw material streams and a standard percentage of production recycled gypsum - Trial1
 - Maximized the percentage of C&D waste (post-consumer recycled gypsum) from various jobsites, keeping the same percentage of production recycled gypsum as in the first round (*Note: the aim was to maximize C&W waste – not production waste*).
3. Producers, recyclers and the laboratory Loemco:

¹ Production of recycled gypsum from waste plasterboard, incorporating the removal of contamination and the paper lining



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- Analysed the technical and toxicological parameters for the recycled gypsum. The partners decided to use the technical and toxicological criteria as developed by BV Gips as a benchmark, as well as the analysis methods defined by BV Gips.
4. Laboratory Loemco:
- Carried out the testing. Test results

a. Introduction

Each producer sent to Loemco:

- Sample of conventional gypsum: natural gypsum and/or FGD gypsum
- Samples of recycled gypsum first re-incorporation trials (business as usual),
 - Production waste only,
 - Production, construction and demolition waste
- Sample of recycled gypsum second re-incorporation trials (optimization of the percentage up to 30%)
 - Production, construction and demolition waste stemming from the job site
 - Production and demolition waste stemming from the job site

b. Samples received and samples tested

23 samples for the first trials were tested and 20 for the second trials.



Figure 1. One sample tested by LOEMCO

c. Conclusions

The five manufacturers did not observe any chemical or toxicological issues when re-incorporating the recycled gypsum. On the other hand some issues with production equipment have been reported; e.g. the need to invest in broader conveyor belts to cope with the input of a higher volume of recycled powder. These issues have no direct relation to the quality of the gypsum waste. But better paper separation and removal from the scrap is often achieved with a finer grinding, which lead to a less dense powder. In most cases the recycling and the gypsum equipment's are not designed to handle, transport, convey and dose very low density materials. This can be a cause for process stops and loss of yield or for additional Capex in this area.



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Nickel has higher values than foreseen in the toxicological parameters foreseen by BV Gips² and derived from the reference values for heavy metals concentration in gypsum of the Beckert study³. For Nickel, the maximum concentration in the Beckert dataset was 13 mg/kg. The values from the Beckert study are widely recognized as reference values for heavy metal concentrations in FGD and natural gypsum. However, these values do not represent the concentrations above which a human health risk occurs. These "risk-based threshold values" have not been defined. Further study in relation to the toxicological parameter of FGD Gypsum is currently being carried out by the Gypsum Industry. After the Life-project, the results of the study can be analysed for the recycled gypsum. The quality criteria would then be revised in 2017.

The test results (technical and toxicological) are as follows:

² German Gypsum Association

³ BECKERT J., 1990. Comparison of natural gypsum and FGD gypsum: studies for a comparative assessment of the health impact of natural gypsum and FGD gypsum from coal-fired power plants with a view to their use in the manufacture of building materials. *VGB technical scientific reports "Thermal power plants"*, 707.



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Technical parameters as agreed on 30 April 2015



Technical parameters																								
30 April 2015																								
Parameter	Test method	Powder spec	1 st TRIAL										2 nd TRIAL											
			Conventional gypsum				Recycled gypsum (internal and C&D waste)						Conventional gypsum			Recycled gypsum (internal and C&D waste)								
			GY-F-01	GY-F-02	GY-M-01	GY-M-02	GY-R-01	RG-01	RG-02	RG-03	GY-F-03	GY-M-03	GY-M-04	RG-04	RG-05	RG-06	RG-07	RG-08	RG-09	RG-10	RG-11	RG-12	RG-13	
Max. size measured (mm)	UNE-EN 933-1	----	<0,1	0,1	20	----	4	2	4	14	0,1	20	----	4	8	8	4	14	8	14	8	8	8	
Particles < 4 mm (%)	UNE-EN 933-1	----	100	100	67	----	99	100	96	91	100	61	----	89	92	95	96	92	97	92	83	95	90	
Free moisture	VGB serial number 1	< 10%	0,05	6,64	4,89	0,08	1,00	0,51	2,50	9,94	6,85	4,52	0,12	1,92	0,27	9,47	9,40	10,46	11,74	17,14	4,14	4,50	7,84	
Purity (CaSO ₄ 2H ₂ O)	VGB serial number 2.3	> 80%	96,41	93,89	89,59	89,01	89,85	86,95	87,70	88,78	93,40	90,67	91,42	79,83	82,97	90,22	90,64	90,20	88,72	89,78	83,06	89,26	88,25	
TOC	Gigt 3.1.3.2 DepV DIN EN 13137	< 1.5%	0,01	0,16	0,04	0,03	0,83	3,13	0,75	0,44	0,22	0,03	0,04	0,63	0,82	0,79	0,75	0,83	0,84	0,84	0,78	0,30	0,19	
Magnesium salts, water sol.	VGB serial number 8.1.2	< 0.1%	0,006	0,012	0,009	0,004	0,012	0,010	0,029	0,012	0,012	0,008	0,005	0,038	0,013	0,013	0,013	0,012	0,012	0,033	0,019	0,009	0,008	
Sodium salts, water sol.	VGB serial number 8.2.2	< 0.06%	0,004	0,007	0,004	0,002	0,019	0,066	0,019	0,023	0,008	0,004	0,003	0,026	0,023	0,019	0,019	0,019	0,018	0,017	0,028	0,021	0,019	
Potassium salts, water sol.	VGB serial number 8.3.2	< 0.05%	0,001	0,003	0,003	0,001	0,006	0,034	0,012	0,011	0,003	0,003	0,004	0,021	0,024	0,007	0,007	0,007	0,006	0,007	0,020	0,036	0,007	
Sol. Chloride	VGB serial number 8,8,3	< 0.02%	0,002	0,005	0,006	0,001	0,011	0,124	0,013	0,008	0,004	0,006	0,003	0,009	0,009	0,009	0,012	0,010	0,012	0,014	0,019	0,007	0,009	
pH	VGB serial number 4	7-9	6,50	7,03	8,10	7,42	8,51	8,35	8,22	7,87	7,28	8,05	7,45	8,91	8,82	7,78	7,62	7,56	7,53	8,42	8,43	8,34	7,80	

Table 1. Technical parameters as agreed on 30 April 2015



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Toxicological parameter as agreed on 29 May 2015

Toxicological parameters																								
Values can be adjusted to new human-toxicological assessments and limits																								
29 May 2015																								
Element [mg/kg]	Test method	Proposed limits		1 st TRIAL								2 nd TRIAL												
		BV Gips DE	Quality Protocol UK	Conventional gypsum				Recycled gypsum (production and C&D waste)				Conventional Gypsum				Recycled gypsum (production and C&D waste)								
				GY-F-01	GY-F-02	GY-M-01	GY-M-02	GY-R-01	RG-01	RG-02	RG-03	GY-F-03	GY-M-03	GY-M-04	RG-04	RG-05	RG-06	RG-07	RG-08	RG-09	RG-10	RG-11	RG-12	RG-13
As	DIN EN ISO 11885 Determination of selected elements ICP-OES (acc to DepV)	< 4	5,23	<0,21	<0,21	<0,21	<0,21	<0,21	<0,21	<0,21	<0,21	<0,21	<0,21	<0,21	<0,21	<0,21	<0,21	<0,21	<0,21	<0,21	<0,21	<0,21	<0,21	
Be		< 0,7	-	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01
Pb		< 22	31,9	<0,18	<0,18	<0,18	<0,18	<0,18	<0,18	<0,18	<0,18	<0,18	<0,18	<0,18	<0,18	130,40	<0,18	<0,18	<0,18	<0,18	<0,18	<0,18	<0,18	<0,18
Cd		< 0,5	0,3	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01	<0,01
Cr		< 25	17,9	<0,01	1,42	<0,01	0,85	1,39	<0,02	5,97	1,37	<0,01	<0,01	0,78	4,85	3,47	2,06	1,10	2,03	1,79	2,34	5,94	1,22	<0,02
Co		< 4	-	<0,01	<0,01	<0,01	<0,01	<0,02	<0,02	<0,01	<0,02	<0,01	<0,02	<0,01	<0,02	2,61	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02
Cu		< 14	32,8	<0,01	<0,01	<0,01	<0,01	<0,01	<0,02	<0,02	<0,01	<0,01	<0,01	<0,01	<0,01	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	<0,02	4,13	<0,02
Mn		< 200	2,412	16,10	53,40	18,80	43,80	25,23	52,83	33,90	14,82	52,80	17,40	62,20	56,10	50,60	26,20	21,10	25,40	24,00	26,08	52,80	10,24	20,40
Ni		< 13	7,31	<0,01	<0,01	<0,01	<0,01	7,52	40,50	12,30	7,64	<0,01	<0,01	<0,01	30,70	31,40	7,91	8,51	10,40	8,60	2,88	31,60	11,30	11,10
Se		< 16	7,37	<0,37	<0,37	<0,37	<0,37	<0,37	<0,37	<0,37	<0,37	<0,37	<0,37	<0,37	<0,37	<0,37	<0,37	<0,37	<0,37	<0,37	<0,37	<0,37	<0,37	<0,37
Te		< 0,3	-	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05	<0,05
Tl		< 0,4	-	<0,12	<0,12	<0,12	<0,12	<0,12	<0,12	<0,12	<0,12	<0,12	<0,12	<0,12	<0,12	<0,12	<0,12	<0,12	<0,12	<0,12	<0,12	<0,12	<0,12	<0,12
V		< 26	-	4,11	2,74	2,96	3,11	4,37	5,99	7,36	6,07	1,03	4,03	5,44	4,58	4,61	4,50	3,54	3,99	4,32	5,09	7,42	3,70	5,29
Zn		< 50	40,3	4,30	15,30	4,19	4,31	15,50	6,39	29,54	39,52	16,90	3,94	5,32	52,90	31,29	18,41	18,31	13,96	17,24	16,67	43,11	16,02	13,68
Hg	DINEN 1483 AAS-DINEN 12338- Mercury process after enrichment by amalgamation. DIN ISO 1785 atomic fluorescence spectrometry (acc to MatelV0)	< 1,3	< 2	0,20	0,43	<0,05	<0,05	0,30	0,08	0,23	<0,05	0,39	<0,05	<0,05	0,21	0,21	0,28	0,29	0,29	0,31	0,29	<0,05	<0,05	
Radioactivity Index	RP 112 Document (EC)	< 0,5		----	----	----	----	----	----	----	----	<0,02	<0,05	<0,07	<0,14	<0,17	<0,04	<0,04	<0,05	<0,05	<0,04	<0,08	<0,06	<0,07

Table 2. Toxicological parameters as agreed on 29 May 2015



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Agreed quality criteria on the recycled gypsum



Technical parameters

Parameter	Powder spec	Test method
Particle size	0 - 15 mm	UNE-EN 933-1
Free moisture	< 10%	VGB serial number 1
Purity (CaSO ₄ 2H ₂ O)	> 80%	VGB serial number 2.3
TOC	<1.5%	Gigt 3.1.3.2 DepV DIN EN 13137
Magnesium salts, walter sol.	< 0.1%	VGB serial number 8.1.2
Sodium salts, walter sol.	< 0.06%	VGB serial number 8.2.2
Potassium salts, water sol.	< 0.05%	VGB serial number 8.3.2
Sol. Chloride	0.02%	VGB serial number 8.8.3
Ph	6-9	VGB serial number 4

Table 3. Recycled gypsum technical parameters

Toxicological parameters

Important note: the values of all the toxicological parameters are reference values (not limit values-minimum or maximum values).

Element [mg/kg]	Powder spec	Test method
As	< 4	DIN EN ISO 11885 Determination of selected elements ICP-OES (acc to DepV)
Be	< 0,7	
Pb	< 22	



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Cd	< 0,5	
Cr	< 25	
Co	< 4	
Cu	< 14	
Mn	< 200	
Ni	< 13	
Se	< 16	
Te	< 0,3	
Tl	< 0,4	
V	< 26	
Zn	< 50	
Hg	< 1,3	DINEN 1483 AAS-DINEN 12338-Mercury process after enrichment by amalgamation. DIN ISO 1785 atomic fluorescence spectrometry (acc to MatelVO)
Radioactivity Index	< 0,5	RP 112 Document (EC)
Asbestos	none	atomic absorbance-method and PLM **

Table 4. Recycled gypsum toxicological parameters

Guidance on the quality criteria of recycled gypsum

Purity

From a manufacturing point of view, it is preferable to work with a purity level as high as possible.

The purity of recycled powder is mainly influenced by the market where the boards were originally produced, i.e. the type of gypsum that has been used to produce these boards. For markets where FGD has been used many years, a purity of 85% or more can be reached and the target value may be increased accordingly.



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Test frequency

The frequency of testing needs to be agreed between the recycler and the manufacturer. In general, toxicological parameters are recommended to be tested monthly or quarterly, depending on volume of recycled powder that is supplied.

Technical parameters are recommended to be tested either weekly or monthly. Some parameters may have to be tested daily, depending on location, e.g. moisture and chloride.

Asbestos testing method

It is recommended to use the atomic absorbance-method and if asbestos is found, then to use PLM to confirm the type of asbestos.

Sampling

Outcomes of testing can be uncertain as powder composition varies. It is important that samples are taken correctly; i.e. that the samples are homogenized and prepared in the laboratory using a riffle splitter (VGB M-701). In the recycling environment one sample is not representative; the sample that is forwarded for testing should consist of min. 10 individual samples that have been homogenized into one that is sent to the laboratory.

Comments by the Eurogypsum Recycling Working Group

The Eurogypsum Recycling Working Group added the following comments to the technical parameters which were decided in the GtoG project:





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Parameter	Test Method	GtoG Powder spec	Recycling Group Comments ¹
Particle size	Granulometry	0 - 15 mm	Particle size ok, depending on plant specifics
Free moisture	VGB serial number 1	< 10%	≤ 5% (up to < 10%) ²⁾
Purity (Calcium Sulphate CaSO ₄ 2H ₂ O)	VGB serial number 2.3	> 80%	> 85% (at least 80%) ³⁾
TOC	Gigt 3.1.3.2 DepV DIN EN 13137	< 1.5% w/w	≤ 1,0% (≤ 1,5%)
Magnesium salts, water sol.	VGB serial number 8.1.2	< 0.1% w/w	≤ 0,02% (≤ 0,1%) ⁴⁾
Sodium salts, water sol.	VGB serial number 8.2.2	< 0.06% w/w	≤ 0,02% (≤ 0,04%) ⁴⁾
Potassium salts	VGB serial number 8.3.2	< 0.05% w/w	< 0,02% (< 0,06%); water sol.
Sol. Chloride	VGB serial number 8.8.3	< 0.02% w/w	< 0,01% (< 0,02%) ⁵⁾
Ph	VGB serial number 4		pH, 5-9 ⁴⁾
Fluoride		< 0.02% w/w	
Radioactivity	Radioactivity Lab specific method (Bq/kg)		

Table 5. Eurogypsum Recycling Working Group's comments to the technical parameters

1) Values in (): Plant specific deviations after special agreement permitted.

2) The 10 % comes from **wet** flue gas desulphurisation and is inherent in the system. In contrast it is possible without any technical or logistical problems to meet at least the 5%. Increased moisture contents incur costs for the gypsum industry.

3) Low purity compared with FGD gypsum (≥ 95%) considers the possible lower purity of natural gypsum.

4) According to EUROGYPSUM/ECOBA/VGB Quality Requirements on FGD gypsum.

5) Depending on water quality in plasterboard production.

The Eurogypsum Recycling WG considers that the frequency of testing should be left at the plant level decision.