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REPORT ON ANALYSES OF COPPER SLAG (GRIT) AS ABRASIVE MATERIAL FOR SAND BLASTING AND ITS ECOLOGICAL CHARACTERISTICS

Stara Pazova, June 2016

1. BASIC DATA

Subject:	Analyses of copper slag (grit) as abrasive material for sand blasting and its ecological characteristics
User information (name, address, phone/fax, e-mail):	**GRIT COMMERCE d.o.o.** Bulevar Mihaila Pupina 115v, Novi Beograd
Information from the user's application /date:	Application dated May 12th, 2016
Sampling performed by/date:	User
Sampling plan and procedures:	-
Sample receipt date:	May 12th, 2016
Sample description, type, number and identification:	6 (six) samples, Lab. no. 1284, 1285, 1288, 1289, 1290, and 1293
Determination methods:	Given in Tables with results
Test results:	Given in Tables
Team that carried out the testing/function:	Vladimir Dražić, graduate chemist/analyst Dejan Savić, graduate engineer of technology/analyst Slavko Ćušić, PhD, specialist in toxicological chemistry/analyst Igor Urošević, graduate chemist/analyst Snežana Arsić/technician
Data analysis and report preparation:	Jelena Petrović, graduate chemist/data processing analyst

Results of the analysis are provided in the tables below. Results refer to the analysis of the samples submitted by the client only. If no technical objection is received within 15 days from the report submission date, the examination shall be deemed completed.

HIGHLIGHTS FROM THE CONCLUSION (PAGE 17 OF THIS REPORT)

- All the measured physical characteristics of the analysed material, copper slag (grit) show that it is excellent for application in sand blasting.
- Harmful substances are not eluted during the use of this material so that it can be considered an inert material from the aspect of its impact on the environment as well.
- Mineralogical composition of the material and present macro components make it safe for application when it comes to quality of the environment.
- The material is classified as **NON-HARMFUL** and after the use it can be disposed on the landfill of non-harmful waste in compliance with the valid legislation.

2. SUBJECT AND GOAL OF ANALYSIS

The subject of the analysis is copper slag (grit) – granulation 0.5-1.68 mm and 1.68-3.00 mm.

The goal of the analysis is to determine the applicability of this material as sand blasting abrasive and its ecological characteristics.

3. APPLICATION ANALYSES

The application analyses for sand blasting were performed on corroded steel sheet metal with 8 mm of thickness and with the original fraction and multifold use on the working pressure of 6 Bars.

EQUIPMENT USED:
Atlas Copco XAS 186 Compressor
MAXIV TECH DBS 200 Sand blaster (SGV valves)
Ceramic nozzle with 8mm of diameter
Technical potentials of sand blasting 15 m^2/h

3.1. GRANULATION 0.5-1.68 mm

Results of the first use
Roughness average - arithmetic average value Ra = 100
Grit consumption 32 kg/ m^2

Results of the second use
Roughness average - arithmetic average value Ra = 100
Grit consumption 33 kg/ m^2

Results of the third use
Roughness average - arithmetic average value Ra = 80
Grit consumption 38 kg/ m^2

Results of the fourth use
Roughness average - arithmetic average value Ra = 50
Grit consumption 42 kg/ m^2

3.2. GRANULATION 1.68-3.00 mm

Results of the first use

Roughness average - arithmetic average value	Ra = 100
Grit consumption	30 kg/m^2

Results of the second use

Roughness average - arithmetic average value	Ra = 100
Grit consumption	30 kg/m^2

Results of the third use

Roughness average - arithmetic average value	Ra = 100
Grit consumption	33 kg/m^2

Results of the fourth use

Roughness average - arithmetic average value	Ra = 80
Grit consumption	36 kg/m^2

4. CHEMICAL ANALYSES

4.1. RESULTS OF ANALYSES – ANALYSES OF SOLID SAMPLES AND THEIR ELUATES

4.1.1. Granulation 0.5-1.68 mm

The analyses were performed in order to determine micro and macro components both because of useful ion types and because of negative impact on the quality of the environment.

Table 1 – Results of physical-chemical analyses of the delivered sample lab. no. 1284, fraction 0.5-1.68 mm, **original sample of copper slag (grit)**

Parameter	Method	Measuring unit	Found value
Lead (Pb)	VM 030-1	mg/kg	124.64
Cadmium (Cd)	VM 042-1	mg/kg	0.40
Zinc (Zn)	VM 035-1	%	0.16
Copper (Cu)	VM 032-1	%	0.39
Chrome, total (Cr)	VM 037-1	mg/kg	21.94
Nickel (Ni)	VM 033-1	mg/kg	7.37
Arsenic (As)	VM 043-1	mg/kg	25.92
Vanadium (V)	VM 059-1	mg/kg	23.63
Manganese (Mn)	VM 036-1	mg/kg	104.69
Iron (Fe)	VM 038-1	%	8.75

Note: The results are given in relation to a dry sample weight

COMMENT: It is important to point out that copper concentration in this sample is significant. It is certain that hydro-metallurgic procedure should be considered for potential copper obtaining, all depending on the quantity of the material. No ion concentrations in the sample were detected that would characterise it as hazardous material.

Analyses of eluates were performed after the analyses of the solid phase. Eluting was performed on a mixer, 24 hours continuously, with 40 rpm, in 1 l bottles. The ratio of the solid and liquid phase was 1 : 20. The same treatment was applied on both slag concentrations.
Ione types were determined in eluate. The found concentrations are presented in Table 2.

Table 2 – Results of physical-chemical analyses of eluate of the delivered sample lab. no. 1284, fraction 0.5-1.68 mm, **original sample of copper slag (grit)**

Parameter	Method	Measuring unit	Results of analysis
Content in EP extract after 24 h (one-step test, solid/liquid ratio = 10 l/kg) SRPS EN 12457-4			
pH value	SRPS H.Z1.111:1987	-	7.66
Electrolytic conductibility	ASTM D 1125A- 95:2009	μS/cm	110
Lead (Pb)	EPAM 239.2:1978	mg/kg	<0.03
Cadmium (Cd)	EPAM 213.2:1978	mg/kg	<0.003
Zinc (Zn)	EPAM 289.1:1978	mg/kg	<0.16
Copper (Cu)	EPAM 220.1:1978	mg/kg	<0.60
Chrome, total (Cr)	EPAM 218.2:1978	mg/kg	<0.03
Nickel (Ni)	EPAM 249.1:1978	mg/kg	<0.03
Arsenic (As)	EPAM 206.2:1978	mg/kg	<0.03

COMMENT: We found no increased concentrations of the ion types, nor increased conductibility. This shows that the material is completely safe for use.

The analyses after use, namely surface treatment, indicate potential structural changes in the material. These structural changes may results with larger contact surface and increased elution of ion types. That is why we performed characterisation after the first and fourth "passage" of the same material.

Table 3 - Results of physical-chemical analyses of the delivered sample lab. no. 1284, fraction 0.5-1.68 mm, **"first passage"**

Parameter	**Method**	**Measuring unit**	**Found value**
Lead (Pb)	VM 030-1	mg/kg	149.29
Cadmium (Cd)	VM 042-1	mg/kg	0.48
Zinc (Zn)	VM 035-1	%	0.16
Copper (Cu)	VM 032-1	%	0.36
Chrome, total (Cr)	VM 037-1	mg/kg	22.36
Nickel (Ni)	VM 033-1	mg/kg	7.29
Arsenic (As)	VM 043-1	mg/kg	23.43
Vanadium (V)	VM 059-1	mg/kg	17.89
Manganese (Mn)	VM 036-1	mg/kg	106.78
Iron (Fe)	VM 038-1	%	8.48

Note: The results are given in relation to a dry sample weight

Table 4 – Results of physical-chemical analyses of eluate of the delivered sample lab. no. 1284, fraction 0.5-1.68 mm, **"first passage"**

Parameter	**Method**	**Measuring unit**	**Results of analysis**
Content in EP extract after 24 h (one-step test, solid/liquid ratio = 10 l/kg) SRPS EN 12457-4			
pH value	SRPS H.Z1.111:1987	-	7.67
Electrolytic conductibility	ASTM D 1125A- 95:2009	$\mu S/cm$	103
Lead (Pb)	EPAM 239.2:1978	mg/kg	<0.03
Cadmium (Cd)	EPAM 213.2:1978	mg/kg	<0.003
Zinc (Zn)	EPAM 289.1:1978	mg/kg	<0.16
Copper (Cu)	EPAM 220.1:1978	mg/kg	<0.60
Chrome, total (Cr)	EPAM 218.2:1978	mg/kg	<0.03
Nickel (Ni)	EPAM 249.1:1978	mg/kg	<0.03
Arsenic (As)	EPAM 206.2:1978	mg/kg	<0.03

Table 5 - Results of physical-chemical analyses of the delivered sample lab. no. 1284, fraction 0.5-1.68 mm, **"fourth passage"**

Parameter	Method	Measuring unit	Found value
Lead (Pb)	VM 030-1	mg/kg	154.00
Cadmium (Cd)	VM 042-1	mg/kg	0.62
Zinc (Zn)	VM 035-1	%	0.17
Copper (Cu)	VM 032-1	%	0.38
Chrome, total (Cr)	VM 037-1	mg/kg	19.44
Nickel (Ni)	VM 033-1	mg/kg	7.23
Arsenic (As)	VM 043-1	mg/kg	23.88
Vanadium (V)	VM 059-1	mg/kg	14.62
Manganese (Mn)	VM 036-1	mg/kg	108.11
Iron (Fe)	VM 038-1	%	8.15

Note: The results are given in relation to a dry sample weight

Table 6 – Results of physical-chemical analyses of eluate of the delivered sample lab. no. 1284, fraction 0.5-1.68 mm, **"fourth passage"**

Parameter	Method	Measuring unit	Results of analysis
Content in EP extract after 24 h (one-step test, solid/liquid ratio = 10 l/kg) SRPS EN 12457-4			
pH value	SRPS H.Z1.111:1987	-	7.47
Electrolytic conductibility	ASTM D 1125A- 95:2009	µS/cm	111
Lead (Pb)	EPAM 239.2:1978	mg/kg	<0.03
Cadmium (Cd)	EPAM 213.2:1978	mg/kg	<0.003
Zinc (Zn)	EPAM 289.1:1978	mg/kg	<0.16
Copper (Cu)	EPAM 220.1:1978	mg/kg	<0.60
Chrome, total (Cr)	EPAM 218.2:1978	mg/kg	<0.03
Nickel (Ni)	EPAM 249.1:1978	mg/kg	<0.03
Arsenic (As)	EPAM 206.2:1978	mg/kg	<0.03

COMMENT: The content of ion types in the solid sample, namely its eluate after the first and fourth passage has practically not changed. This indicates that, when it comes to eco-chemical characteristics, four "passages", namely four cycles of use of the same material make the minimum number for use. We point out that copper concentration is significant in the fourth passage as well, which indicates the possibility of use.

4.1.2. Granulation 1.68 – 3.00 mm

Table 7 – Results of physical-chemical analyses of the delivered sample lab. no. 1289, fraction 1.68 – 3.00 mm, **original sample of copper slag (grit)**

Parameter	Method	Measuring unit	Found value
Lead (Pb)	VM 030-1	mg/kg	76.18
Cadmium (Cd)	VM 042-1	mg/kg	0.08
Zinc (Zn)	VM 035-1	%	0.07
Copper (Cu)	VM 032-1	%	0.21
Chrome, total (Cr)	VM 037-1	mg/kg	8.60
Nickel (Ni)	VM 033-1	mg/kg	<6.00
Arsenic (As)	VM 043-1	mg/kg	12.20
Vanadium (V)	VM 059-1	mg/kg	9.20
Manganese (Mn)	VM 036-1	mg/kg	45.74
Iron (Fe)	VM 038-1	%	3.90

Note: The results are given in relation to a dry sample weight

COMMENT: In this case, the copper concentration is lower than in the previous, smaller size fraction, which is understandable. However, the copper concentration is significant in this sample. It is certain that hydro-metallurgic procedure should be considered for potential copper obtaining, all depending on the quantity of the material. No ion concentrations in the sample were detected that would characterise it as hazardous material.

Table 8 – Results of physical-chemical analyses of eluate of the delivered sample lab. no. 1289, fraction 1.68 – 3.00 mm, **original sample of copper slag (grit)**

Parameter	**Method**	**Measuring unit**	**Results of analysis**
Content in EP extract after 24 h (one-step test, solid/liquid ratio = 10 l/kg) SRPS EN 12457-4			
pH value	SRPS H.Z1.111:1987	-	7.30
Electrolytic conductibility	ASTM D 1125A- 95:2009	µS/cm	60
Lead (Pb)	EPAM 239.2:1978	mg/kg	<0.03
Cadmium (Cd)	EPAM 213.2:1978	mg/kg	<0.003
Zinc (Zn)	EPAM 289.1:1978	mg/kg	<0.16
Copper (Cu)	EPAM 220.1:1978	mg/kg	<0.60
Chrome, total (Cr)	EPAM 218.2:1978	mg/kg	<0.03
Nickel (Ni)	EPAM 249.1:1978	mg/kg	<0.03
Arsenic (As)	EPAM 206.2:1978	mg/kg	<0.03

COMMENT: We found no increased concentrations of the ion types, nor increased conductibility. This shows that the material is completely safe for use.

Table 9 - Results of physical-chemical analyses of the delivered sample lab. no. 1290, fraction 1.68 – 3.00 mm, **"first passage"**

Parameter	Method	Measuring unit	Found value
Lead (Pb)	VM 030-1	mg/kg	56.13
Cadmium (Cd)	VM 042-1	mg/kg	<0.016
Zinc (Zn)	VM 035-1	%	0.05
Copper (Cu)	VM 032-1	%	0.13
Chrome, total (Cr)	VM 037-1	mg/kg	<8.00
Nickel (Ni)	VM 033-1	mg/kg	<6.00
Arsenic (As)	VM 043-1	mg/kg	7.82
Vanadium (V)	VM 059-1	mg/kg	4.44
Manganese (Mn)	VM 036-1	mg/kg	34.20
Iron (Fe)	VM 038-1	%	3.10

Note: The results are given in relation to a dry sample weight

Table 10 – Results of physical-chemical analyses of eluate of the delivered sample lab. no. 1290, fraction 1.68 – 3.00 mm, **"first passage"**

Parameter	Method	Measuring unit	Results of analysis
Content in EP extract after 24 h (one-step test, solid/liquid ratio = 10 l/kg) SRPS EN 12457-4			
pH value	SRPS H.Z1.111:1987	-	7.85
Electrolytic conductibility	ASTM D 1125A- 95:2009	$\mu S/cm$	64
Lead (Pb)	EPAM 239.2:1978	mg/kg	<0.03
Cadmium (Cd)	EPAM 213.2:1978	mg/kg	<0.003
Zinc (Zn)	EPAM 289.1:1978	mg/kg	<0.16
Copper (Cu)	EPAM 220.1:1978	mg/kg	<0.60
Chrome, total (Cr)	EPAM 218.2:1978	mg/kg	<0.03
Nickel (Ni)	EPAM 249.1:1978	mg/kg	<0.03
Arsenic (As)	EPAM 206.2:1978	mg/kg	<0.03

Table 11 - Results of physical-chemical analyses of the delivered sample lab. no. 1293, fraction 1.68 – 3.00 mm, **"fourth passage"**

Parameter	Method	Measuring unit	Found value
Lead (Pb)	VM 030-1	mg/kg	73.23
Cadmium (Cd)	VM 042-1	mg/kg	<0.016
Zinc (Zn)	VM 035-1	%	0.07
Copper (Cu)	VM 032-1	%	0.18
Chrome, total (Cr)	VM 037-1	mg/kg	<8.00
Nickel (Ni)	VM 033-1	mg/kg	<6.00
Arsenic (As)	VM 043-1	mg/kg	9.14
Vanadium (V)	VM 059-1	mg/kg	4.82
Manganese (Mn)	VM 036-1	mg/kg	43.56
Iron (Fe)	VM 038-1	%	3.46

Note: The results are given in relation to a dry sample weight

Table 12 – Results of physical-chemical analyses of eluate of the delivered sample lab. no. 1293, fraction 1.68 – 3.00 mm, **"fourth passage"**

Parameter	Method	Measuring unit	Results of analysis
Content in EP extract after 24 h (one-step test, solid/liquid ratio = 10 l/kg) SRPS EN 12457-4			
pH value	SRPS H.Z1.111:1987	-	7.54
Electrolytic conductibility	ASTM D 1125A- 95:2009	µS/cm	81
Lead (Pb)	EPAM 239.2:1978	mg/kg	<0.03
Cadmium (Cd)	EPAM 213.2:1978	mg/kg	<0.003
Zinc (Zn)	EPAM 289.1:1978	mg/kg	<0.16
Copper (Cu)	EPAM 220.1:1978	mg/kg	<0.60
Chrome, total (Cr)	EPAM 218.2:1978	mg/kg	<0.03
Nickel (Ni)	EPAM 249.1:1978	mg/kg	<0.03
Arsenic (As)	EPAM 206.2:1978	mg/kg	<0.03

COMMENT: The content of ion types in the solid sample, namely its eluate after the first and fourth passage has practically not changed. This indicates that, when it comes to eco-chemical characteristics, four "passages", namely four cycles of use of the same material make the minimum number for use. We point out that copper concentration is significant in the fourth passage as well, although lower than in the "fourth" passage of a smaller size fraction, which indicates the possibility of use.

5. GRANULOMETRY (PARTICLE SIZE) ANALYSES

Granulometry (particle size) analyses were also performed on the same fractions as the basic chemical analyses: original material, first passage and fourth passage, naturally for both fractions (for both 0.50-1.68 mm and 1.68-3.00 mm). In that way we determined the fragmentation degree/rate. Namely, the main fraction is dominant after the "fourth passage" as well, which indicates that the material is exceptionally applicable for sand blasting in the minimum of four cycles with the same material.

Granulometric composition is presented in Tables 13 and 14, and granulometric curves in the Appendix to this Report.

SAMPLE CODE	MOISTURE SRPS U.81.012 - withdrawn	GRANULOMETRIC COMPOSITION SRPS U.81.012 - withdrawn									
	W	Fractions					d_{60}	d_{30}	d_{10}	Cu	Cz
		Crushed d>60.00 mm	Gravel d=60.0-2.0 mm	Sand d=2.0-0.063 mm	Dust d=0.063-0.002 mm	Clay d,0.002 mm					
	%	%	%	%	%	%	mm	mm	mm	d_{60}/d_{10}	$d_{30}/d_{10}xd_{60}$
0.50-1.68	0.06		9	89	2		1.19773	0.68231	0.27348	4.38	1.42
I passage	0.06		5	94	1		0.95638	0.48917	0.17273	5.54	1.45
IV passage	0.06		4	95	1		0.86444	0.39761	0.14838	5.83	1.23

Table 13 – Granulometry (particle size) analyses in the copper slag (grit) fraction of 0.50 – 1.68 mm

SAMPLE CODE	MOISTURE SRPS U.81.012 - withdrawn	GRANULOMETRIC COMPOSITION SRPS U.81.012 - withdrawn									
	W	Fractions					d_{60}	d_{30}	d_{10}	Cu	Cz
		Crushed d>60.00 mm	Gravel d=60.0-2.0 mm	Sand d=2.0-0.063 mm	Dust d=0.063-0.002 mm	Clay d,0.002 mm					
	%	%	%	%	%	%	mm	mm	mm	d_{60}/d_{10}	$d_{30}/d_{10}xd_{60}$
0.50-1.68	0.06		35	64	1		1.92474	1.47931	1.18236	1.63	0.96
I passage	0.06		25	75			1.74858	1.25616	0.62041	2.82	1.48
IV passage	0.06		23	76	1		1.68508	1.14327	0.43328	3.89	1.79

Table 14 – Granulometry (particle size) analyses in the copper slag (grit) fraction of 1.68 – 3.00 mm

NOTE: The determined granulometry and fraction names of samples differ to an acceptable extent so that in this Report we kept the technical name of the delivered original samples.

6. CRUSHING RESISTANCE

6.1. Crush resistance – Degremont Method

Crush resistance test was performed in order to confirm that the material is suitable for sand blasting. Although the conclusions of granulometry (particle size) analyses of the original sample and its cycles have already been given, the method of this kind points to exact indicators.

DESCRIPTION: Based on the results of sieving the diagrams were made before and after the testing and they were used to calculate the crushability. The crushability testing was performed with 18 steel balls with 12 mm of diameter, after 30 minutes, namely 1,500 revolutions.

Testing equipment

- Dryer – "Instrumentaria", Croatia
- Electronic scale with 10 kg of measuring range – "Tuf Co." Serbia
  Measurement uncertainty U(R) = 4.082483 g
  Confidence level is better than 95%
- Set of sieves
- Laboratory dishes and accompanying accessories
- Deval machine

6.2. Results of testing

6.2.1. Copper slag (grit), granulation 0.5 – 1.68 mm

First measuring

Crushability: 10 %

Second measuring

Crushability: 8.9 %

Mean measuring value: 9.45 %

Evaluation grade: ordinary use domain: **very good**

6.2.2. Copper slag (grit), granulation 1.68 – 3.00 mm

First measuring

Crushability: 8.9 %

Second measuring

Crushability: 7.8 %

Mean measuring value: 8.35 %

Evaluation grade: ordinary use domain: **very good**

COMMENT:

These results are similar with the results that are obtained in quartz sandstone testing. This means that the application value of the material is similar with the quartz sandstone!

The above-mentioned method gives certain classifications, material class 15-20% loss of the dominant granulometric fraction is considered “very good”. In our case, the crushability in all the tested samples is practically lower than 10%.

The method has no qualifications for smaller losses than the above-mentioned, which confirms again the usability of the material for sanding.

7. ADDITIONAL ANALYSES

Additional analyses have been given in the original in the Appendix to this Report and they include hardness determination, mineralogical composition determination, and, up to a smaller extent, the eluate composition and main components of solid sample on representational quantities, as well as radioactivity. Determination of hardness according to Moss scale also shows a very high similarity with the quartz. All additional analyses confirm the value of the material and its ecological harmlessness.

Additional analyses were also used for characterisation of the material as waste. The Report on characterisation has been given in whole in the Appendix.

The waste has been characterised as NON-HAZARDOUS.

8. CONCLUSION

The above-mentioned testing methods show the usability and harmlessness of the material – copper slag (grit) as the sanding medium. The reports of the renowned companies given in the Appendix to this Report confirm the comments referred to above. All the performed analyses can be summarised in several points:

1. **All measured physical characteristics of the material indicate that it is excellent for application in sanding.**

2. **The minimum number of cycles of use of the material is four. During four sanding cycles the material maintains the basic physical characteristics and its efficiency is not reduced.**

3. **During the use of material harmful substances are not eluted and from the aspect of its impact on the environment it can be considered an inert material.**

4. **Mineralogical composition of the material and present macro components make it safe for application from the aspect of quality of the environment.**

5. **The material has been classified as NON-HAZARDOUS and after the use it can be deposited on the landfill of non-hazardous waste in compliance with the valid legislation.**

Place and time of test completion:
Stara Pazova, June 02, 2016

Date of the Report delivery:
June 02, 2016

Report verified by:
Head of MOL Laboratory

Danijela Ilić, B.Sc.Chem.

Report approved by:
General Manager

Dr Bojana Stanimirović, M.Sc.Biochem.

The end of Test report

APPENDICES TO THE REPORT

APPENDIX No. 1

Акредитационо тело Србије 00557
Accreditation Body of Serbia
Београд
Belgrade
додељује
awards

СЕРТИФИКАТ О АКРЕДИТАЦИЈИ
Accreditation Certificate

којим се потврђује да
confirming that

ИНСТИТУТ МОЛ Д.О.О.
Привредно друштво за хемију, биотехнологију и консалтинг

Стара Пазова

акредитациони број
accreditation number
01-172

задовољава захтеве стандарда
fulfils the requirements of

SRPS ISO/IEC 17025:2006
(ISO/IEC 17025:2005)

те је компетентна за обављање послова испитивања
and is competent to perform testing activities

који су специфицирани у обиму акредитације
as specified in the scope of accreditation

Важеће издање обима акредитације доступно је на интернет адреси: www.ats.rs
Valid scope of accreditation can be found at: www.ats.rs

Сертификат додељен
Date of issue
14.04.2015.

Акредитација важи до
Date of expiry
13.04.2019.

ATC

ilac-MRA

в. д. Директор
Acting Director

М.П.

Акредитационо тело Србије је потписник Мултилатералног споразума о

Slika 1. Akreditacija Instituta MOL d.o.o.

NAPOMENA: Obim akreditacije je naveden na sajtu ATS-a (www.ats.rs)

SGS

ANALYSIS REPORT

No:20 0190/16

Our reference: BO 2000219 Belgrade, 18th March 2016.

Client	: Bakar Komerc Stil doo, Kovin
Commodity said to be	: Copper slag (grit)
Scope of inspection	: Analysis on as received samples

This is to report that we received sample of material said to be grit. Upon instructions received from Messrs Bakar Komerc Stil doo, Kovin, we performed analyses on sample as received.

Upon the request of our principal sample was submitted to SGS laboratory, Turkey for physical-mechanical characteristic (Mohs hardness test) and the findings reported by them in their work order No.TR1600445 dtd 17.03.2016. are as follows:

Sample	Hardness by Mohs
Cu slag/Grit	7.0000

- MOHS: Mohs hardness test

FOR SGS
Minerals Services

SGS

ANALYSIS REPORT

No:20 0191/16

Our reference: BO 2000219 Belgrade, 22nd March 2016.

Client : Bakar Komerc Stil doo, Kovin
Commodity said to be : Copper slag (grit)
Scope of inspection : Analysis on as received samples

This is to report that we received samples of material said to be copper grit. Upon instructions received from Messrs Bakar Komerc Stil doo, Kovin, we performed analyses on sample as received. Upon the request of our principal sample was submitted to Faculty of Chemistry, Belgrade for analyses on delivered sample and the findings reported by them in their report dtd 21.03.2016 are as follows :

Sample of Cu grit	Result	Method
Water soluble chlorides	0,63 ppm	ISO 11127-7
Conductivity of aqueous extract	18,58 mS/m	ISO 11127-6

FOR SGS
Minerals Services

SGS

These findings are reported herein for convenience only and SGS has no liability for the subcontracted results, which remain with subcontractor laboratory Faculty of Chemistry, Belgrade

The sample(s) to which the findings recorded herein (the "Findings") relate was(were) drawn and / or provided by the Client or by a third party acting at the Client's direction. The Findings constitute no warranty of the sample's representativeness of any goods and strictly relate to the sample(s). The Company accepts no liability with regard to the origin or source from which the sample(s) is/are said to be extracted

Reference No : BO 2000219

Belgrade, 29.03.2016.

ANALYSIS REPORT No. 20 0215/16

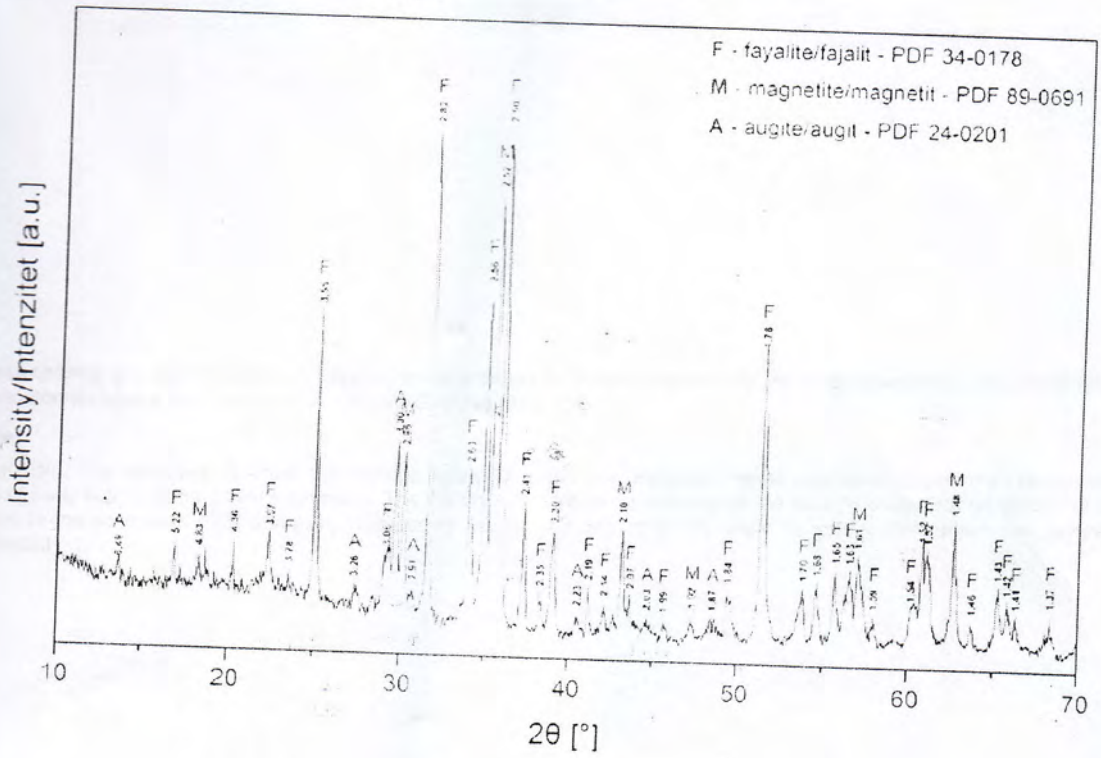
Commodity said to be :	Copper slag (grit)
Client :	Bakar Komerc Stil doo, Kovin
Sample received:	Analysis on as received samples

Upon the request of our principal Bakar Komerc Stil doo, Kovin we sent the received sample to subcontracted laboratory of Faculty of Mining and Geology, Belgrade and the findings reported by them in their report as per request no. No: 0321 3/07/2016 dtd 07.03.2016. were as follows:

The sample was analyzed by X-Ray powder diffraction (XRPD) method using PHILIPS PW 1710 diffractometer. The radiation source was CuK^{-} = 1 54178 Å (U = 40 kV, I = 30 mA), and instrument was equipped with graphite monochromator. The data were recorded in 4 – 70 2θ (°) range with step size 0,02°, and step time 1.25 s. Determined diffraction peak positions 2θ (°), and interplanar distances *d* (Å), with corresponding intensities are given graphically (Fig. 1).

The crystal phase present in the sample was identified comparing the values of relative intensities I/I_{max} and *d*-values with literature data and ICDD PDF database.

Figure 1: Grit sample diffraction diagram



This is mostly cristalline sample.Three crystaline phases were indetified. The most abundant crystal phase is fayalite (olivine), $(Fe^{2+})_2SiO_4$, rhombic symmetry,PDF card 34-0178 (over 60 wt %).Less abudant is spinel-magnetite, $Fe^{2+}(Fe^{3+})_2O_4$, cubic symmetry,PDF 89-0691. Augite (pyroxene) $Ca(,Fe,Mg)Si_2O_6$ monoclinic symmetry,PDF 24-0201 is the least abundant phase.

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Certificate N°: 14080503C1

ANALYSIS REPORT

Client : Bakar Komerc Stil
Commodity said to be : Cooper grit A1 and B1
Scope of inspection : Analysis on as received samples
Our Reference : 14/1921/2500

This is to report that we received samples of material said to be cooper grit A1 and B1. Upon instructions received from Messrs Bakar Komerç Stil, we performed analyses on samples as received.

Upon the request of our principal sample was submitted to subcontracted IRM laboratory, Bor for chemical analyses and size test and the findings reported by them in their report No.15092 dtd 09.07.2014 and report No.14/2014 dtd 03.07.2014 are as follows:

Element	Result A1, %	Result B1, %	Analytic method
% H_2O	< 0.2	< 0.2	G
% SiO_2	33.60	33.43	G
% FeO	41.65	40.45	V
% Fe_2O_3	0	0	calculated
% Al_2O_3	4.99	4.72	ICP-AES
% MnO	0.35	0.042	AAS
% CaO	6.70	1.44	AAS
% Cl	< 0.10	0.12	NTU
% Cu	0,24	0.74	AAS
% Pb	0.005	0.040	AAS
% As	< 0.003	0.018	ICP-AES
% S	0.96	0.71	ICP-AES
% Zn	0.59	0.60	AAS

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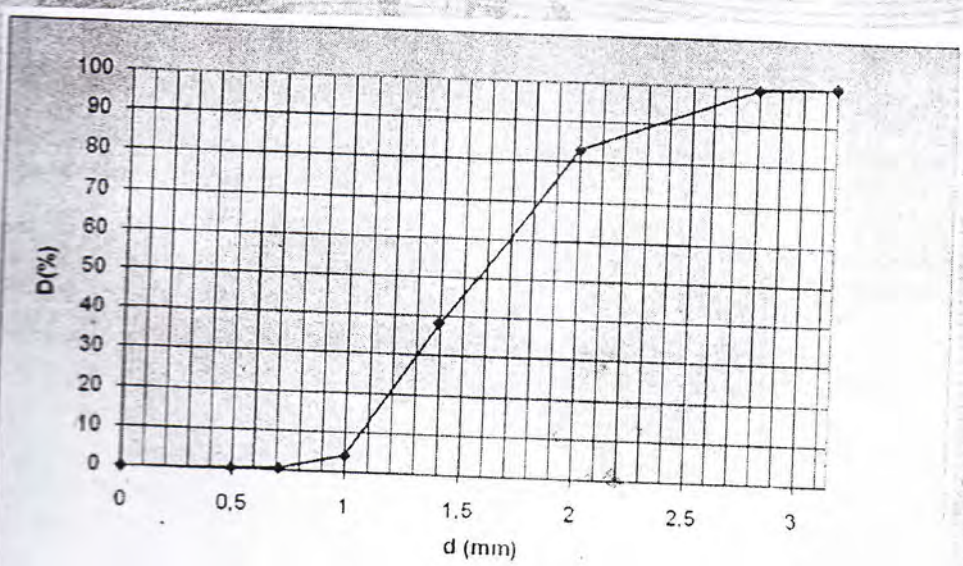
RESULT OF SIZE TEST FOR SAMPLE COPPER GRIT A1

D (mm)	m(%)	R (%)	D(%)
-3,15+2,8	0,70	0,70	100
-2,8+2,0	16,20	16,90	99,30
-2,0+1,4	44,80	61,70	83,10
-1,4+1,0	34,00	95,70	38,30
-1,0+0,710	3,50	99,20	4,30
-0,710+0,500	0,40	99,60	0,80
-0,500+0,000	0,40	100	0,40



Graphical ilustration of size test for sample copper grit A1

RESULT OF SIZE TEST FOR SAMPLE COPPER GRIT B1

D (mm)	m (%)	R (%)	D(%)
-2,8+2,0	4,15	4,15	100
-2,0+1,4	30,65	34,80	95,85
-1,4+1,0	54,60	89,40	65,20
-1,0+0,710	7,75	97,15	10,60

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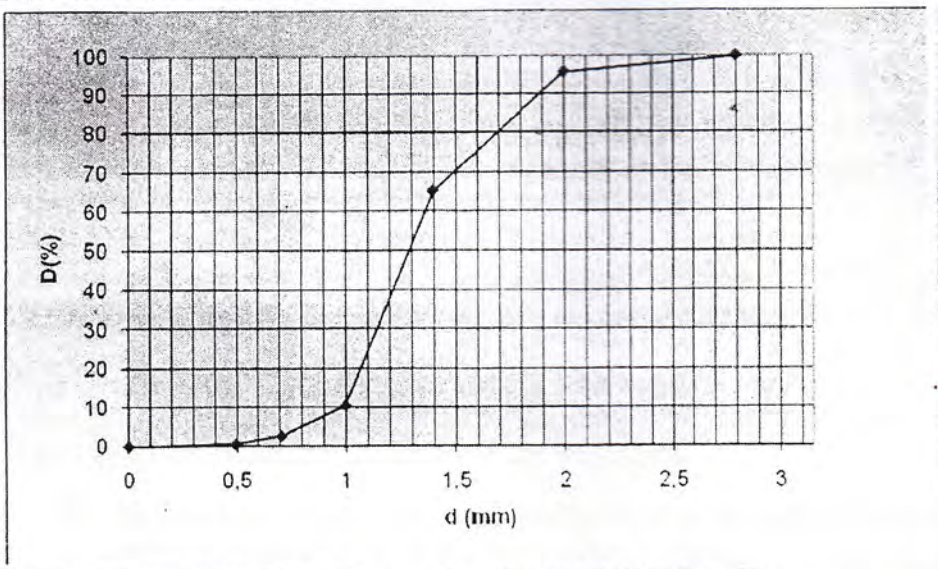
-0,710+0,500	2,10	99,25	2,85
-0,500+0,000	0,75	100	0,75



Graphical ilustration of size test for sample copper grit B1

Upon the request of our principal sample was submitted to subcontracted IRM laboratory, Bor for physical-mechanical characteristic and the findings reported by them in their report No.13/2014 dtd 16.07.2014 are as follows:

Sample	Hardness by Moss (1-10)	By description
Copper grit A1	6	Scratch the glass
Copper grit B1	6	Scratch the glass

Issued in Belgrade
09th July, 2014

For and on behalf of
SGS Beograd
Mineral Sector

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INSPECTION REPORT OF RADIOACTIVITY

No: 2469/14

Our reference: 14/1921/2500

Belgrade, 30th June 2014.

Commodity said to be :	Cooper grit A1
Client / Principal :	Bakar Komerc Stil
Scope of Inspection:	Analysis on as received sample

Hereby we certify that, we received a sample of material said to be cooper grit A1. Upon instructions received from Messrs Bakar Komerc Stil, we performed analyses on sample as received.

Upon the request of our principal sample was submitted to subcontracted Institute of Nuclear Science "VINCA" – Beograd (sample marked as sample number 862) and the findings reported by them in their report No.1-588 dtd 27.06.2014 are as follows:

a) Sample preparation: The preparation of the building material consisted of drying at 105^{0}C, sifting and measuring in the appropriate measurement geometry (IAEA TRS 295).Radioactive equilibrium was not achieved in the sample.

b) Measurement methods- The sample was counted using a high purity germanium detector (HPGe) with relative efficiency of 20 %, according to the method IAEA TRS 295

c) Measurement results: are presented in the Table 1

Table 1. Radionuclide concentration in the sample (Bq/kg)

Sample no.	^{226}Ra	^{232}Th	^{40}K	^{137}Cs
862	77±12	32±13	330±70	< 2

Measurement uncertainty is expressed as an expanded measurement uncertainty for the factor k=2 which corresponds to a normal distribution with a confidence level of 95%.

d) Conclusion- based on the results and according to Regulation on limits of radioactive contamination of people, working and living environment and decontamination (Official Gazette RS.38/11 dated 31.05.2011.) we conclude that the sample meets criteria of the existing Regulation. The measurement results apply only to the tested sample.

These findings are reported herein for convenience only and SGS has no liability for the subcontracted results, which remain with Institute of Nuclear Science "VINCA" – Beograd.

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INSPECTION REPORT OF RADIOACTIVITY

No: 2470/14

Our reference: 14/1921/2500

Belgrade, 30th June 2014.

Commodity said to be :	Cooper grit B1
Client / Principal :	Bakar Komerc Stil
Scope of Inspection:	Analysis on as received sample

Hereby we certify that, we received a sample of material said to be cooper grit B1. Upon instructions received from Messrs Bakar Komerc Stil, we performed analyses on sample as received.

Upon the request of our principal sample was submitted to subcontracted Institute of Nuclear Science "VINCA" – Beograd (sample marked as sample number 863) and the findings reported by them in their report No.1-589 dtd 27.06.2014 are as follows:

a) Sample preparation: The preparation of the building material consisted of drying at 105^{0}C, sifting and measuring in the appropriate measurement geometry (IAEA TRS 295).Radioactive equilibrium was not achieved in the sample.

b) Measurement methods- The sample was counted using a high purity germanium detector (HPGe) with relative efficiency of 20 %, according to the method IAEA TRS 295

c) Measurement results: are presented in the Table 1

Table 1. Radionuclide concentration in the sample (Bq/kg)

Sample no.	^{226}Ra	^{232}Th	^{40}K	^{137}Cs
863	47±9	46±15	460±80	< 2

Measurement uncertainty is expressed as an expanded measurement uncertainty for the factor k=2 which corresponds to a normal distribution with a confidence level of 95%.

d) Conclusion- based on the results and according to Regulation on limits of radioactive contamination of people, working and living environment and decontamination (Official Gazette RS.38/11 dated 31.05.2011.) we conclude that the sample meets criteria of the existing Regulation. The measurement results apply only to the tested sample.

These findings are reported herein for convenience only and SGS has no liability for the subcontracted results, which remain with Institute of Nuclear Science "VINCA" – Beograd.

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