TREATMENT OF WASTED WATERS AND ACID MINE DRAINAGE STREAMS TO REMOVE COPPER AND OTHER POLLUTANT METALS PROCEDURE

Cooperation beyond borders.

Interreg-IPA Cross-border Cooperation Romania-Serbia Programme is financed by the European Union under the Instrument for Pre-accession Assistance (IPA II) and co-financed by the partner states in the Programme.

Project RoRS 337- ROmania Serbia NETwork for assessing and disseminating the impact of copper mining activities on water quality in the cross-border area (RoS-NET2)

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OBJECTIVES OF TREATMENT OF WASTED WATERS AND ACID MINE DRAINAGE STREAMS TO REMOVE COPPER AND OTHER POLLUTANT METALS

Objectives of treatment the wasted waters and acid mine drainage streams to remove copper and other pollutant metals are given in Table 1.

Table 1. Objectives of treatment of wasted waters and acid mine drainage streams to remove copper and other pollutant metals

Objectives	**Appropriate sample type**	**Appropriate test method**	**Type of assessment**
Reducing the negative impact of AMD on the environment and treating sludge after neutralisation process aim to reach the zero-waste technology			
Development of procedures for copper and other metals removal from acid mine drainage resulted as mine activities on laboratory conditions	Selected AMD waters	Neutralization method	Comparison with national / international legislation permitted values
Verification of procedures optimized in laboratory conditions on scale up equipment	Selected AMD waters	Neutralization method	Comparison with national / international legislation permitted values

Objectives	Appropriate sample type	Appropriate test method	Type of assessment
Development of procedures for copper and other metals removal from sludge obtained during the neutralization processes on different pH value in laboratory conditions	Sludge obtained during the neutralization processes of selected AMD waters on different pH value	Acid leaching	Comparison with potential user requests

FRAMEWORK OF TREATMENT OF WASTED WATERS AND ACID MINE DRAINAGE STREAMS TO REMOVE COPPER AND OTHER POLLUTANT METALS

The framework of treatment the wasted waters and acid mine drainage streams to remove copper and other pollutant metals is given in Table 2.

Table 2. The framework of treatment of wasted waters and acid mine drainage streams to remove copper and other pollutant metals

QUARTER	ACTIVITY
I	- Literature review of methods for extraction of metals from mine waters and treatment of acid mine water (AMD), procedures for leaching of sludge formed after neutralization and procedures for removal the copper and metal pollutants from alkaline solutions, stabilization of residues after leaching, etc. - Familiarize yourself with sampling locations through Google Earth - Preparation of scheme with sampling points - Control of devices that will be used for laboratory neutralization and leaching tests - Creating tables in which the parameters of neutralization and leaching tests will be entered during the experiments (Annex I and II) - Analysis of physicochemical characteristics of water samples from defined

	sampling locations - Preparation of tender documentation - Preparation of the technical quarterly report
II	**Neutralization of water from the first selected site with $Ca(OH)_2$** - Analysis of the results of physicochemical characterization of water samples in order to select acidic mine waters for neutralization - Preparation of the experiments plan under laboratory conditions - Complete laboratory equipment for neutralization with NaOH, $Ca(OH)_2$, $CaCO_3$, - Sampling of water from the first selected site for neutralization tests (3 x 20 l) - Preparation of the necessary solutions for neutralization - Neutralization of selected acid mine water on an automatic titrator with NaOH solution to different pH values. - $Ca(OH)_2$ mass calculation for water neutralization based on NaOH consumption - Neutralization of selected AMD with $Ca(OH)_2$ in several stages (up to different pH values, from pH start up to pH 11 depending on chemical characterization of neutralized water, and depending on the legislation for surface water) - Filtering samples to separate solid from liquid phase **Sludge leaching and solid residue stabilization** - Acid leaching of sludge obtained after neutralization of water from the first selected site with $Ca(OH)_2$ in laboratory conditions - Testing of acid leaching parameters: choice of type and concentration of leaching reagent, solid-liquid ratio, time, temperature - Copper removal from solution after leaching - Purification of waste leaching solutions - Preparation of orders for sending samples for chemical analysis and submission of orders and samples to the responsible person for the field of chemistry. All samples will be analysed on: Fe (total), Fe^{2+}, Fe^{3+} (calculated), Mn, Cu, Mo, Zn, As, Ni, Pb, Cd, Cr, Hg, S and Se (Annex III) - Stabilization of the solid residue formed after leaching process - Verification the stabilizing process of the residue obtained after sludge leaching, using TCLP and LP procedures (standard methods EPA1311, SRPS EN12457-2)

	- Preparation of the quarterly technical report
III	**Neutralization of water from the first selected site with $CaCO_3$** - Analysis of obtained results of neutralization tests with $Ca(OH)_2$ - Preparation of the experiment plan under laboratory conditions - Sampling of water from the first selected site for neutralization tests (3 x 20 l) - Preparation of the necessary solutions for neutralization - Neutralization of selected acid mine water on an automatic titrator with NaOH solution to different pH values. - $CaCO_3$ mass calculation for water neutralization based on NaOH consumption - Neutralization of waters with $CaCO_3$ in several stages (up to different pH values, from pH start up to pH 11 depending on chemical characterization of neutralized water, and depending on the regulations for surface waters) - Filtering samples to separate solid from liquid phase - Preparation of orders for sending samples for chemical analysis and submission of orders and samples to the responsible person for the field of chemistry - Defining the optimal conditions for the neutralization test on semi-industrial equipment (reagent for neutralization, pH value, floculant, etc.) **Sludge leaching and solid residue stabilization** - Acid leaching of sludge obtained after neutralization of water from the first selected site with $CaCO_3$ in laboratory conditions - Testing of acid leaching parameters: choice of type and concentration of leaching reagent, solid-liquid ratio, time, temperature - Copper removal from solution after leaching - Purification of waste leaching solutions - Preparation of orders for sending samples for chemical analysis and submission of orders and samples to the responsible person for the field of chemistry. All samples will be analysed on: Fe (total), Fe^{2+}, Fe^{3+} (calculated), Mn, Cu, Mo, Zn, As, Ni, Pb, Cd, Cr, Hg, S and Se. - Stabilization of the solid residue formed after leaching process - Verification the stabilizing process of the residue obtained after sludge leaching, using TCLP and LP procedures (standard methods EPA1311, SRPS EN12457-2) - Preparation of the quarterly technical report

IV	**Neutralization of water from the first selected site on scale up equipment** - Sampling of about 2000 l of water from the first selected site for the neutralization test, which should verify the neutralization process selected as optimal during laboratory testing - Test implementation on scale up equipment (Procedure with technological description is given in Annex IV) - Preparation of orders for sending samples for chemical analysis and submission of orders and samples to the responsible person for the field of chemistry - Compilation and interpretation of results after neutralization of AMD from the first selected location on a semi-industrial plant **Sludge leaching and solid residue stabilization** - Acid leaching of sludge obtained after neutralization of water from the first selected site on scale up equipment - Testing of acid leaching parameters: choice of type and concentration of leaching reagent, solid-liquid ratio, time, temperature - Copper removal from solution after leaching - Purification of waste leaching solutions - Preparation of orders for sending samples for chemical analysis and submission of orders and samples to the responsible person for the field of chemistry. All samples will be analysed on: Fe (total), Fe^{2+}, Fe^{3+} (calculated), Mn, Cu, Mo, Zn, As, Ni, Pb, Cd, Cr, Hg, S and Se. - Stabilization of the solid residue formed after leaching process - Verification the stabilizing process of the residue obtained after sludge leaching, using TCLP and LP procedures (standard methods EPA1311, SRPS EN12457-2) - Preparation of the quarterly technical report
V	**Neutralization of water from the second selected site with $Ca(OH)_2$** - Analysis of the results of physicochemical characterization of water samples in order to select acidic mine water for neutralization - Preparation of the experiment plan under laboratory conditions - Complete laboratory equipment for neutralization with NaOH, $Ca(OH)_2$, $CaCO_3$, - Sampling of water from another selected site for neutralization tests (3 x 20 l) - Preparation of the necessary solutions for neutralization

	- Neutralization of selected acid mine water on an automatic titrator with NaOH solution to different pH values. - $Ca(OH)_2$ mass calculation for water neutralization based on Na(OH) consumption - Neutralization of water with $Ca(OH)_2$ in several stages (up to different pH values, from pH start to pH 11 depending on chemical characterization of neutralized water, and depending on the regulations for surface water) - Filling the tables during the neutralization processes - Filtering samples to separate solid from liquid phase - Preparation of orders for sending samples for chemical analysis and submission of orders and samples to the responsible person for the field of chemistry **Sludge leaching and solid residue stabilization** - Acid leaching of sludge obtained after neutralization of water from the second selected site with $Ca(OH)_2$ in laboratory conditions - Testing of acid leaching parameters: choice of type and concentration of leaching reagent, solid-liquid ratio, time, temperature - Copper removal from solution after leaching - Purification of waste leaching solutions - Preparation of orders for sending samples for chemical analysis and submission of orders and samples to the responsible person for the field of chemistry. All samples will be analysed on: Fe (total), Fe^{2+}, Fe^{3+} (calculated), Mn, Cu, Mo, Zn, As, Ni, Pb, Cd, Cr, Hg, S and Se. - Stabilization of the solid residue formed after leaching process - Verification the stabilizing process of the residue obtained after sludge leaching, using TCLP and LP procedures (standard methods EPA1311, SRPS EN12457-2) - Preparation of the quarterly technical report
VI	**Neutralization of water from the second selected site with $CaCO_3$** - Preparation of the experiment plan under laboratory conditions - Sampling of water from another selected site for neutralization tests (3 x 20 l) - Preparation of the necessary solutions for neutralization - Neutralization of selected acid mine water on an automatic titrator with NaOH solution to different pH values. - $CaCO_3$ mass calculation for water neutralization based on NaOH

	consumption - Neutralization of waters with $CaCO_3$ in several stages (up to different pH values, from pH start to pH 11 depending on chemical characterization of neutralized water, and depending on the regulations for surface waters) - Filling the tables during the neutralization process (Annex I) - Filtering samples to separate solid from liquid phase - Preparation of orders for sending samples for chemical analysis and submission of orders and samples to the responsible person for the field of chemistry - Defining the optimal conditions for the neutralization test on semi-industrial equipment (reagent for neutralization, pH value, floculant, etc.) **Sludge leaching and solid residue stabilization** - Acid leaching of sludge obtained after neutralization of water from the second selected site with $CaCO_3$ in laboratory conditions - Testing of acid leaching parameters: choice of type and concentration of leaching reagent, solid-liquid ratio, time, temperature - Copper removal from solution after leaching - Purification of waste leaching solutions - Preparation of orders for sending samples for chemical analysis and submission of orders and samples to the responsible person for the field of chemistry. All samples will be analysed on: Fe (total), Fe^{2+}, Fe^{3+} (calculated), Mn, Cu, Mo, Zn, As, Ni, Pb, Cd, Cr, Hg, S and Se. - Stabilization of the solid residue formed after leaching process - Verification the stabilizing process of the residue obtained after sludge leaching, using TCLP and LP procedures (standard methods EPA1311, SRPS EN12457-2) - Preparation of the quarterly technical report
VII	**Neutralization of second selected water on scale up equipment** - Sampling of about 2000 liters of water from second selected site for a neutralization test that should verify the neutralization process selected as optimal during laboratory testing - Test implementation on scale up equipment (Procedure with technological description is given in Annex IV) - Compilation and interpretation of results after neutralization of long selected locations at a semi-industrial plant

	Sludge leaching and solid residue stabilization - Acid leaching of sludge obtained after neutralization of water from the second selected site on scale up equipment - Testing of acid leaching parameters: choice of type and concentration of leaching reagent, solid-liquid ratio, time, temperature - Copper removal from solution after leaching - Purification of waste leaching solutions - Preparation of orders for sending samples for chemical analysis and submission of orders and samples to the responsible person for the field of chemistry. All samples will be analyzed on: Fe (total), Fe^{2+}, Fe^{3+} (calculated), Mn, Cu, Mo, Zn, As, Ni, Pb, Cd, Cr, Hg, S and Se. - Stabilization of the solid residue formed after leaching process - Verification the stabilizing process of the residue obtained after sludge leaching, using TCLP and LP procedures (standard methods EPA1311, SRPS EN12457-2) - Preparation of the quarterly technical report
VIII	- Preparation the Report with the procedure to remove copper and other heavy metals from acid mine drainage. - Preparation of quarterly technical report Deliverable D.T1.6.1- Report with the procedure to remove copper and other heavy metals from acid mine drainage streams

RESOURCES AND RESPONSIBILITIES

Resources	Responsibility
Project coordinator	Monitoring the realization of treatment of wasted waters and acid mine drainage streams to remove copper and other pollutant metals activities Exchange of information with Romanian partner

Responsible person - Expert for waste water treatment on scale up equipment	Coordination of the all activities towards treatment of wasted waters and acid mine drainage streams to remove copper and other pollutant metals Monitoring the experimental activities and management of the tests on laboratory level Participating in the field of sampling on site
Expert for laboratory testing of waste water (neutralisation of selected water)	Development of the methods for waste water treatment on laboratory level Data collecting and analysis of the results obtained in the purification processes of different kind waste water. Water (surface and ground water, acid mine drainage water) sampling, measurements on site. Participate in physical characterization of water samples on site
Expert for tests of copper leaching (sludge leaching and solid residue stabilization)	Sample preparation for experimental investigation of leaching process Investigation of experimental procedure for acid leaching of sludge obtained after neutralization of water Determination effect of key leaching parameters on dissolution of heavy metals (type and concentration of leaching reagent, solid-liquid ratio, time, temperature) Investigation of experimental procedure for copper removal from solution after leaching Experimental data analysis and defining the optimal leaching method at the laboratory level
Expert for pollutant metals removal (sludge leaching and solid residue stabilization)	Separation of pollutant metals from solution obtained after leaching processes Summarizing end collection results obtained after treatment of wasted waters and acid mine drainage streams aim to remove copper and other pollutant metals
Expert in field of waste management (treatment of wasted waters and acid mine drainage streams to remove copper and other pollutant metals activities)	Collecting, summarizing, analyzing and interpretation results of physic-chemical testing Reporting/presenting results Participate in activities of soil and water sampling on site

ANNEXES

ANNEX I - TABLES WITH PARAMETERS OF NEUTRALIZATION TESTS

Table AI.1. Measurements during neutralization on scale up equipment – part A

Number	Sample (TA)	pH Thickener A (TA)	Time	Water flow rate, l/min
Start	Start AMD Fe^{2+}			
	Start AMD Filt. + HNO_3			
1.	1 TA Fe^{2+}			
	1 TA Filt. + HNO_3			
2.	2 TA Fe^{2+}			
	2 TA Filt. + HNO_3			
3.	3 TA Fe^{2+}			
	3 TA Filt. + HNO_3			
4.	4 TA Fe^{2+}			
	4 TA Filt. + HNO_3			
5.	5 TA Fe^{2+}			
	5 TA Filt. + HNO_3			
End	End TA Fe^{2+}			
	End TA Filt. + HNO_3			

Table AI.2. Measurements during neutralization on scale up equipment – part B

Number	Sample (TB)	pH Thickener B (TB)	Time	Water flow rate, l/min
Start	Start TB Fe^{2+}			
	Start TB Filt. + HNO_3			
1.	1 TB Fe^{2+}			
	1 TB Filt. + HNO_3			
2.	2 TA Fe^{2+}			
	2 TB Filt. + HNO_3			
3.	3 TB Fe^{2+}			
	3 TB Filt. + HNO_3			
4.	4 TA Fe^{2+}			

	4 TB Filt. + HNO_3			
5.	5 TB Fe^{2+}			
	5 TB Filt. + HNO_3			
End	End TB Fe^{2+}			
	End TB Filt. + HNO_3			

Table AI.3. Consumption of lime and lime milk

Number	Time	Addition of lime, kg	Volume of lime milk, l	Flow rate , ml/min

Table AI.4. Flocculant consumption

Number	Time	Flocculant volume, l	Flow rate, ml/min

Table AI.5. Measurements during neutralization tests in laboratory

Number	Sample	pH	Volume, ml	Time

ANNEX II - TABLES WITH PARAMETERS OF LEACHING TESTS

Table AII.1. Measurements during sludge leaching process in laboratory conditions

No	Sludge sample	Conditions					Volume of pregnant leaching solution - PLS (ml)	Mass of sample (g)		Start		Finish		PLS sample
		Leaching solution	Pulp density (g/ml)	Temper. (°C)	Stirring speed (o/min)	Time (min)		Start	Finish	pH	ORP	pH	ORP	

ANNEX III- CHEMICAL ORDER

- Chemical order will be given in form of following template, where will be added elements for testing: Fe (total), Fe^{2+}, Fe^{3+} (calculated), Mn, Cu, Mo, Zn, As, Ni, Pb, Cd, Cr, Hg, S and Se.

	ЗАХТЕВ ЗА ИСПИТИВАЊЕ	Ознака: P191.NNN-GG.NNN

Датум:

Наручилац испитивања (корисник):
Подаци о узорку:
Назив:
Количина:
Треба испитати:
Посебни захтеви:
Стандард / метод по коме се жели да изврши испитивање:
Треба известити корисника о почетку испитивања: ☐ Да ☐ Не
Извештај о испитивању доставити до:
Извештај о испитивању доставити на адресу:
Простор за додатне напомене:

Достављено:
- Руководиоцу лабораторије 1x
- Архива корисника 1x

Наручилац:

IF-IRM.P191 Захтев за испитивање Издање обр.:3 Стр 1 од 1
Матични документ IP-IRM.P19, Издање:4 Прилог 1

ANNEX IV - GENERAL DESCRIPTIONS OF SCALE UP EQUIPMENT

The scale up equipment that will continuously perform pH control and flocculation-precipitation of the acid mine drainage (AMD) in two steps is consisted of the next units (Fig.1):

1. Unit A: Waste Water Supply

Unit A is consisting of:

- Receiving Pump, flow rate 20 l min^{-1}, for transport the feed water in waste water tank
- Waste Water Tank, volume 100 l, for storage of feed waste water
- Waste Water Pump, flow rate 2 - 5 l min^{-1}, for feed waste water transport in unit B

2. Unit B: pH Control and Flocculation-Precipitation

Unit B is configured from: Unit B-1, Unit B-2 and Unit B-3.
The following are descriptions of the respective unit:

• Unit B-1 : Thickener A, volume 410 l

Solid-liquid separation of the feed waste water that has been done primary pH control (according to the first set pH value) and flocculation

• Unit B-2: pH Control Tank A/B, volume 50 l each, Flocculation Tank A/B, volume 50 l each

Primary pH control (according to the first set pH value), secondary pH control (according to the second set pH value) and flocculation of the feed waste water. pH Control Agitator A/B is used for solution mixing in pH Control Tank A/B. Flocculation Agitator A/B is used for solution mixing in Flocculation Tank.

• Unit B-3: Thickener B, volume 410 l

Solid-liquid separation of the feed water that has been done secondary pH control (according to the second set pH value) and flocculation.

3. Unit E: Filtration

Thickener A and Thickener B of Unit B should be visually checked regularly for slurry buildup, and as it has grown to a substantial level, manually operated valves under the respective thickeners should be opened for discharge of the slurry by Slurry Pump, flow rate 20 l min^{-1}, to Filter Press, capacity 3 l, for filtration. The filtrate is to be either discharged by a portable filtrate pump or returned to Waste Water Tank depending on the level of its water quality. Filter Press will be of an fully automatic type with a pneumatic press function built in.

4. Unit C: Slaked Lime Feed

Slaked lime and water are to be charged into Lime Slurry Tank, volume 250 l, in advance for controlling its concentration to 2.5 mass %. The conditioned lime slurry will be sent

automatically, by Lime Slurry Pump A/B, flow rate 0.5 l min^{-1}, to pH Control Tank A and pH Control Tank B according to their respective pH values.

5. Unit D: Flocculant Feed

Polymer flocculant and water are to be charged into Flocculant Tank, volume 100 l, in advance for controlling its concentration up to 0.5 g l^{-1}. The conditioned flocculant will be sent to Flocculation Tank A and Flocculation Tank B at a constant feed rate irrespectively of the feed water flow rate by Flocculant Pump A/B, flow rate 0.05 l min^{-1}

6. Compressor

This compressor (370 l min^{-1}) will be used in order to supply the compressed air to filter press and solenoid valves.

7. Control Panel

Panel will be used for control, operation and power supply of equipment

8. Storage Tank for Waste Water, volume 1000 l

This tank will be used for sampling and storage of AMD that will be used for two-step neutralisation process.

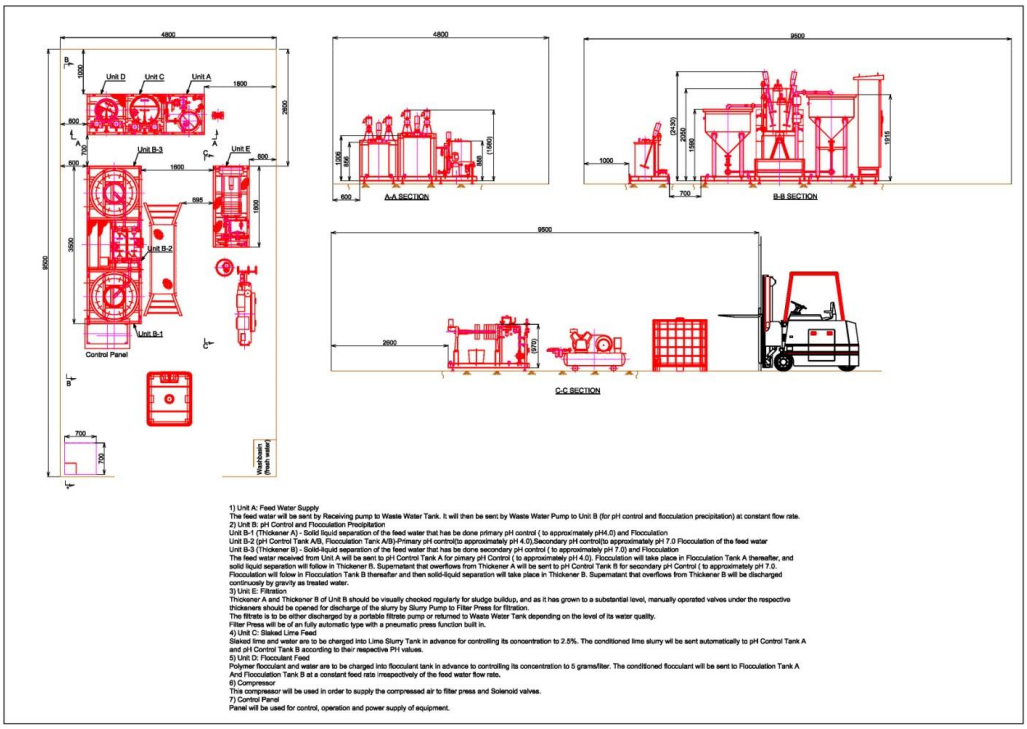

Fig. 1 Scale up equipment for neutralisation of acid mine water

ANNEX V - SECURITY MEASURES (SCALE UP EQUIPMENT)

• To prevent injury to personnel or damage to equipment, read "Precautions" carefully and do your job properly.
• The instructions given in this material are critical to safety. Always respect them.
• The operating procedures provided in this installation manual must be followed in strict accordance with safety .
• The responsible person should keep and know: Installation manual and Manual for operation and maintenance of the equipment in one place.
• Symbol marking
- Different categories of symbols have been used in this installation manual to alert personnel of the potential risk that could result in personal injury and damage to equipment in the event of incorrect handling of the equipment. Be fully aware before performing the work.

 ”WARNING”

• Failure to follow the "Warning" instruction can cause very serious incidental situations. Always respect this sign.

 ”CAUTION”

• Failure to follow the instruction "Caution" may cause minor injuries to personnel or damage or equipment problems. Never fail to obey this warning.

 ”WARNING”

• Protective equipment must be worn: safety helmet, safety shoes, gloves, and safety goggles. Additional safety equipment is required based on the situation on site.

• Cracking ropes or load chains can cause the load to fall, which can result in serious injury. Use ropes and chains of adequate strength to lift different loads.

• Do not use worn or damaged ropes and load chains.

• Be sure to use the specified points - the lifting points of the equipment to lift it. Lifting loads at the wrong points can cause equipment to fall and can cause serious injury.

• Do not approach the transported equipment. The equipment may fall during transport and cause injury

• Do not stand under a raised load. The load can fall and lead to injury and various accidents.

• Do not stand on materials such as wooden pallets and frames. Packaging materials can collapse and cause personnel to fall, resulting in serious accidents and damage to equipment.

• Strong magnets are used in some equipment. Strong magnetic forces can be dangerous for those wearing medical electronic devices such as cardiac pacemakers. Avoid approaching such equipment.

• Never attempt to change the equipment. We will not take any responsibility for any accidents or damage resulting from this.

 ”CAUTION”

• Only those with complete knowledge, experience and skills can handle or operate this equipment.

• Never place any materials other than those intended for a particular treatment in vessels, tanks or equipment. Insertion of improper materials can cause malfunction or damage to the equipment and can be extremely harmful.

• Wear safety equipment and avoid other equipment. Chemicals or other hazardous liquids can be sprayed when water is added or when a chemical test is being performed.

• Wear protective equipment, avoid the other while sampling and open the valve slowly during sampling. Because chemicals may leak / splash during sampling.

ANNEX I - TABLES WITH PARAMETERS OF NEUTRALIZATION TESTS

Table AI.1. Measurements during neutralization on scale up equipment – part A

Number	Sample (TA)	pH Thickener A (TA)	Time	Water flow rate, l/min
Start	Start AMD Fe^{2+}			
	Start AMD Filt. + HNO_3			
1.	1 TA Fe^{2+}			
	1 TA Filt. + HNO_3			
2.	2 TA Fe^{2+}			
	2 TA Filt. + HNO_3			
3.	3 TA Fe^{2+}			
	3 TA Filt. + HNO_3			
4.	4 TA Fe^{2+}			
	4 TA Filt. + HNO_3			
5.	5 TA Fe^{2+}			
	5 TA Filt. + HNO_3			
End	End TA Fe^{2+}			
	End TA Filt. + HNO_3			

Table AI.2. Measurements during neutralization on scale up equipment – part B

Number	Sample (TB)	pH Thickener B (TB)	Time	Water flow rate, l/min
Start	Start TB Fe^{2+}			
	Start TB Filt. + HNO_3			
1.	1 TB Fe^{2+}			
	1 TB Filt. + HNO_3			
2.	2 TA Fe^{2+}			
	2 TB Filt. + HNO_3			
3.	3 TB Fe^{2+}			
	3 TB Filt. + HNO_3			
4.	4 TA Fe^{2+}			
	4 TB Filt. + HNO_3			
5.	5 TB Fe^{2+}			
	5 TB Filt. + HNO_3			
End	End TB Fe^{2+}			
	End TB Filt. + HNO_3			

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Table AI.3. Consumption of lime and lime milk

Number	Time	Addition of lime, kg	Volume of lime milk, l	Flow rate , ml/min

Table AI.4. Flocculant consumption

Number	Time	Flocculant volume, l	Flow rate, ml/min

Table AI.5. Measurements during neutralization tests in laboratory

Number	Sample	pH	Volume, ml	Time

ANNEX II - TABLES WITH PARAMETERS OF LEACHING TESTS

Table AII.1. Measurements during sludge leaching process in laboratory conditions

No	Sludge sample	Conditions					Volume of pregnant leaching solution - PLS (ml)	Mass of sample (g)		Start		Finish		PLS sample
		Leaching solution	Pulp density (g/ml)	Temper. (°C)	Stirring speed (o/min)	Time (min)		Start	Finish	pH	ORP	pH	ORP	

ЗАХТЕВ ЗА ИСПИТИВАЊЕ

Датум:

Наручилац испитивања (корисник):
Подаци о узорку:
Назив:
Количина:
Треба испитати:
Посебни захтеви:
Стандард / метод по коме се жели да изврши испитивање:
Треба известити корисника о почетку испитивања: ☐ Да ☐ Не
Извештај о испитивању доставити до:
Извештај о испитивању доставити на адресу:
Простор за додатне напомене:

Достављено:
- Руководиоцу лабораторије 1x
- Архива корисника 1x

Наручилац:

Cooperation beyond borders.

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ANNEX IV - GENERAL DESCRIPTIONS OF SCALE UP EQUIPMENT

The scale up equipment that will continuously perform pH control and flocculation-precipitation of the acid mine drainage (AMD) in two steps is consisted of the next units (Fig.1):

1. Unit A: Waste Water Supply

Unit A is consisting of:

- Receiving Pump, flow rate 20 l min^{-1}, for transport the feed water in waste water tank
- Waste Water Tank, volume 100 l, for storage of feed waste water
- Waste Water Pump, flow rate 2 - 5 l min^{-1}, for feed waste water transport in unit B

2. Unit B: pH Control and Flocculation-Precipitation

Unit B is configured from: Unit B-1, Unit B-2 and Unit B-3.
The following are descriptions of the respective unit:

・ Unit B-1 : Thickener A, volume 410 l

Solid-liquid separation of the feed waste water that has been done primary pH control (according to the first set pH value) and flocculation

・ Unit B-2: pH Control Tank A/B, volume 50 l each, Flocculation Tank A/B, volume 50 l each

Primary pH control (according to the first set pH value), secondary pH control (according to the second set pH value) and flocculation of the feed waste water. pH Control Agitator A/B is used for solution mixing in pH Control Tank A/B. Flocculation Agitator A/B is used for solution mixing in Flocculation Tank.

・ Unit B-3: Thickener B, volume 410 l

Solid-liquid separation of the feed water that has been done secondary pH control (according to the second set pH value) and flocculation.

3. Unit E: Filtration

Thickener A and Thickener B of Unit B should be visually checked regularly for slurry buildup, and as it has grown to a substantial level, manually operated valves under the respective thickeners should be opened for discharge of the slurry by Slurry Pump, flow rate 20 l min^{-1}, to Filter Press, capacity 3 l, for filtration. The filtrate is to be either discharged by a portable filtrate pump or returned to Waste Water Tank depending on the level of its water quality. Filter Press will be of an fully automatic type with a pneumatic press function built in.

4. Unit C: Slaked Lime Feed

Slaked lime and water are to be charged into Lime Slurry Tank, volume 250 l, in advance for controlling its concentration to 2.5 mass %. The conditioned lime slurry will be sent automatically, by Lime Slurry Pump A/B, flow rate 0.5 l min^{-1}, to pH Control Tank A and pH Control Tank B according to their respective pH values.

5. Unit D: Flocculant Feed

Polymer flocculant and water are to be charged into Flocculant Tank, volume 100 l, in advance for controlling its concentration up to 0.5 g l^{-1}. The conditioned flocculant will be sent to Flocculation

Tank A and Flocculation Tank B at a constant feed rate irrespectively of the feed water flow rate by Flocculant Pump A/B, flow rate 0.05 l min^{-1}

6. Compressor

This compressor (370 l min^{-1}) will be used in order to supply the compressed air to filter press and solenoid valves.

7. Control Panel

Panel will be used for control, operation and power supply of equipment

8. Storage Tank for Waste Water, volume 1000 l

This tank will be used for sampling and storage of AMD that will be used for two-step neutralisation process.

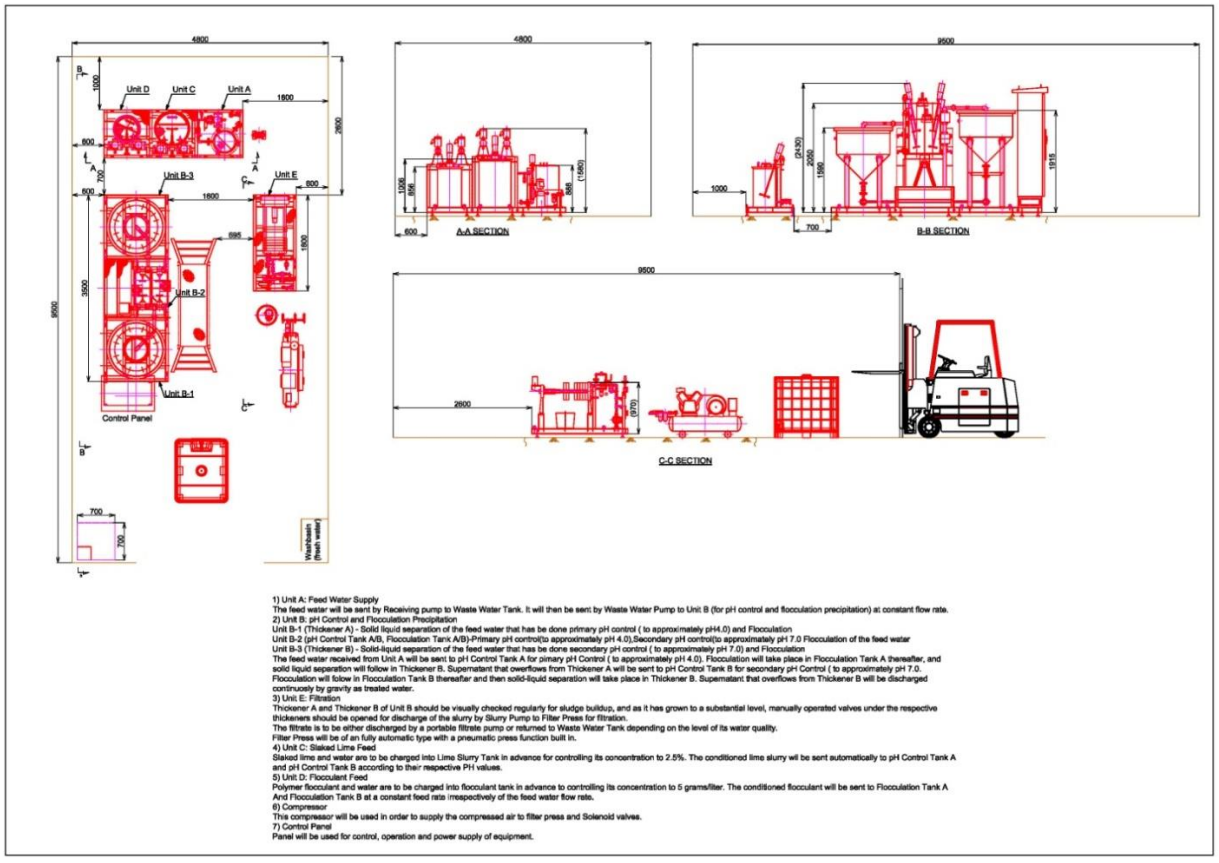

Fig. 1 Scale up equipment for neutralisation of acid mine water

ANNEX V - SECURITY MEASURES (SCALE UP EQUIPMENT)

• To prevent injury to personnel or damage to equipment, read "Precautions" carefully and do your job properly.
• The instructions given in this material are critical to safety. Always respect them.
• The operating procedures provided in this installation manual must be followed in strict accordance with safety .
• The responsible person should keep and know: Installation manual and Manual for operation and maintenance of the equipment in one place.
• Symbol marking
- Different categories of symbols have been used in this installation manual to alert personnel of the potential risk that could result in personal injury and damage to equipment in the event of incorrect handling of the equipment. Be fully aware before performing the work.

 ”WARNING”

• Failure to follow the "Warning" instruction can cause very serious incidental situations. Always respect this sign.

 ”CAUTION”

• Failure to follow the instruction "Caution" may cause minor injuries to personnel or damage or equipment problems. Never fail to obey this warning.

 ”WARNING”

• Protective equipment must be worn: safety helmet, safety shoes, gloves, and safety goggles. Additional safety equipment is required based on the situation on site.

• Cracking ropes or load chains can cause the load to fall, which can result in serious injury. Use ropes and chains of adequate strength to lift different loads.

• Do not use worn or damaged ropes and load chains.

• Be sure to use the specified points - the lifting points of the equipment to lift it. Lifting loads at the wrong points can cause equipment to fall and can cause serious injury.

• Do not approach the transported equipment. The equipment may fall during transport and cause injury

• Do not stand under a raised load. The load can fall and lead to injury and various accidents.

• Do not stand on materials such as wooden pallets and frames. Packaging materials can collapse and cause personnel to fall, resulting in serious accidents and damage to equipment.

• Strong magnets are used in some equipment. Strong magnetic forces can be dangerous for those wearing medical electronic devices such as cardiac pacemakers. Avoid approaching such equipment.

• Never attempt to change the equipment. We will not take any responsibility for any accidents or damage resulting from this.

 ”CAUTION”

• Only those with complete knowledge, experience and skills can handle or operate this equipment.

• Never place any materials other than those intended for a particular treatment in vessels, tanks or equipment. Insertion of improper materials can cause malfunction or damage to the equipment and can be extremely harmful.

• Wear safety equipment and avoid other equipment. Chemicals or other hazardous liquids can be sprayed when water is added or when a chemical test is being performed.

• Wear protective equipment, avoid the other while sampling and open the valve slowly during sampling. Because chemicals may leak / splash during sampling.

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