Underground laboratories working environment common standard

Baltic Sea Underground Innovation Network (BSUIN)

Interreg Baltic Sea Region
EUROPEAN REGIONAL DEVELOPMENT FUND
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1. BSUIN project introduction

The aim of the BSUIN project is to make the underground laboratories (hereinafter ULs) in the Baltic Sea Region more accessible for innovation, business development, and science by improving the information about the underground laboratories, the operation, user experiences, and safety.

Baltic Sea Underground Innovation Network (hereinafter BSUIN) is a collaboration project between 13 partners from 8 Baltic Sea Region (hereinafter BSR) countries. Besides project partners, 17 associated partners contribute to achieving project goals.

In the project participate six (6) underground laboratories around BSR. They all will be characterized and presented to potential customers in order to attract developing innovative activities and active use of those laboratories. Six underground laboratories by name are:

1. Callio Lab, Pyhäsalmi mine, Finland
2. Äspö Hard Rock Laboratory, Oskarshamn, Sweden
3. Reiche Zeche, TU Freiberg Research and Education mine, Germany
4. Lab development by KGHM Cuprum R&D centre, Poland
5. Khlopin Radium Institute Underground Laboratory, Russia
6. Ruskeala Mining Park, Russia

The main outcome of the project is a sustainable network organization, which will disseminate the technical, marketing, operational quality, training, and other information about the BSR ULs created during the project.

The project is funded by Interreg Baltic Sea funding cooperation. Its duration is 36 months with a total budget of 3.4 M€.

2. Content of present Document

2.1 Document justification

The present document is a part of the project BSUIN work package 4.1 output, where one of the activities covers the establishment of a common standard of underground working environment among in six above mentioned UL-s.

The purpose of work package 4 is a description of the working environment and risks assessment among ULs, including also the dissemination of best practices and development guidelines.

2.2 Content description

A common standard of an underground working environment is an overview of national regulations and requirements. They act as the minimum level on which the working environment must meet and will be the basis to establish a common standard of underground working conditions among the participating ULs.

A common standard is based on a held questionnaire (see Appendix 1) carried out during March-July 2018. In the questionnaire, ULs asked to answer several questions regarding their working environment conditions. Questions touched such topics as ownership and regulation, air and water quality, safety and monitoring in ULs, lighting requirements, noise, vibration, and radiation measurements, including risks and monitoring. In next chapter will be presented the results of the questionnaire in each topic. In final chapter is presented a summary and conclusions of the working environment standard.

3. Common working environment standard in underground laboratories

3.1 Ownership, laws and regulations

The common aspect of the ULs is that they all have owner, i.e some sort of legal entity and they manage the underground laboratories under their own name. The only exception, conditionally, is a laboratory in KGHM Cuprum in Poland, because officially this laboratory as a separate legal body doesn't exist yet. This laboratory working as part of one of the existing, still operational copper mines Zakłady Górnicze „Rudna", Zakłady Górnicze „Lubin", Zakłady Górnicze „Polkowice-Sieroszowice". Then this UL receive legal status, most likely government-owned public limited company will be the legal owner.

Another common characteristic is that all activities in ULs are subordinated to local laws and regulations. These laws and regulations are nation-wide (state or federal laws) and/or local type (county) and they all contain requirements on which ULs operate, including starting new activities or changing existing ones in ULs.

Since all ULs are historically located in countries with long mining traditions, overall the national regulations are well developed and ownership relations, including liability, are sufficiently clear.

3.2 Safety, practices and monitoring

Assuring safety to work in underground conditions is a top priority in every UL, although monitored parameters for assuring safety varies quite much in UL-s. The main differences are related to the physical parameters of the UL, such as depth, bedrock conditions, state or company policy requirements, occurrence risks of gases and/or radiation, etc.

Every UL monitor parameters what are important, required by law or company policy, and can occur in their local condition. Minimum what every UL monitor **is airflow in the underground (except Ruskeala) and access to the underground.** Other monitored

parameters differ in ULs, depending on their local conditions. For instance, in some ULs radiation is monitored and others not, in another ULs temperature is monitored and others not, etc. A common observation is that the ULs located in operational mines like Callio Lab in Pyhäsalmi Mine and Conceptual UL at KGHM Cuprum mine monitoring more parameters than others. Quite a lot of parameters is monitored in Ruskeala, Russia, where monitoring mainly demanded by ULs own policy. Ruskeala is a former marble quarry with underground excavation sites which now is turned mainly into the touristic site to preserve mining and industrial heritage. Somewhat different is the situation in Khlopin Radium Institute, Russia, because this facility locates in the city center of St-Petersburg, between two underground metro stations, in smaller separated rooms inside metro infrastructure. This means that inside UL-s premises they measure only temperature and radiation, other important parameters, like airflow, etc, are monitored by city metro company.

One common aspect that is similar in UL-s is the availability of self-rescue devices or rescue shelters and trained personnel to give first-aid on site. First-aid can be given by specific first-aid crew or by individual personnel who are trained accordingly. Availability of rescue devices/shelters and knowledgeable personnel in first-aid are demanded by law or by company policy in every UL. The only exception is Khlopin Radium Institute where they have only med-kit available for medical situations because the facility is rather small.

In most UL-s are also mandatory existence of trained personnel in fire-fighting and occasional rescue drill training. The only exceptions are Ruskeala and Khlopin in Russia, where is no rescue team or trained personnel at the site but they use fire extinguishers instead.

Regarding access to the underground, able-bodied persons in all ULs can have access to the underground but people in a wheelchair and in most ULs people using crutches can`t have access to the underground. The only exception is Ruskeala, where people in a wheelchair and people using crutches or cane have access to Ruskeala underground touristic site.

Also, during blasting, access is not granted due to safety reasons. Overall, access to the underground for healthy persons is possible, in some ULs even in the night time on special occasions and it`s been strictly monitored. For safety reasons access is prohibited during blasting works and in most cases also for people in wheelchair and people using crutches or cane. Although the entrance ban for people in a wheelchair and people using crutches or cane is understandable for safety reasons and in many cases this restriction comes by law requirements, all ULs work towards making an entrance for them possible in the future.

3.3 Air quality and impurities in the air

Supervision of air quality and supervision of substances in the air varies significantly in UL-s. Such a big difference in monitoring air quality depends on the two main components – the physical characterization of bedrock surrounding UL-s and UL-s own activity.

In some UL-s natural gases, exhaling from surrounding bedrock, are determined as risk and being monitored. For instance radon in most UL-s. For radon, which occurs naturally in some UL-s, state regulations have set nominal value and threshold limit which is periodically measured by personal or infrastructural sensors.

In some cases, like UL-s in KGHM Cuprum in Poland and Callio Lab in Finland, besides natural gases, they monitor air quality and many impurities in the air because UL locates in still working mine where blasting works and gases from machinery, etc can be a source of air deterioration. On the other hand, Ruskeala Mining Park in Russia doesn`t monitor any impurities in the air, except radon, because there are no significant air quality risks in old marble quarry, which now is publicly used for touristic activities.

Important to note is that all UL-s are aware of their air quality risks and monitor impurities in the air periodically. They are aware of the possible sources reducing air quality and take actions accordingly, i.e stop blasting/drilling works, ventilating properly mining front before other activities, etc. A slightly different situation is in Khlopin Radium Institute, where inside Institute premises they don`t measure impurities in the air, i.e it is made by

city metro company who surrounding UL premises. They regulate their air quality inside UL premises via ventilation.

In general, laws and regulations in UL-s which regulate air quality and limits of the impurities in the air are well developed, based on the historical information and scientific approach.

3.4 Water quality and treatment

Half of the UL-s, except Äspo, Khlopin, and Ruskeala, state that water is a risk to their facilities and this risk is related to water quantity. Since all UL-s locate in underground they all monitor, except Khlopin, water influx quantity, and some ULs also quality. It also varies type of influx water what is monitored – in some UL-s they monitor process and surface water, in some UL-s only floodwater observation is important. Although Äspo and Ruskeala indicate that water is not risk in their facility, they still monitor water influx and efflux, including treatment need, and pump out water what affects the facility's daily work. The exceptional situation is Khlopin Radium Institute because it is located in the metro and has central water system, i.e potable water, and canalization. Used water will be purified in the city central water system.

Water-related risks in the underground working environment depend mostly of the depth of the UL and the main concern is water influx. In some UL-s also water removal and purification before exiting is an important issue where they purify several substances from efflux water according to local law and environmental permit.

In all UL-s water influx and water removal, including purification needs and limits for different substances, is regulated by local laws, environmental permit, and company policy. All new activities in UL-s must meet local regulations and permits which regulate water influx and monitoring, also removal and treatment.

3.5 Noise and mechanical vibrations, geomechanics and seismicity

Observation of noise and mechanical vibrations in UL-s depends on the geographical location and the type of UL. In these UL-s, where active mining has finished, they usually don`t monitor noise and vibration level and it is not a serious risk issue. Protective measures are implemented by whose persons who operate with noisy and vibrating equipment, other personnel working in UL can protect themselves by keeping sufficient distance from the source of noise and vibration.

In UL-s where active mining is still ongoing, like Cuprum in Poland, noise and vibration are considered as a risk. Workers in mine wear hearing protection when operating with machines and equipment and vibrations are tried to keep as low as possible by using modern machines and equipment. Noise and vibrations are being monitored with personal devices. They also have set threshold limits to the source of noise and vibration.

3.6 Radiation

Man-made radiation by instruments is not considered as a risk in UL-s, although in UL-s it is allowed to use radioactive devices for research and measurement purposes but in a controlled manner. This means that most UL-s have pointed responsible radiation safety officer who firstly denies or allow usage of radioactive man-made devices and demand monitoring of radioactive sources via personal or infrastructural devices. In these UL-s where responsible radiation safety officer is not pointed, they monitor man-made radioactive source by personal devices, i.e personal responsibility. In a little bit of exceptional situation is Khlopin Radium Institute, where they are doing radiation low background measurements, therefore it is not allowed to bring to Khlopin any man-made radiation instruments.

UL-s working environment is affected more by naturally occurring radiation where the radiation source is surrounding bedrock. The situation varies in different UL-s, but the common baseline is that they all monitor some components of naturally occurring radiation, like Radon (Rn-222) for instance. Some UL-s have declared naturally occurring

radiation as a risk in their facility, some don`t, but they all monitor the most hazardous components via periodical measurements and/or personal devices.

The risk of radiation occurrence and its monitoring demand is very well regulated by state law policies. Monitoring is required by law and in some cases by company policy as an additional safety requirement.

3.7 Lighting

Lighting as one part of the underground working environment varies between UL-s. Every UL has its own policy for light sources and lighting technologies also vary significantly. Depending on UL they use light bulbs, halogens, indacent lights, LEDs, or intelligent LEDs.

In most UL-s the whole facility is not illuminated but the main working and transport areas, also used machines are illuminated. Depending on the client needs UL-s organise lighting ability and try to fulfill client needs as much as possible. In most UL-s there are no specific guidelines or regulations concerning lighting. Lighting is regulated by state law or by UL's own policy which regulates what areas must be illuminated, what lighting technologies are used, how to provide illumination to the working area etc.

4. Summary and conclusions of working environment common standard

The underground working environment is a complex system, where all activities must obey certain rules and legislation. It consists of several monitored parameters regarding safety, access, air and water quality, noise, vibration and radiation level, and lighting characteristics.

A lot of things of underground working environment is prescribed by local laws, permits or UL-s own policy which need to be followed, like which substance to measure in the air and water, what components can not exceed the set limits, what activities and access are allowed or prohibited during blasting, etc.

In general, UL-s ownership relations are clear, meaning that they all have a legal entity. In addition, local laws and regulations in these historical mining countries are very well developed containing all needed requirements on which UL-s can operate.

All UL-s consider safety aspects very important in their everyday activity and monitor parameters that are important, required by law or company policy, and can occur in their local conditions. This also corresponds to the air, water, noise, vibration, radiation, and lighting parameters that UL-s must monitor and take countermeasures or mitigation measures according to local legislation and permits.

Present standard describe the minimum level of the underground working environment in six UL

Appendix 1. Working Environment Questionnaire

Underground Working environment 4.1.
Owners, Authorities, Laws and Regulations
Official name of the underground facility
What type of organisation owns your facility (private / govermental / institutional)?
What it is the legal entity owning the underground facilities / laboratories?
What is the legal entity managing the underground facilities /laboratories?
Is the facility part of any other larger context e.g. single underground laboratories within an operational mine etc.?
What are the governing institutions, authorities and regulators covering the use of your underground facility? (e.g. state, occupational safety authorities, chemical safety authorities etc.)
Which top laws and regulations are related to the current use of your underground facility? (e.g. mining law, occupational safety law chemical safety regulations)
What type of documentation and to which autority do you have to provide to the governing institutions when applying for a permit - to operate or to change the nature of your operation underground?
- to make or alter your underground facilities e.g. building permit?
- to close the underground facility (e.g. mine closure)?
Are there in near future to be changes in the type of use of your underground facility? - if yes, what type (e.g. mine closure)? - how these will change the governing laws and regulations related to your facility?

Underground Working environment 4.1.

Safety, practices and monitoring

Safety and monitoring parameters	Is the parameter/ function monitored		How the parameter / function is monitored		Is the monitoring required		How the alarm of the parameter / function effects the possibility to continue working			
	yes		periodicaly measurement		by law	by company policy	To evacuate	To exit	Nothing	Other
Air flow monitoring										
Air flow to individual facilities monitoring										
Air quality monitoring										
Gas monitoring										
Temperature monitoring										
Pressure monitoring										
Radiation (alpha/gamma)										
Fire detection										
Access to underground										
Access to individual facilities										
Communications										

Practices	Is the practice / system available?		Is the practice / system required	
	yes	no	by law	by company policy
Rescue shelters				
self-rescue devices				
First -aid team				
Fire crew				
Rescue drills				

Access	Full access	Access with aid	Limited access	No access	Not effecting your facility
Able bodied					
Using cructches / cane					
Wheel chair					
With existing medical conditions					
- flue					
- respitory related					
- hearth related					
- other					
During blasting					
During night time					

Laws and regulations	
Which laws and regulations are related to above sections?	Which authority is responsible for monitoring the adaptation of rules and regulations?

Underground Working environment 4.1.

Air quality and impurities in the air

Air quality	yes	no	if yes why?
Is the air quality being monitored?			
Is air quality a risk in your facility?			
Are there times when air quality is bad?			

Impurities in the air									
	Is it a a risk in your facility		Is it monitored in your facility		How it is monitored?		What is the nominal value in your facility?	What is the 'known to be harmful concentration ' limit?	
Impurity	yes	no	yes	no	Personal sensors	Infrastructural sensors		in your facility	in your country
Dust laying on the surfaces (particles < 30 µm)									
Particles reaching upper airways (particles < 10 µm)									
Particles reaching alveolar level (particles < 2,5 µm)									
Sulphur dioxide (SO2)									
Hydrogen sulphide (H2S)									
Other sulphuric compounds (TRS)									
Nitric oxide (NO2), other nitrogen oxides (NO)									
Hydrocarbons (HC)									
Carbon monoxide (CO)									
Carbon dioxide (CO2)									
Other volatile organic compounds (VOC)									
Radon gas									
Any other compounds not mentioned in the list above									

Are the limits within your facility following the national rules and regulations or do you have stricter limits? How these have been achieved?

Laws and regulations	
Which laws and regulations are related to above sections?	Which authority is responsible for monitoring the adaptation of rules and regulations?

Underground Working environment 4.1.

Water related risks to underground working environment

Water in your facility		
Is water a risk in your facility	Yes	No
Is water risk related to	quantity	quality

Water influx	Is the water influx quantity being monitored		Is the water quality monitored?		Does the water influx provide a risk to work in your facility?		Is the risk related to quantity or quality of the water?		If quality, is the riks related to chemical or biological substances	
	yes	no	yes	no	yes	no	quantity	quality	bio	chem
Process water	yes	no	yes	no	yes	no	quantity	quality	bio	chem
Surface water	yes	no	yes	no	yes	no	quantity	quality	bio	chem
Ground water	yes	no	yes	no	yes	no	quantity	quality	bio	chem
Deep bedrock water pockets	yes	no	yes	no	yes	no	quantity	quality	bio	chem
Flood waters	yes	no	yes	no	yes	no	quantity	quality	bio	chem
	yes	no	yes	no	yes	no	quantity	quality	bio	chem
	yes	no	yes	no	yes	no	quantity	quality	bio	chem

Water removal and treatment	Is the water treated /purified before exiting your facility		What is the water treating capasity m3/h?	What is the free capasity of your water treatment facility?	What agents and / substances are removed from the waste water?
Water removal	yes	no			

Substances	What agents and / substances are removed from the waste water?		What are the limit values for the substances in the efflux water?		Is so called "pollution-tax" adapted in your country for discharging those substances to the environment in your efflux waters?	
organic substances (BHT7)	yes	no	By law	By company policy	yes	no
phosphorous compounds	yes	no	By law	By company policy	yes	no
nitrogen compounds	yes	no	By law	By company policy	yes	no
suspended solids	yes	no	By law	By company policy	yes	no
sulfates (SO42-)	yes	no	By law	By company policy	yes	no
monobasic phenols	yes	no	By law	By company policy	yes	no
nafta or other organic substance as liquid product from thermal treatment	yes	no	By law	By company policy	yes	no
wastewater there pH is below or above scale 6-9	yes	no	By law	By company policy	yes	no
other dangerous substances what are not mentioned above	yes	no	By law	By company policy	yes	no

Are the limits within your facility following the national rules and regulations or do you have stricter limits? How these have been achieved?

Laws and regulations	
Which laws and regulations are related to above sections?	Which authority is responsible for monitoring the adaptation of rules and regulations?

Underground Working environment 4.1.

Noise and mechanical vibrations, geomechanics and seismicity

Noise and mechanical vibrations	Does this produce a risk in your facility?		Is this been monitored?		Is it been monitored with		What is the threshold limit to use protection?
Noise levels	Yes	no	Yes	No	personal devices	infrastructural devices	
Mechanical vibrations	Yes	no	Yes	No	personal devices	infrastructural devices	

Geomechanics and seismicity	Does this produce a risk in/at your facility?		Is this been monitored?		Does this have an effect to using underground facilities?		What type of effect it has underground operators			
Blasting	yes	No	yes	No	yes	No	no entrance to underground	no entrance to the area in question	Limited acces to area in question	Full access to area in question
Excavation	yes	No	yes	No	yes	No	no entrance to underground	no entrance to the area in question	Limited acces to area in question	Full access to area in question
Known weak zones	yes	No	yes	No	yes	No	no entrance to underground	no entrance to the area in question	Limited acces to area in question	Full access to area in question
known old mine entrances and caverns	yes	No	yes	No	yes	No	no entrance to underground	no entrance to the area in question	Limited acces to area in question	Full access to area in question
Natural seismicity	yes	No	yes	No	yes	No	no entrance to underground	no entrance to the area in question	Limited acces to area in question	Full access to area in question

Laws and regulations	
Which laws and regulations are related to above sections?	Which authority is responsible for monitoring the adaptation of rules and regulations?

Underground Working environment 4.1.

Man-made and naturally occuring radiation

Radiation	Does this produce a risk in your facility?		Is the risk been monitored		How this is monitored		Is the monitoring required	
Naturally occurring radiation	yes	No	yes	no	personal devices	infrastructural devices	by law	by company policy
Man-made radiation (instruments, sources)	yes	No	yes	No	personal devices	infrastructural devices	by law	by company policy

Naturally occurring radiation	Does this produce a risk in your facility?		Is the risk been monitored		How this is monitored		Is the monitoring required		What is the threshold limit for personnel safety (if monitored)?
Uranium (U-238, U-235)	Yes	No	Yes	No	personal devices	infrastructural devices	by law	by company policy	
Thorium (Th-228,Th-232)	Yes	No	Yes	No	personal devices	infrastructural devices	by law	by company policy	
Radium (Ra-226, Ra-228)	Yes	No	Yes	No	personal devices	infrastructural devices	by law	by company policy	
Radon (Rn-222)	Yes	No	Yes	No	personal devices	infrastructural devices	by law	by company policy	
Polonium (Po-210)	Yes	No	Yes	No	personal devices	infrastructural devices	by law	by company policy	
Lead (Pb-210)	Yes	No	Yes	No	personal devices	infrastructural devices	by law	by company policy	
	Yes	No	Yes	No	personal devices	infrastructural devices	by law	by company policy	
	Yes	No	Yes	No	personal devices	infrastructural devices	by law	by company policy	
	Yes	No	Yes	No	personal devices	infrastructural devices	by law	by company policy	
	Yes	No	Yes	No	personal devices	infrastructural devices	by law	by company policy	
	Yes	No	Yes	No	personal devices	infrastructural devices	by law	by company policy	
	Yes	No	Yes	No	personal devices	infrastructural devices	by law	by company policy	
	Yes	No	Yes	No	personal devices	infrastructural devices	by law	by company policy	

Man-made radiation	Is it allowed to use radioactive devices within your facility?		Is the use of radiactive sources been controlled in your facility?		How the use of radiactive source is monitored?		Does your facility have a responsible radiation safety officer?	
Research instrumentation	Yes	No	Yes	No	personal devices	infrastructural devices	yes	no
Measurement instrumentation	Yes	No	Yes	No	personal devices	infrastructural devices	yes	no
Process instrumentation	Yes	No	Yes	No	personal devices	infrastructural devices	yes	no

Laws and regulations	
Which laws and regulations are related to above sections?	Which authority is responsible for monitoring the adaptation of rules and regulations?

Underground Working environment 4.1.

Lighting at your facility and at work

Lighting at your facility	Lights		Are there any specific guidelines or regulations concerning lighting?		Are these regulations due to	
Is your whole facility illuminated	Yes	No	Yes	No	by law	by company
Are only spesific underground facilities illuminated	Yes	No	Yes	No	by law	by company

Practical lighting	Does your facility have a policy for light sources		What kind of lighting technologies are used					
Infrastructural lights	Yes	No	Light bulps	halogens	indacent lights	LED	intelligent leds	other
Machine lights	Yes	No	Light bulps	halogens	indacent lights	LED	intelligent leds	other
Personnel torches and headlights	Yes	No	Light bulps	halogens	indacent lights	LED	intelligent leds	other

Laws and regulations	
Which laws and regulations are related to above sections?	Which authority is responsible for monitoring the adaptation of ru