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Location of People and Machines with the Use of the PORTAS System

In this article, the author presents the specifics of legal, functional and technical issues related to the systems of personnel location and materials logistics for underground mining, with particular focus on coalmining. An example of fulfilment of comprehensive and multidimensional requirements is the PORTAS system by SYBET sp. z o.o. The company specialises in RFID technology and other radio technologies for mining. The role of the PORTAS system in risk management has been discussed and examples of the location system integration with alarm and broadcasting as well as mobile manometry systems provided.

1. INTRODUCTION

The monitoring systems used in underground mines cover more and more areas. Among them is the monitoring of the location of staff and machines. Particularly the first aspect is of significant importance in the case of underground mines where special hazard zones are present, for example owing to rockburst, methane presence or fire, or in the case of carrying out works or rescue actions. The second aspect contributes to improvement transport routes safety and to higher effectiveness. Therefore, there are already several companies to offer their monitoring systems to support the functioning of underground staff and machines movements. This article presents the latest solutions in that area.

2. SAFETY FUNCTIONS OF THE PORTAS SYSTEM

The system of staff location in underground mining serves the safety of work in three different manners. One of the strategies assumed for risk is the risk acceptance. This refers to such risk whose probability and consequences have been mitigated with the available measures. In such cases the personnel location system enables supervision of risk exposure. It becomes a control tool as regards excess of the maximum number of people and time of stay in a hazard zone. In this way the individual risk for personnel is minimised.

Another area of the location system operation is the limitation of the probability of risk occurrence. The system performs the strategy within the dispatcher's supervision of the local control of equipment by virtue of remote granting of authorisations (e.g. to start the transport line), blockade of the automatic operation of equipment (e.g. wall support) and automatic switch-off of equipment (e.g. crusher).

The third area of impact is limitation of the risk consequences. An example here may be automatic supervision of evacuation: counting of the number of people in the hazard zone and number of people lead out from the hazard zone, as well as those who have already reached the ground level. Assistance in setting out the hazard zones and the guard posts is another example of location systems development. This also includes rescue team supervision performed with the use of a mobile devices that monitor the position of the rescue team members and facilitate searching for unconscious people in smoke atmosphere.

3. PORTAS SYSTEM VS LEGAL REQUIREMENTS

The PORTAS system fulfils specific legal requirements. As a safety system it has been approved by the State Mining Authority for use in mines. Electronic devices of the system fulfil the electronic compatibility requirements. The sending and receiving radio devices fulfil the requirements of the Telecommunications Law. All of the devices within the PORTAL system operating in explosion hazard

zones possess ATEX certificates allowing continuous operation in any methane concentration atmosphere. The electric circuits are made to IA safety level, whereas the optical devices – to OP IS safety level.

Lamps with the PORTAS system identifiers incorporated therein have been approved by the Central Mining Rescue Station, which confirmed that the identifier in the lamp does not affect the proper operation of the GLON/GLOP system.

3.1. Specific functional requirements

It is worth mentioning that the system of location for underground mines must fulfil specific functional requirements. These need to be included in the system design assumptions. When analysed closely, it appears that the set of requirements is quite specific and different from many other typical applications of the RFID systems. The first, most important requirement is the reliability of counting – registration of the identifiers passing through the system gates. It is an important parameter on which all of the safety system functions depend. Another requirement is throughput – the maximum number of people within the range of the gate, owing to the necessity of counting staff in the trains and on platforms. Still another requirement is the most possible precision in setting out the limits of the zones, as some hazard zones are very small (30-50 m).

It should also be remembered that the system is subject to frequent reconfiguration, particularly in the production area, and must be fit for easy gate reinstallation. PORTAS has been designed and produced with the simplicity of use in mind. The client may use all of its functions without any limitations. Possible is independent reconfiguration along the progress of the wall and independent installation in new headings – see example in Fig. 1.

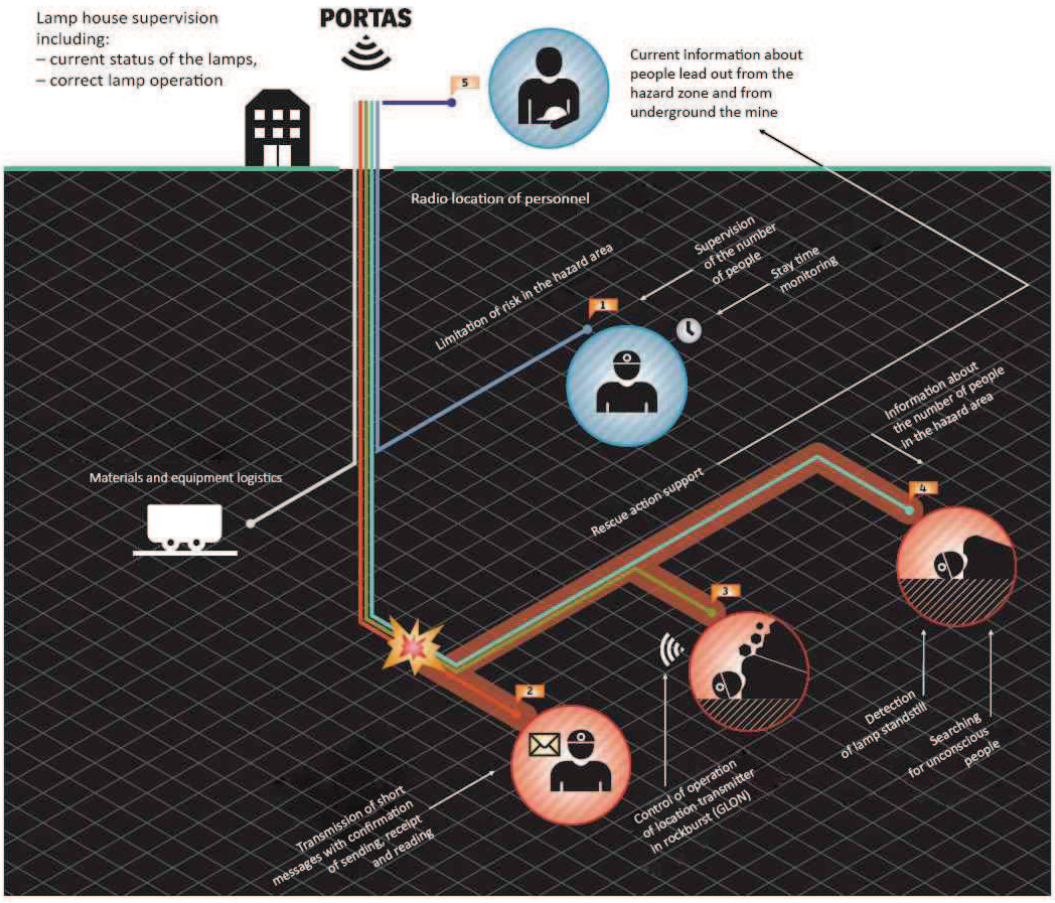

Fig. 1. Example of the PORTAS system functionality (proprietary material)

Functional requirements result in the necessity of applying active RFID technology, as the passive or semi-passive systems do not ensure reliability and the proper throughput. In the passive solutions precision is achieved at the cost of limiting the scope of operation and, therefore, reliability. Additionally, even the minimum scope necessary for operation requires high energy supply, which in the explosion hazard zones is an additional problem. Active devices emit radiation of capacity exceeding the permitted values.

3.2. Technical characteristics of the PORTAS system

Assumption of active technology results in the necessity of providing the system identifiers with their independent sources of supply. For that purpose the mining lamps are the best, while the lamps maintenance is easily to ensure by assigning them to specific staff members. On the other hand, this requires cooperation with lamp manufacturers and re-certification of lamps provided with the system identifiers. Another condition related to the use of mining lamp is the presence of the GLON transmitter, which is relatively strong – frequency between 4 and 6 kHz, with strong interference properties. However, the problem is not only undisturbed operation of the GLON system but also the adequate resistance of the location system and its electromagnetic compatibility with the GLON system.

An important condition is also such combining of the data from the location system with personal data. In mines there are systems in which the current information about the staff employed is recorded, including the numbers assigned and lamps. The best solution for the problem of cohesion and up-to-datedness of personal data is the use of data from the existing personal data database. The solution requires cooperation with the administrator and often with the supplier of software for the company personal data management.

A neutral place where the data from the PORTAS system are available is the dispatcher's room. A separate station may be defined or the data may be included in the existing dispatcher's system of the mine.

Owing to the fact that the PORTAS system covers with its scope practically the whole mine, it is important to use the existing telecommunication infrastructure – including fibre optic guides, data transmission cables and the automatic messaging system.

In the PORTAS system, linking location gates may be effected with the use of a fibre optic guide or copper wire. The switchboard of the gate is provided with two types of ports: 100Base-LX and RS485is [1]. In the case of fibre optic guide, the medium are two single-mode optical fibres. In the case of copper wire, a dedicated wire or the existing telecommunication lines may be used [5].

Thanks to open architecture and use of standard mechanisms of access to the SQL database, the PORTAS system may cooperate practically with any dispatcher's system. The selected data regarding the location of people and transport as well as the status of operation of equipment and the transmission network may be forwarded for presentation in another IT system through the computer network or through a dedicated transmission channel. The same mechanism also enables cooperation with the alarm and broadcasting system, e.g. by TELVIS, for the purpose of automatic passing of warning and alarm messages regarding the condition of the staff and the time of stay in limited stay zones. The use of identification mechanisms provides also for additional possibility of the communication system, such as automatic identification of the person using the phone or detection and identification of people in close vicinity.

Owing to flexible construction of the system software it is easy to adjust the information exchange mode to the requirements of other IT systems which do not render standard open transmission protocols. Because the whole PORTAS system software is provided by SYBET, the adaptation of the scope and method of information exchange, even in the case of very specific requirements, does not pose any problem. This enables maximum integration with other systems and use of full functional capacity of such link.

4. PORTAS SYSTEM DEVICES

UltraTAG-L is a radio identifier of the system incorporated as an assembly of a mining lamp. It is provided with the supply line and data transmission line. Beside of the basic function of location, it enables auxiliary data transmission, GLON transmitter measurement, supply voltage measurement, temperature measurement, detection of location and motion/standstill [9].

UltraTAG-B is an identifier with own battery supply, which enables the identifier operation for 3-5 years, depending on the function performed. The identifier serves identification of vehicles, some more important materials or places [8].

PORTAL is the switchboard which serves data processing within the system gate and enables redundant transmission of data with the use of fibre optic guides or copper wires. The device has its own UPS battery able to operate for at least 8 hours [1].

RFnode is a radio node of the system gate intended for cooperation with the PORTAL switchboard. Depending on the gate configuration there are needed between 6 and 9 radio nodes connected to the switchboard [1][2].

WireNode is an auxiliary radio node that enables the function of panel service authorisation, extension of the scope of the system radio or provision of the so called linear gate that extends along the heading [6].

WireNode-IO is an auxiliary system input/output module serving the imposition of auxiliary blockades or local control [7].

OPIS is an 8-port fibre optic concentrator built to explosion-proof standard with own casing. It serves the provision of star-structure data transmission in the system [3].

ExLPS intrinsically safe linear feeder serves the system sub-assemblies feeding. Its parameters have been optimised with regard to spark safety, reliability and economics of the PORTAS system. It enables remote monitoring of work, voltage and load [4].

TagScanner mobile multifunction device serves searching for unconscious people, supervision of the rescue team, materials loading/unloading recording and control of the system elements correct operation.

5. INFRASTRUCTURE, STRUCTURE AND OPERATION OF THE PORTAS SYSTEM

The PORTAS system uses the active RFID technology for the purpose of registration of identifiers movement through location gates. This enables simultaneous following of a large number of identifiers, ensures high reliability of the gate passing registration and a large reach of radio communication for auxiliary functions. PORTAS, unlike non-interference systems using RFID technology, has been designed with the focus on the specifics of the functions of personnel location. Use of the active UltraTAG-L identifiers does not require staff to perform any additional activities with regard to the necessity of confirming their presence (e.g. by approaching an id card to the reader). Fitting of the identifiers in mining lamps, which are mandatory elements of every miner's equipment, eliminates the possibility of forgetting about the identifier, losing it or dismantling by a staff member.

The PORTAS system uses active personal identifiers (UltraTAG-L transponders), which are incorporated in mining lamps. The UltraTAG-L identifier, after it has been incorporated in the lamp, is assigned to the lamp, thanks to which it clearly identifies the staff member who uses the lamp. The UltraTAG-L identifier structure enables its incorporation in most mining lamps available on the world's markets. The signal sent by personal identifier is received by radio nodes of the location gates provided on the edges of the defined zones. The task of the gate is to identify personnel passage from one zone to another. Location of the gates depends on the defined zone and is of crucial importance for the effective operation of the whole personnel location system. The radio nodes configuration depends on the type of underground junctions, where the location gates are provided, as well as on the precision of information to be generated.

For the PORTAS location system, the configuration in which data transmission system framework is based on fibre optic guides is recommended. In other areas, particularly in the mining zones, transmission is effected with the use of copper wire. In this way high throughput of the fibre optic bus is used, as well as the easiness to connect and service the copper lines.

The location gates combined in any configuration are connected to the system switchboard located on ground of the mine, which is integrated with the client's local network.

PORTAS is a safety system, so it must fulfil the requirements set out for increased reliability systems. For that purpose several technical measures have been applied. Active redundancy has been used for bus connections, which may be provided in parallel along two different bus lines at the same time: fibre optic guide and cooper wire. Simultaneously, the system has an incorporated QoS protocol enabling current monitoring of the correct operation of all of the system devices and transmission lines. In case of damage of one of the lines, the system – operating without downtime – informs about the damage to be repaired. For each system also the passive redundancy of back-up devices is determined, together with the procedures of their installation. PORTAS is also secured against power failure – the devices possess their own buffers sufficient for independent operation support of up to 12 hours. All of the electronic devices are intrinsically safe and are provided with reinforced casing owing to their use in the most difficult industrial conditions. The structure guarantees tightness to water and dust, as well as thermal, chemical and mechanical resistance.

6. SYSTEM FUNCTIONS

The basic function of the system is to count the number of persons in the defined zones. The system provides up-to-date information about the presence of people in each of the zones on a current basis. It is also possible to display history for the particular zone or a selected staff member. In case of failures, automatic counting is a function supporting supervision of evacuation. If the number of people in the zone exceeds the allowed limit, the system automatically

warns the staff member with the use of banners or signal informing about the ban to enter that zone.

Such information is also available in the dispatcher's room – as in the example shown in Fig. 2.

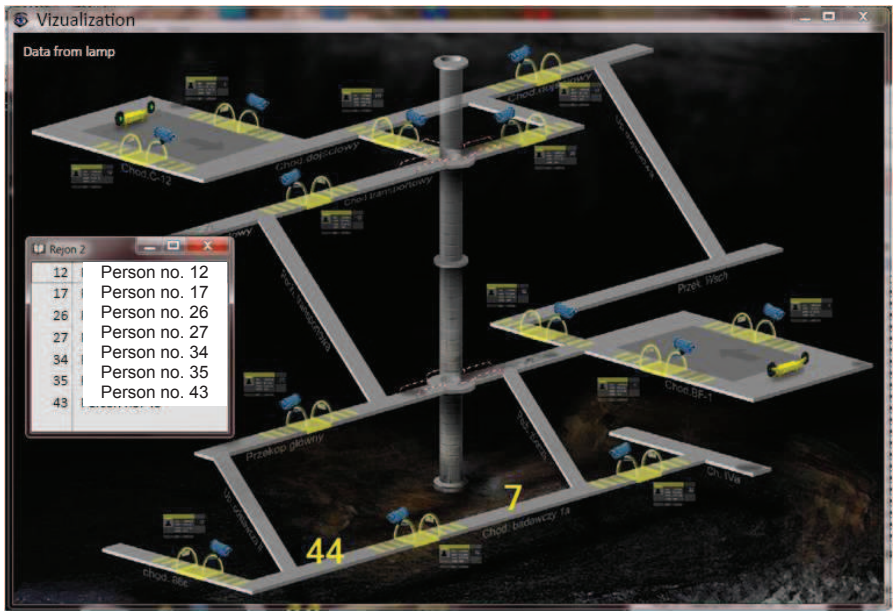

Fig. 2. Example of visualisation of staff location (proprietary material).

Another function is counting of the time of each person's stay in the given zone. If the time limit is exceeded, the dispatcher's system produces a warning, and if the staff member is within the reach of the signaller or banner, the warning is also displayed.

With the use of special lamps provided with a display, it is possible to transmit short text messages to the selected lamp. The lamp may also forward to an employee some specific information through a change of the light colour, blinking or going off of a specific LED. Confirmation of the message reading is effected through a button in the lamp. The system enables individual message sending to one staff member, a group of staff or generally staff in the specific zone.

UltraTAG identifiers are provided with the function of motion/standstill as well as location detection. In case of detecting standstill for a set out time (typically 20 s), the system generates a warning in the dispatcher's room. The standstill information may be correlated with the lamp location. The system may be programmed such that putting aside the lamp in a vertical position does not generate warning.

Each UltraTAG identifier has an incorporated detector of the field generated by the GLON transmitter. The measurement of the transmitter frequency is made with the accuracy of 1 Hz, thus, the frequencies of all of the GLON transmitters present in the zone are known. Thanks to that solution, GLON transmitter control takes place at the moment of entering the zone. If GLON transmitter irregular operation is detected, a warning for the staff member is generated at the entrance to the zone, and also in the dispatcher's room.

Providing lamps with UltraTAG identifiers enables at the same time the performance of supervision and support of the lamps supervision system in the lamp house. The system automatically counts the lamps present in charging units. In the case of some lamps also the charging process control is possible. Moreover, the system enables continuous control of the correct operation of GLON transmitters.

In the case of staff unconsciousness or identifier standstill it is possible to start searching with the use of a mobile multifunctional device. When searching for a missing person, particularly in difficult action conditions also such functions as signal strength measurement or light signalling are useful.

Moreover, the system enables remote granting of authorisation to switch on/off the equipment. The panel with a radio node provides information on who is present in the vicinity. If a person who has been granted authorisation by the dispatcher is in the close vicinity of the panel, blockades performed by the system sub-assemblies enable equipment control. The authorisations are granted by the dispatcher in the dispatcher's system on the ground. This limits the risk of incorrect starting up of equipment, particularly the transport lines.

PORTAS cooperates with the SAT system, whose signal phones may be provided with dedicated radio nodes. This enables interlocutor identification, as

well as automatic calling of a person searched for by the dispatcher (if the person is present near any of the signallers).

Another application of the system is cooperation with mobile methane concentration meters by SEVITEL. The records of the meters may be sent wireless within the radio reach of the system to the dispatcher's system. It is also possible to correlate the measurements with the places that are identified by radio markers. Such function enables supervision of the measurements made.

7. MATERIALS LOGISTICS IN THE PORTAS SYSTEM

The materials logistics system has been built based on the same infrastructure. The basic difference in operation is that the system registers materials movement. A mine is a company of complex logistics and supervision of the same is a required function. The materials logistics system enables the location of the registered materials, thanks to which a report for materials located in the specific zone may be printed. The system stores data regarding when, where and by whom the materials were dispatched or unloaded – the history of the route of the given material may be printed.

The logistics functions may also be performed in two manners. One of them is identification of vehicles (carriages, containers) and registration of materials loading and unloading. Another is identification of the very materials. Registration of loading and unloading takes place with the use of a computer station on the ground and underground at the dispatchers, as supported with the mobile TagScanner device.

8. SUMMARY

In the modern PORTAS system factors related to improvement of both staff safety and coal output effectiveness have been incorporated.

Important areas of monitoring performed by the PORTAS system are:

– supervision of staff exposure to risk resulting from the level of hazard present;
– limitation of the probability of risk through dispatcher's supervision of the local control of equipment and remote granting of authorisations;
– mitigation of the consequences of risk by automatic supervision of evacuation (including counting of the number of people in the hazard zone, people lead out of the hazard zone, as well as those who have already reached the ground level).

The PORTAS system also supports the complicated system of logistics by virtue of materials movement registration.

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