Utilisation safety of integrated control systems for longwall and road mining complexes.

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Abstract: Basing on the experience of the certification body in the field of evaluation of integrated control systems for longwall and road mining complexes, as part of the procedure for their authorisation for use in mines, in this article the applicable requirements for these systems have been reviewed (chapter 2), issues important from the safety point of view taken into account by the KOMAG Institute of Mining Technology Division of Attestation Tests Certifying Body in the process of their evaluation have been identified (chapter 3), and measures the fulfilment of which will increase the level of safety in the use of mining and longwall mining complexes in underground mining have been proposed (chapter 4). Issues addressed in this article bear importance for all underground mines, in which the deposit exploitation and excavation is performed using the longwall and road mining complexes.

1. Introduction

Resource extraction in coal mining is performed by longwall mining complexes. Drilling of corridor excavations, to enable exploitation of coal deposits, is done using road mining complexes. Both the aforementioned complexes should be understood as a set of machinery and equipment realizing it’s function and ensuring safety of the crew without negative impact on the environment.

The Act on the conformity assessment system [1] defines, among others, the principles of functioning of the system for assessing the conformity of products with the basic and detailed safety requirements. The conformity assessment system consists of regulations defining essential and specific requirements as well as regulations and standards defining activities of entities participating in the conformity assessment process. The conformity assessment process involves manufacturers, their authorised representatives, importers, distributors, certification bodies, inspection bodies and laboratories.

The European Union requirements for the harmonisation of the laws of the Member States relating to machinery intended for use in potentially explosive atmospheres are specified in Directive 2014/34/EU [2], Directive 2006/42/EC [3] and harmonised standards, e.g. PN-EN 60079-25:2011 [4], PN-EN 61508-1:2010 [5].

Division of Attestation Tests, Certifying Body has been involved with the issues of technical safety for several dozens of years, especially with regards to underground mining.

On the basis of many years of experience of the certification body this article points out issues whose inclusion in the design and assessment of integrated control systems for longwall and road mining complexes will contribute to increasing the level of safety.
2. Requirements

2.1 Definition of longwall and road mining complexes

The mining complex is understood as a set of machinery intended for mining and transportation of coal and securing crew and equipment.

The primary machinery and equipment of the mining complex are:
- powered roof supports control,
- mining machine (longwall shearer or coal plough),
- armoured face conveyor,
- beam stage loader,
- crusher built on a armoured face conveyer or/and beam stage loader,
- pumping unit,
- auxiliary equipment (air conditioners, belt tail pieces of the gate assembly),
- power supply equipment,
- interlock, signalling and loud-speaking communication system,
- security and alarm system equipment.

The primary machinery and equipment of the road mining complex are:
- roadheader,
- belt or chain feeder, installed directly behind the roadheader,
- belt conveyor,
- dust suppression system,
- interlock, signalling and loud-speaking communication system.

Machinery of the longwall and read mining complexes are linked structurally, forming an integrated system. Correct choice of machinery, equipment and systems in a complex (technical potential) is a key factor deciding about the efficiency and productivity of the wall or the efficiency of tunnelling the roadway. It also determines the safety related to utilisation of the longwall mining complex in underground mine workings, which is most important from the view point of market regulatory authorities in the area. Mining complex is built at the destination site – it cannot be tested and assessed before it is transported and assembled on a longwall face and galleries.

2.2 Formal requirements

Particular machines and pieces of equipment of the complex are foremost subject to a conformity assessment with regards to safety requirements specified in separate regulations and verification with regard to compliance with technical specifications required by the user. The assessment of the integrated control system is carried out on the assumption that the individual devices constituting the system meet the requirements for conformity assessment set out in separate regulations [6]. Additionally, with respect to longwall mining and road mining machines, operating in an integrated manner, an assessment of the control system is carried out, which cannot be performed by the manufacturers of individual products (without the knowledge of all machines, equipment and systems forming the mining complex). The assessment of relations between machines that are important for proper operation and safety is made on the basis of technical documentation (project assessment), in most cases developed by a system integrator, which is usually the supplier of power and control equipment acting on behalf of a user (mining plant) or the user himself. The purpose of such assessment, carried out by authorised certification bodies, is to determine whether the control systems of longwall and road mining complexes, when properly installed and used for their intended purpose, do not endanger the safety of people and the environment. On the basis of the results of research and assessment, as well as other formal and legal requirements specified in the regulations, the President of the Higher Mining Authority issues a decision on the approval of the product for use in mining plants [6].
2.3 Technical requirements

Integrated control systems of the longwall and road mining complexes should conform to technical requirements included in Appendix No. 2, „Technical requirements for products, the application of which in mining plants requires, due to the need to ensure safety of their use in conditions of hazards occurring in mining operations, the issuance of approval” to the Regulation of the Council of Ministers of 30 April 2004 on the approval of products for use in mining plants [7].

The following aspects are taken into account during the assessment of integrated control systems for longwall and road mining complexes:

- provision of information, mainly about:
  - correct operation and technical condition of machinery and equipment,
  - parameters of media influencing operation of machinery and equipment,
  - environmental threats,
  - stopping or blocking of a particular machine and emergency warning,

- ensuring safety in both remote and automatic control modes through:
  - turning on and off of particular machines without creating additional hazards,
  - warning of personnel in the hazardous area with a clear acoustic or optical signal or both,
  - enabling stopping the starting up or stopping and blocking of any piece of machinery,

- the construction of control circuits that:
  - provides protection against electric shock (voltage up to 25 V AC or 60 V DC, SELV or PELV circuits),
  - are resistant to damage which could lead to unintentional starting of the mining equipment or machinery and to blocking the possibility of shutting down the equipment or machinery by the direct control elements and elements controlling the working parameters
  - prevent uncontrolled switching on of the switch as a result of shock and mechanical vibration or stray current influence; in case of voltage decay and it’s subsequent return or upon the voltage rising to 1.5 times the nominal voltage
  - work properly when supplied with 0.85 to 1.2 nominal voltage
  - ensure disengagement and blocking of the disengagement state when the resistance of the external loop of the control circuit increases to 600 Ω, the isolation resistance between control wires or between any control wire and earth decreases to 2000 Ω (external circuits) or the resistance of the ground continuity control circuit increases above 100 Ω,

- the machinery stopping device also stops any machinery installed before and after the machinery if its continued operation would create a hazard.

3. Assessment criteria used by the Division of Attestation Tests, Certifying Body

When assessing integrated control systems for mining and face complexes intended for use in mining excavations in potentially explosive atmospheres, in addition to the criteria specified in applicable regulations and briefly discussed in Chapter 2, the Division of Attestation Tests, Certifying Body also performs an assessment of the system with regard to the following factors:

1. the conditions of use of the devices incorporated in the control system
2. selection of machinery and equipment taking into account the level of protection - Group I machinery of category M2 and certified electrical equipment of Group I of category M1 or Group I of category M2 should be used in mining plants
3. selection of electric cables - power supply cables should be chosen taking into account ensuring proper cooperation with the built-in protections in the power supply equipment (overcurrent protection, leakage protection, monitoring of earthing of mobile/replaced machinery)
4. choice of protections in power supply circuits - so that the applied protections work correctly in the system type IT (unearthed system) and protection against electric shock (Earthing system of protective conductors together with continuous monitoring of the insulation status), and so that they meet the requirements of mining standards,
5. compliance with the requirements of mining standards for individual machines (structural and functional requirements) - functions performed by the control system should comply with the functions required by industry standards (European or national)

6. ensuring intrinsically safe electrical system - all intrinsically safe circuits should be assessed in accordance with the requirements of the PN-EN 60079-25:2011 [4] standard. According to this standard, harmonised with Directive 2014/34/EU, intrinsic safety of the system should be presented in a document (document describing the system) in which all electrical equipment, its electrical parameters and the parameters of connecting cables should be specified.

4. Factors contributing to the increase in the level of safety

Many years of experience of the Division of Attestation Tests, Certifying Body, which assesses integrated control systems of longwall and road mining complexes, allow us to formulate problems, the solution of which will contribute to increasing the level of safety of their use.

1. Conformity with the electrical equipment provided by the manufacturer of the machinery. Scope of the designer's intervention in the integrated control system of the complex in the control system of a particular machine shall not affect its conformity with the original technical file compiled by the manufacturer. This is a necessary condition for keeping the EU declaration of conformity issued by the manufacturer of the machinery valid.

2. Taking into account the conditions of use of individual machines and equipment in the integrated system. This task is only possible if the type of each machine can be identified and its instructions are available. When designing a master system, all conditions, limitations or additional protective measures must be taken into account in order to adapt to the requirements of the machine manufacturer.

3. Powered roof supports control

Where powered roof supports are operated by hydraulic systems, manually operated roof supports are outside the scope of the integrated system. However, if an electro-hydraulic system is used, whether remotely controlled or in automatic mode, as is the case in a plough wall, then such a system is part of the integrated system and must be assessed in accordance with the applicable regulations.

4. Other equipment for longwall and road mining complexes.
The integrated control system should include all remote-controlled equipment whose operation is necessary to provide safe operation of the longwall and road mining complex. Additional devices should be assessed not only because of the control mode but also because of mechanical hazards (possibility of reducing the dimensions of the passageway for workers, impact on environmental conditions, etc.).

5. Equipment for control stations.
Each control station shall be equipped with emergency switch-off facilities by means of which it is possible to switch off the relevant machinery. The emergency shutdown function, as well as other safety functions, shall be performed with a PL performance level or SIL safety integrity level [5]. In particular, it is required that programmed functions are subject to detailed analysis from the functional safety point of view (due to the risk of failure to perform the initiated function).

6. Technological interlocks
Designing a system, it is easy to introduce technological interlocks, which make the work of a particular machine dependent on others who cooperate with it. An example is a
technological interlock which makes the operation of a chain scraper conveyor dependent on the operation of a conveyer of a haulage line receiving the excavation, or the operation of a chain scraper conveyor depends on the operation of a armoured face conveyer. Due to the lack of standard requirements, despite the fact that this dependence eliminates the risk of backfilling the receiving conveyer with excavated material, it is not commonly used. In the opinion of the certifying body, the integrated control system should implement all technological interlocks, even if they are not required by standards, and in special, clearly described situations, the operators should be able to deactivate them.

7. Use of control cables in intrinsically safe circuits.

The documentation describing the intrinsically safe system contains information about the type of control cables and their permissible capacitance and inductance. The user is responsible for checking whether the cables used in a particular control system meet the conditions specified by the designer. A great facilitation for users would be to specify in the documentation the maximum cable length for which the circuit is still intrinsically safe.

8. Control in automatic mode

Due to potential hazards, automatic mode control should be subject to detailed analysis. The operator should be warned about hazards in time and should have adequate means to stop the dangerous process. For example, the operator of a ladder working near the dump of a longwall conveyer should have at least access to information about the plough head approaching the dump. Despite the lack of such a requirement in mining standards and regulations, technical means implementing the above mentioned function are provided.

5. Summary

The article reviews the current requirements for integrated control systems for longwall and roadhead mining complexes. On the basis of many years of experience in conformity assessment, the Department of Attestation Testing has indicated the aspects the inclusion of which in the process of designing integrated control systems contributes to increasing the level of safety of use of the longwall and roadhead mining complexes. The proposals contained in this article should be taken into account by all entities participating in the process of conformity assessment of each individual mining machines and equipment and in the process of approval of the integrated control system for use in underground mines.

References

[1] Act of 30 August 2002 on the Conformity Assessment System (Journal of Laws of 2019, item 155)
[2] Directive 2014/34/EU of the European Parliament and of the Council of 26 February 2014 on the harmonisation of the laws of the Member States relating to equipment and protective systems intended for use in potentially explosive atmospheres (recast). OJ L 96, 29.3.2014
[3] Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast), OJ No L 157, 9 June 2006
[4] PN-EN 60079-25:2011 Explosive atmospheres — Part 25: Intrinsically safe electrical systems
[5] PN-EN 61508-1:2010 Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 1: General requirement
[6] Act of 9 June 2011 - Geological and Mining Law (Journal of Laws of 2019, item 868)
[7] Regulation of the Council of Ministers of 30 April 2004 on the approval of products for use in mining plants (Journal of Laws No. 99, item 1003, as amended)