

B-1500/Ex/AC-2m/s hoisting machine

**Innovative solution for use in underground excavations
in the methane and coal dust explosion hazard zones as well as in safe zones**

first use

deepening of shaft Leon IV KWK "Rydułtowy-Anna" coal mine

The dimensions of the machine result in the possibility of installation in underground workings, near the deepened shaft, segment-based design enables quick and easy underground transport.



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Objective of the project

The design of a multi-purpose, single-end hoisting machine used for shaft sinking, deepening, reinforcement and refitting as well as for repair and transport operations in vertical and sloped workings. The objective of the project was completed. Characteristic features and properties of the designed hoisting machine:

Modular design and small dimensions – enable quick machine assembly and dismantling, transporting in underground workings as well as the installation and operation of the machine even in limited spaces.

ATEX directive compliance – enables the operation of the machine in underground workings, rooms categorised as “a”,

“b” or “c” degree of methane explosion hazard as well as “A” or “B” class of coal dust explosion hazard as well as in non-hazard workings.

Investment effectiveness – in the case of shaft deepening, repairs or other non-standard works carried out from the nearest level, the costs are dramatically lower compared to carrying out these works from the surface. Furthermore, the possibility of reusing the hoisting machine in different locations, its modular design and small dimensions of individual components significantly reduce the costs of transportation and preparing the installation location.

first use

delivery and installation of the B-1500/Ex/AC-2m/s machine in KWK “Rydułtowy-Anna” coal mine

Surroundings

Shaft Leon IV of the KWK Rydułtowy-Anna hard coal mine is an intake shaft, with a strong air inflow into the mine (approx. 7-12m/s), carrying brine (salt from the rock mass), dust, etc. The conditions are very difficult.

Variable methane hazard is present in the shaft. All equipment must be compliant with both methane and coal dust explosion hazard operation conditions.

Due to the location – 1027 m underground, the transport, installation and assembly of all large machinery, such as hoisting machines, etc. need to be proceeded with respect to specific local conditions.

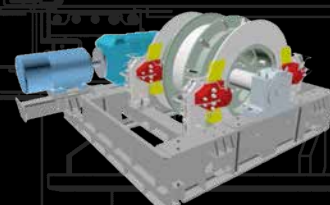
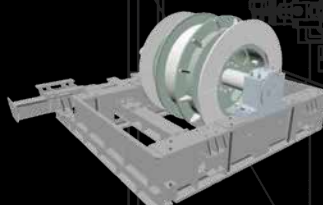
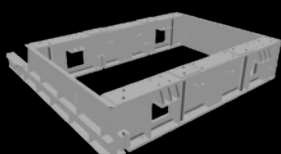
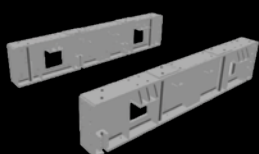
Scope of the project

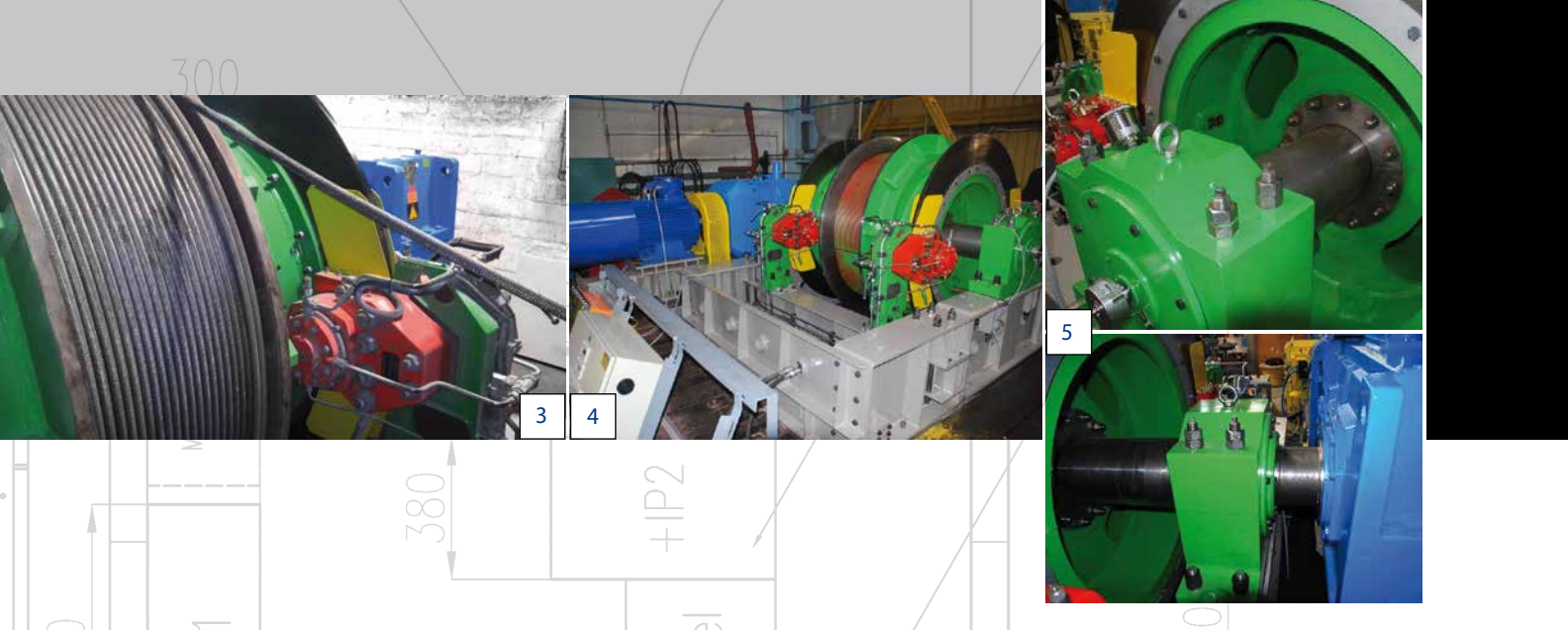
- designing a hoisting machine for sinking shaft Leon IV of the KWK Rydułtowy-Anna hard coal mine,
- development of a machine prototype,
- laboratory testing,
- installation of the prototype in natural conditions (mining plant),
- trial run of the machine.

phot. 1 [Transport roadway on level 1027 – hoisting machine installation location](#)

phot. 2 [Hoisting machine during assembly](#)

Modular design enables transporting the hoisting machine in underground workings and quick assembly





B-1500/Ex/AC-2 m/s hoisting machine

The B-1500/Ex/AC-2m/s hoisting machine was designed for installation in underground workings, including methane and coal dust explosion hazard zones. The dimensions of the machine were carefully selected to enable the transport of modules and components in underground workings and installation in the desired operation location, near the shaft.

The B-1500/Ex/AC-2m/s hoisting machine is used to drive single-end mine shaft hoists in major, minor shafts and sloped workings.

The B-1500/Ex/AC-2m/s hoisting machine was granted a permanent approval by the President of the Central Mining Authority on 18.12.2015.

The machine can be controlled manually from the control panel installed in the ergonomic cabin, protecting against noise and dust or can be controlled remotely from inspection and operation stations, in remote travel mode with smooth speed adjustment.

The main components of the mechanical part are:

- main shaft unit,
- drive unit with asynchronous motor and gear,
- hydraulically controlled brake.

The main components of the electrical part are:

- power supply and drive unit,
- control and adjustment system,
- safety system,
- visualisation and recording system.

The main shaft unit of the hoisting machine consists of a winding drum (hoist drum) with the diameter of 1500 mm mounted on a shaft supported by two rolling bearings: floating and retainer.

The drum has a Lebus type lining, guaranteeing (in case of multi-layer winding) the correct laying of rope on the drum and even pressure on the coat surface.

The winding drum is fitted with two side brake discs, interfacing with the braking system actuators.

phot. 3 Winding drum with one of the four braking actuators

phot. 4 Hoisting machine in the attestation plant

phot. 5 Main shaft

The drive unit of the machine consists of a gearbox mounted on the main shaft (ratio = 56) and a three-phase asynchronous motor (power = 132 kW). The motor is connected to the high-speed shaft of the gear via a flexible coupling.

The drive motor is powered and controlled via a frequency converter in an explosion-proof housing. Due to the implemented software, the set drive unit parameters can be maintained with stability. The application of this type of power supply does not negatively affect the power grid – adverse harmonic currents and voltages have been reduced to minimum.

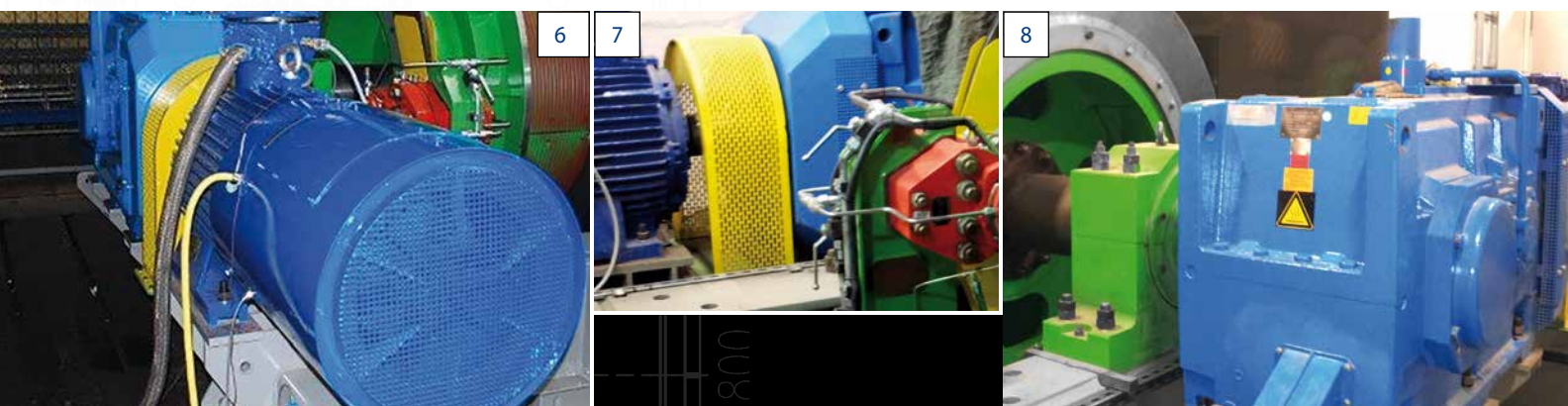
phot. 6 Driving motor – asynchronous

phot. 7 Flexible coupling

phot. 8 Gear

The braking system consists of:

- 4 braking props, each with 1 pair of brake actuators (BSFG 405), interfacing with two brake discs,
- hydraulic system for brake actuators and connecting system elements,
- electrohydraulic control and supply unit type H-C MWM-7Ex,
- emergency oil discharge device.

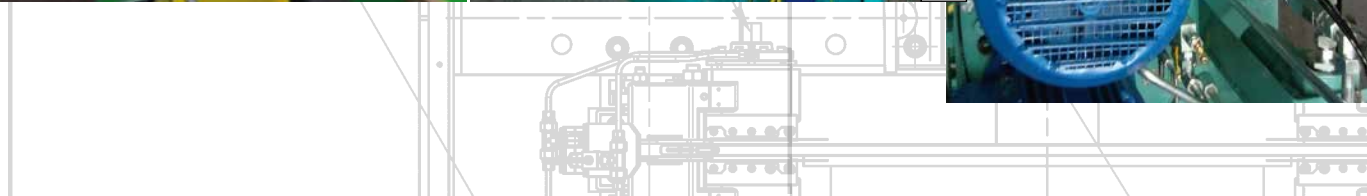
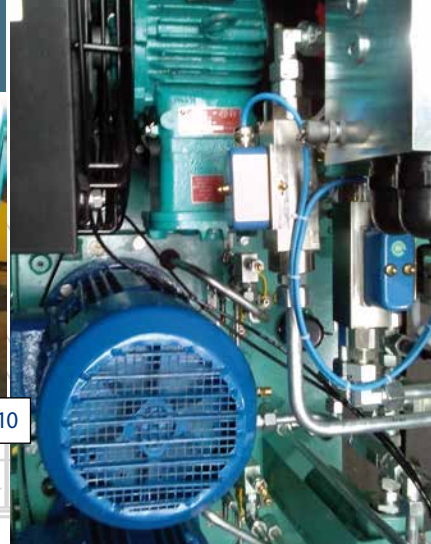




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The electrohydraulic brake control unit enables two types of braking by changing oil pressures:

- a) maneuvering braking – in manual control mode, carried out by the hoist operator by manipulating the controller lever (brake control):
 - to the pressure corresponding to full braking power if the hoist speed does not exceed 1 m/s,
 - to the residual pressure value, if the hoist speed exceeds 1 m/s,
- b) emergency braking – actuated automatically with a single braking moment value maintained for some time at residual pressure value, in order to slow the hoist down to below 1 m/s, at which point the pressure in the system drops – full braking power. The total braking moment provides the required static overweight holding reliability factor during the hoist standstill.

In addition, the braking system is fitted with ZWDSO-Ex – a device intended for the clearing of additional oil drain-path and reducing the pressure – resulting in the safe braking of the mine hoist. The device is actuated by the operator in emergency situations.

phot. 9 Braking actuators

phot. 10 Electrohydraulic control and power unit

The control, regulation and safety systems are based on a Flameproof Set of Programmable Controllers. They are based on the implemented digital travel controller GRZ-13-A (in the single-end hoist version). Its task is to calculate correctly the current position and speed of the conveyance and creating the diagram of travel in the function of the path, based on the calculation. The travel controller uses signals from two incremental encoders installed: one directly on the motor shaft, the other one on the main shaft, on the winding drum side. GRZ-13-A en-

ables the control of hoisting machine's travel diagram according to the requirements of the user, taking the character of the mine shaft hoist into account.

All the control and safety algorithms are implemented in two S7-300 PLC units using the TIA Portal software. One of the controllers (U100) is used as the primary controller and the other one (U200) is only responsible for monitoring the correct operation of the entire system. Both controllers implement the safety features collected in the circuits: safety, emergency drive stop, blocking, speed limit, signaling of emergency status and blockade bypass.

All the important functions describing the operating conditions of the hoisting machine / mine hoist are included in the screen visualisation system, based on a flameproof computer and a visualisation application by MWM Elektro Sp. z o.o. The application provides the user with full control of the operation of the hoisting machines, increasing the efficiency and safety of the operation of the mine hoist.

The hoisting machine and the connected shaft signaling system are compatible with the RG-3Ex recording device, used to record the signals of the mine shaft hoist, required and described by regulations as well as additional signals defined by the user. The user-friendly design of the RG-3Ex device as well as the intuitive working application enable quick and easy access to the data regarding the recorded statuses of the hoisting machine. Mine shaft hoist.

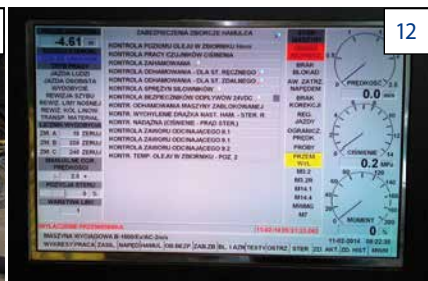
phot. 11 Operator's station (in the attestation plant)

phot. 12 Visualisation system screen

phot. 13 RG-3Ex digital recording device



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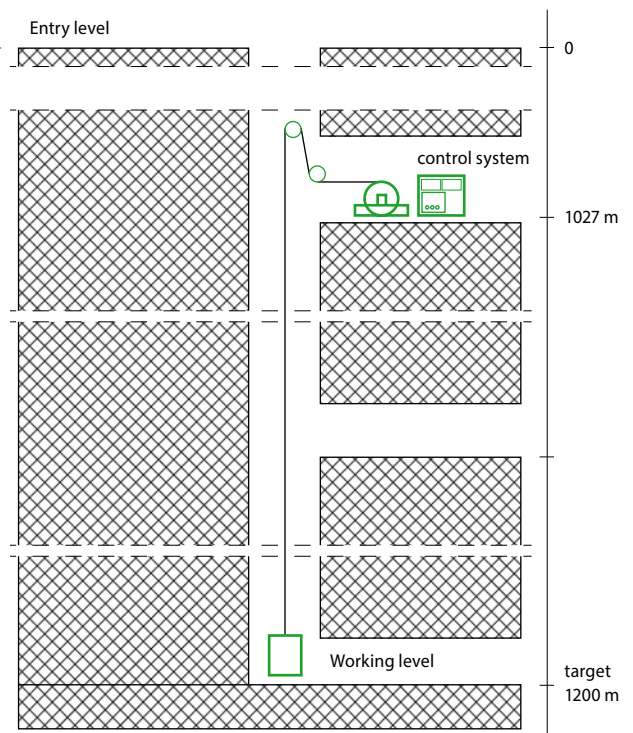


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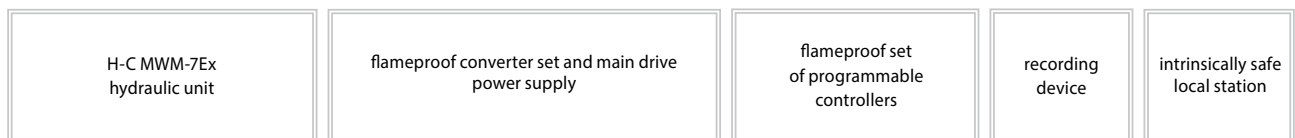
first use

Shaft Leon IV- KWK "Rydułtowy-Anna" coal mine

- Installation location - underground working on the depth of 1027 m in the area of the deepened intake shaft
- Environment - working ventilated with used air flow, with methane and coal dust explosion hazard
- Hoisting machine application - drive for the mine shaft hoist used to deepen and reinforce people transportation the shaft
- Mine hoist functions - people transportation, signaling operator transportation, shaft inspection, main rope inspection, sheave inspection, materials and output transport

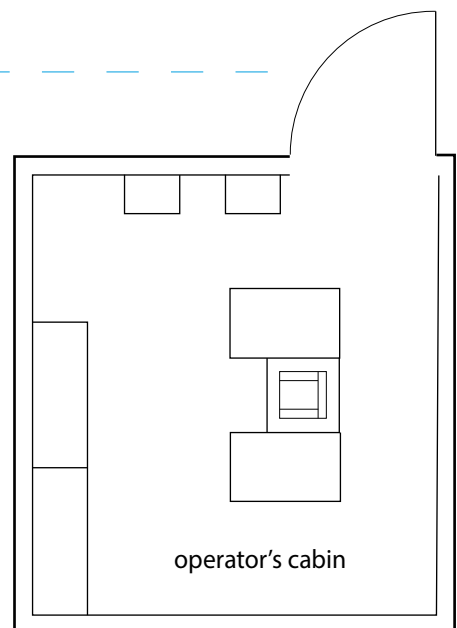
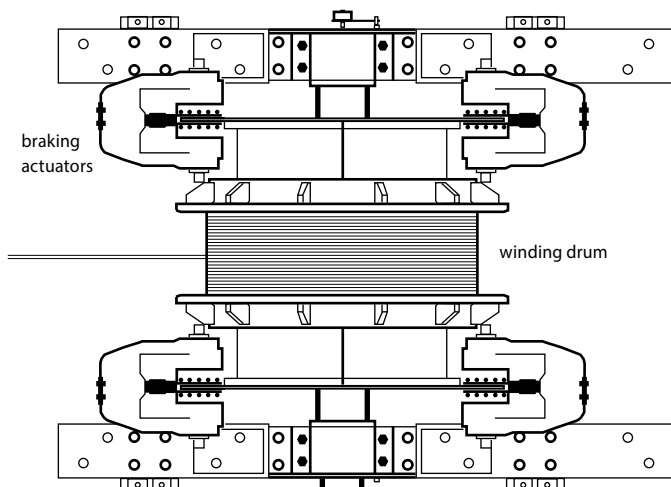


B-1500/Ex/AC-2m/s hoisting machine

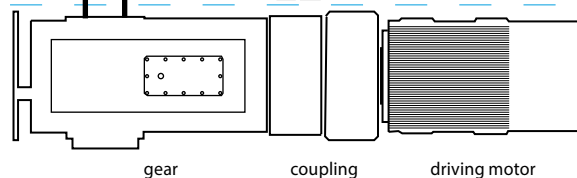


drive, control and safety system for the hoisting machine

main shaft and winding drum unit



drive unit



Technical specifications of the B-1500/Ex/AC-2m/s hoisting machine

machine type	B-1500/Ex/AC-2m/s	
machine location	on level	
control type	manual	
operation modes	people transportation signalling operator transportation shaft inspection bearing rope inspection pulleys inspection output haulage material transport	
travel speeds	2 m/s for haulage and materials transport, people transportation, signalling operator transportation 1 m/s for shaft inspection, limited speed travel travel without controller 0.5 m/s for materials transport on a hook	
acceleration/deceleration	working acceleration	0.4 m/s ²
	working deceleration	0.4 m/s ²
power supply	500 VAC	
drive	inverter drive	
rated motor specifications	type	dSg 315M4A
	rated power	P _n = 132 kW
	rated current	I _n = 178 A
	rated voltage	U _n = 500 V
	rotational speed	n _n = 1487 rpm
maximum static force in the wire rope	50 kN	
maximum lifting rope breaking force	440 kN	

Conclusion

The design and construction of a prototype of a modern hoisting machine intended for use in explosive atmospheres were a technical challenge. During the work on the project, a number of problems were encountered that do not occur while constructing hoisting machines for non-explosive atmospheres.

It was assumed that in terms of operation safety and reliability, the machine will be comparable to modern hoisting machines used on the surface of mining plants.

The issue of machine transport and installation in the limited space of underground mine workings was also taken into ac-

count. For this reason, the system was optimised in terms of modular construction, dimensions of individual components and continuous operation properties – designed for the machine surroundings temperature and air quality in the workings.

MWM Elektro Spółka z o.o. completed 100% of the defined objectives and assumptions. This resulted in the creation of a machine that is fully innovative, functional and, most of all, compliant with all safety requirements.



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