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# Advance rams of longwall powered roof supports – modernization

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Abstract:

Powered roof support consists of repeatable units of support, set to load in the rock mass between the roof and the floor. Their task is a correct protection of the working, of the machines/devices and workers. Its compact design, a big extent of the roof coverage and a unit control ensure a correct and economic operation of a longwall. A walkway in front of the legs ensures safety and a big comfort for the working crew.

Supports meet all the safety and ergonomics requirements according to the PN-EN 1804-1,2,3 Standards concerning safety and ergonomics of constructions. They meet basic safety requirements for machines and components according to the 98/37/EU Directive and basic requirements for devices and protective systems to be used in the spaces where an explosion hazard occurs according to the 94/9/EU Directive as devices of Group I, M2 Category. The main objective of this article is a presentation of a repair of a powered roof support subassembly such as an advance ram.

Keywords: powered roof support, advance ram, modernization, inspection

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## 1. Introduction

Powered roof supports are described as units of supports started hydraulicly or mechanically. They are set to load between the roof and the floor. They must meet safety and ergonomics requirements according to the PN-EN 1804-1:2004 [1] Standards, concerning safety and ergonomics of constructions. They meet safety requirements for machines and components according to the 98/37/EU Directive [2] as well as the requirements for devices and protective systems to be used in the spaces where an explosion hazard occurs according to the 94/9/EU Directive [3] as devices from Group I, M2 Category.

The present supports use hydraulic rams as executive elements and that is why in literature they are described as hydraulic advance supports. Support units are basic components of powered roof supports and they are described as assemblies of supports.

In a powered roof support unit, the following components can be distinguished:

- basic elements,
- elements of fittings,
- additional elements.

Basic elements include all the indispensable components which transmit forces and loads. The following ones can be numbered:

- legs,
- canopies,
- floor bars,
- gob side-shields,
- bush bars,
- connecting elements,
- side shields.

Elements of fittings consist of the components indispensable for a correct operation of supports but they do not transmit loads caused by the rock mass. They include:

- advance system,
- guidance and correction systems,
- control.

Whereas additional elements include those which are indispensable for a correct operation of supports such as:

- relief elements,
- spraying devices,
- lighting.

During an operational cycle, powered roof supports must execute some determined functions. They can be defined in the following way:

- initial setting to load – it is setting to load of support unit between the roof and the floor due to an extension of legs,
- setting to load – an extension of piston rods of legs and rams due to an increase of hydraulic pressure,
- drawing off – an insertion of piston rods of legs and rams due to an action of the hydraulic system,
- yielding – extension/insertion of piston rods of legs and rams due to an action of an external force (e.g. an impact of rock mass),
- advance increment – translational motion of support in the result of advancing front of operations,
- advance – advancing of the conveyer or of the advance beam (following the extraction front) [4, 5].

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## 2. Materials and methods

### 2.1. Advance rams

The main task of advance rams consists in advancing powered roof support units to the wall and that is why they are also called rams of advance increments. They must generate the force needed for conquering frictional resistances between the supports (units) and the floor. While determining the force of advance increment the value of frictional resistances, resulting from an incomplete unloading of the unit from the roof pressure, should be taken into account. Jamming of rear parts of canopies and gob shields from the gob rocks should also be taken into consideration.

In the case of support units of single increment, the task of advance rams consists in advancing the conveyor towards the wall. However, in the case of exploitation with use of a plow, the task of advance rams is a generation of the appropriate force to press the plow head against the wall.

The value of the force which must be generated by advance rams results from:

- the weight,
- the conveyor stiffness,
- the devices connected with it,
- the local operational conditions (strength, shape of the floor),
- the size of the run-of-mine rubble in the panel,
- the pressure forces required for the cutting process.

The forces needed for a conveyor advance are in the range of 20-150 kN, whereas the pressure in advance rams can reach the value of 320 bar.

The rams used in advance rams are mainly made as rams of double action. They can also be made as:

- differential rams with a unilateral piston rod,
- differential rams with a unilateral dragged piston rod,
- rams of uniform motion with a bi-lateral piston rod [4, 5].

### 2.2. Types of advance increments

To execute a translational motion of a powered roof support unit (advance increment) advance rams are used. Three basic principles of advance increments are known:

- simple,
- coupled,
- follow-up.

In the case of a simple advance increment (Fig. 1), individual units of powered roof support, without any interconnections, are pushed to the armoured face conveyor or to the advance beam.

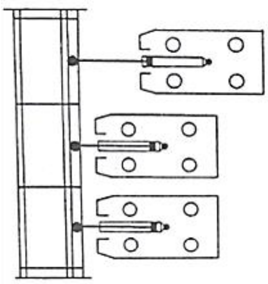

**Fig. 1.** Simple advance increment
Source: [4]

After having advanced the conveyor (or the advance beam) support units are advanced individually one by one. In this motion, the main spot of resistance is the conveyor supported by the units set to load. In the coupled advance increment, two or three frames situated next to one another are interconnected with hydraulic mechanisms of advance increments (Fig. 2).

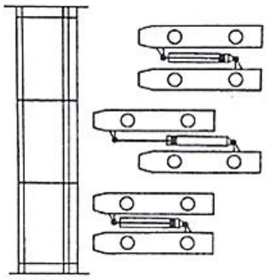

**Fig. 2.** Coupled advance increment
Source: [4]

Such advance increment units composed of two or three frames are called couplers. In practice two – or three-frame couplers are known.

The follow-up advance increment – the following individual units are positioned in series and they are mutually connected by mechanisms of advance increment.

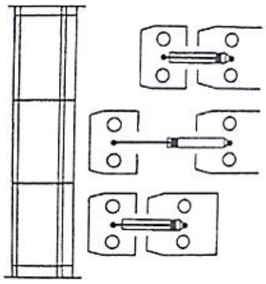

**Fig. 3.** Follow-up advance increment
Source: [4]

During an advance, each time one unit is lowered, whereas all the other ones are set to load. In this system the advancing unit is called a follow-up support. From the principles of advancing, described above, a simple advance increment has a dominating position. An advantage of this method is an individual mechanism of advance, at a simultaneous maintaince of distances of support units from each other. This type of advancing is simple and its resistance is significantly smaller than in the case of coupled advance increment. The support units maintain the direction of advance and the distance automaticly, when they are attached to the conveyor or to the advance beam.

Pulling of the support unit during a follow-up advance uncovers the roof between the front and the rear canopy. A roof fall can occur through such a gap. When the advance ram is not attached to the conveyor, a follow-up advance increment causes problems with maintaining the advance direction and the distance between support units.

Taking into consideration the time sequence of the conveyor transfer and of the advance increment, an operation of powered roof supports can be performed as:

1. advance increment forward,
2. advance increment backwards.

An operation of powered roof support with advance increment forward is understood as a course of the process in the longwall: cutting, conveyor transfer – support advance (Fig. 4).

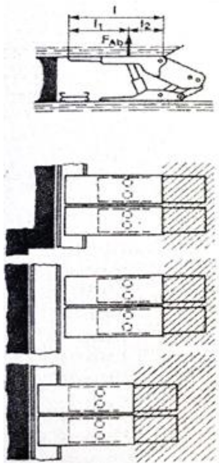

**Fig. 4.** System – with advance increment forward
Source: [4]

However, an operation of powered roof supports with advance increment backwards is a course of the process: cutting – pulling of supports – conveyor transfer (Fig. 5).

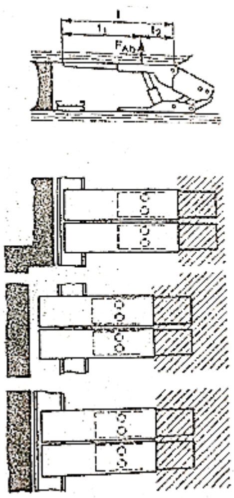

**Fig. 5.** System – with advance increment – backwards. Source: [4]

The time sequence of the conveyor transfer and of the supports advance has an essential impact on a unit design.

During an operation with an advance increment backwards, at the beginning of the cutting process, the support is one increment in the rear. This situation reflects a longer canopy extended towards the wall than in the case of the supports operated with advance increment forward. It is a disadvantage as regards a contact of the canopy with the roof. However, its advantage consists in a possibility of delaying an installation. In turn, an operation with advance increment forward is appropriate for the contact of canopies with the roof but inappropriate due to slowing down an installation.

Disadvantages of the aforementioned operational cycles are "softened" by proper design of support. For supports operated with the advance increment backwards, a better contact of canopies is obtained due to an application of articulated canopies (deflected canopies). However, for supports operated with the advance increment forward, a delay in installation is reduced due to an application of extended canopies. At present it lacks comparative data in the scope of roof control for these two modes of operation.

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In the hard coal mining industry powered roof supports, operated with an advance increment backwards and with deflecting – extendable canopies, are in majority. Their advantages are:

- small lengths of elements – in particular essential for the transportation process,
- short delays in setting to load of supports,
- a good contact of the canopies system with the roof,
- a good roof control.

## 3. Results

### 3.1. Modernization of advance rams

An inseparable stage of extending life of mining support is its repair. After having finished a longwall extraction all the elements of supports are subject to profound inspection to indicate potential damages and then to implement repair processes adequate to damages. The main purpose of these processes consists in restoring initial technical parameters of individual elements of support unit making them useful again. There is special computer software, aiding repair processes. The software is helpful in indicating spots which require reinforcements or in particular cases a reconstruction [5, 6, 7].

A modernization of advance rams of the TAGOR-22/46-POz powered roof supports has been conducted in accordance with the scope of work required by the orderer.

A modernization of the G-2607.01.08.01.R1 (Fig. 6) advance system beam and of the G-2607.01.08.10.R2 (Fig. 7) bush bar has been conducted.

**Fig. 6.** Advance system beam before repair

**Fig.7.** Bush bars of advance system beam

### 3.2. Modernization of the advance system beam

Modernization of the G-2607.01.08.01.R1 advance system beam consisted in:

1. Pad welding of worn-out surface with SG3 wire (Item **6**),
2. An exchange of elements for new ones (Items **10**, **16**, **17**),
3. Welding in an additional holder to the beam of 3-ton load capacity,
4. Regeneration of holes $\phi$ 62 – 2 items through pad welding and boring,
5. Pad welding and grinding of the socket insert to the basic size (Item **1** and **2**),
6. Marking according to operational manual,
7. Painting of one layer.

The advance system beam is presented in Fig. 8 where all the mentioned/repaired elements, in the drawing are marked in red. A system of forces, acting on the advance system beam during the conveyor transfer causes lifting of the beam rear part, the one among bases. Therefore, on the side walls of advance rams short guides are welded to limit this motion. However, the width of guides cannot be too big due to a necessity of installing an advance ram inside the beam. That is why additional plates are welded to the beam side walls. The main task of guides is an elimination of possibility of the beam extension above the guides (at one of bases).

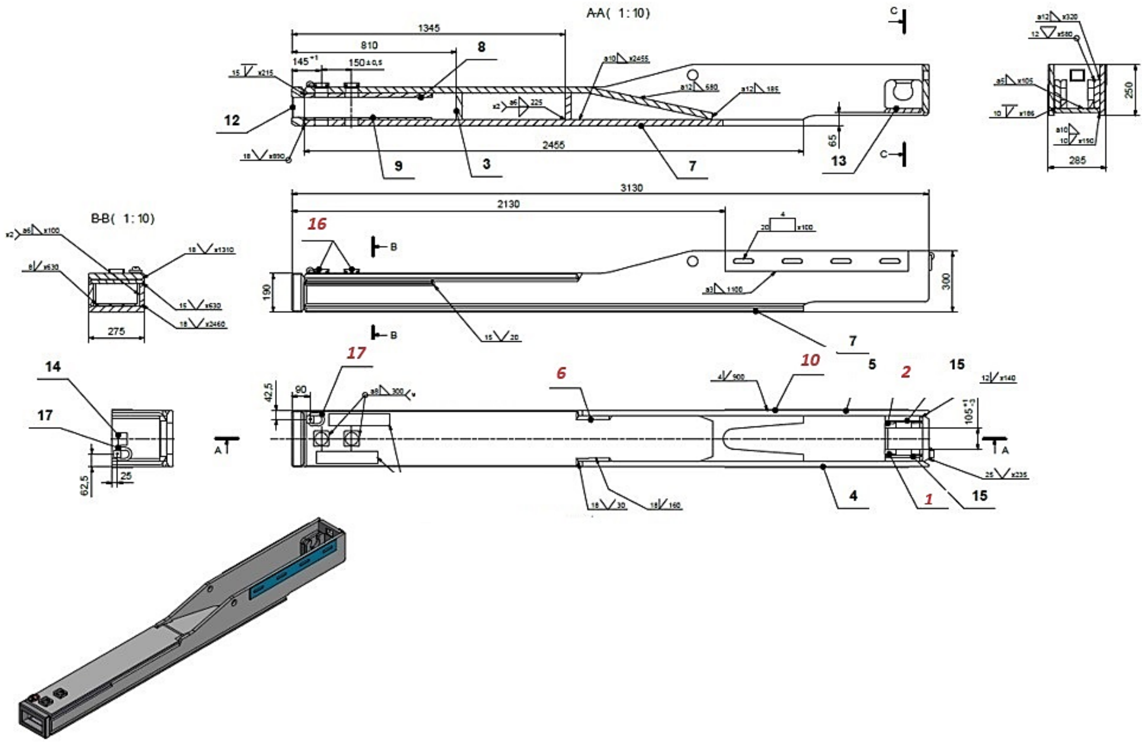


**Fig. 8.** Beam of the advance system

### 3.3. Modernization of the bush bar

Extended beams of the advance ram (bush bar) are used when due to lowering the front part of canopy at the longwall face there is a hazard of collision with the cutting drum. Then the beam is extended with pins inserted into the following holes and the support unit can stay in the rear. A modernization of the G-2607.01.08.10.R2 bush bar consisted in:

1. Straightening (Items **3** and **5**),
2. Regeneration of holes (in Items **3** and **5**) by pad welding and boring,
3. Holes from Items **3** and **5** – which preserved round shape – only cleaning,
4. Marking according to operational manual,
5. Painting of one layer.

The scope of modernization of the bush bar is presented in Fig. 9, where all the repaired/mentioned items are marked in the drawing with red.

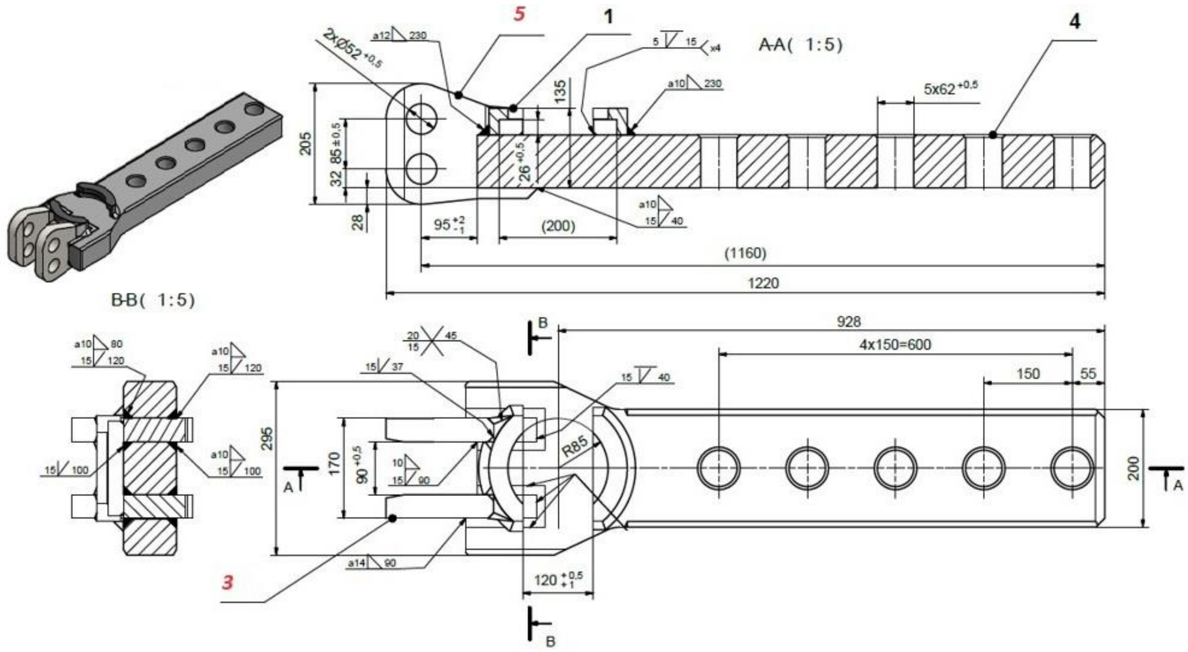


**Fig. 9.** Bush bar

## 4. Technical inspection of the repair process

The welding process of individual elements of the advance system beam was performed exactly according to the general and detailed Welding Technological Cards (Plans of Welding) and Technological Manuals of Welding, observing precisely welding parameters included in them [8]. The SG3 wire was used for welding.

A type of the bush bar, grade of basic material, method and position of welding, parameters of welding and type of additional materials – electrode wire and shielding gas were specified in the mannual. The technological process required to preheat the material initially to the temperature of 120°C. A check up of temperature took place about every 30 minutes with use of a pyrometer. Full penetration welds were made – all the welds were tested (UT). The holes, which required pad welding, were pad welded with the SG3 wire (Conformity Certificate, Fig. 10), with initial preheating to120°C.

| **Material** | **Diameter** | **Type of spool** | **No. of melt** | **Amount [kg]** | **Date** |
|---|---|---|---|---|---|
| SG3 | 1.2 | K300 | 5430492 | 15 | 13.02.2024 |

**Chemical construction:**

| **Melt** | **C** | **Mn** | **Si** | **P** | **S** | **Cr** | **Ni** | **Cu** | **Mo** | **V** | **Al** | **Ti+Zr** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Requirements acc. to PN-EN ISO 14341 – A Standard | 0.06-0.14 | 1.60-1.90 | 0.80-1.20 | max 0.025 | max 0.025 | max 0.15 | max 0.15 | max 0.35 | max 0.15 | max 0.03 | max 0.02 | max 0.15 |
| 5430492 | 0.08 | 1.68 | 0.96 | 0.010 | 0.010 | 0.020 | 0.02 | 0.21 | 0.013 | 0.013 | 0.009 | 0.09 |

**Mechanical properties of binder:**

| **Classification/melt** | **Re [MPa]** | **Rm [MPa]** | **A5 %** | **Operation of breaking KV[J] temp.-40°** | **GAS** |
|---|---|---|---|---|---|
| Requirements acc. to PN-EN ISO 14341 – A Standard | min 420 | 500-640 | min 22 | min 47 | |
| 5430492 | 458 | 545 | 27 | 101 | C1 |
| 5430492 | 476 | 545 | 28 | 101 | M21 |

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**Fig. 10.** Conformity Certificate - SG3 welding wire

An inspection of welds was performed based on the card of welds inspection. The welds were checked according to the requirements of PN-EN ISO 17635:2017-02 Standard [9] and kinds of non-destructive tests PN-EN ISO 17635:2010 Standard [10]. All the welds were tested visually in 100% (VT). The welds which should be tested with use of other methods are determined in the card of the welds inspection.

Before the final operation of painting the beam of advance system and bush bar were subject to final inspection. The inspection consisted in checking a correctness of repaired elements according to the delivered documentation.

The diamensions of diameters and spacing of holes as well as checking a functionality of connection of the advance system beam with the bush bar were carried out with use of gauges and control templets.


**Fig. 11.** Beam of advance system and bush bar after repair

Results of measurements were inscribed in the measurement card and stored in archives. Ready, repaired elements of powered roof support are presented in Fig. 11.

## 5. Conclusions

Powered roof supports, as basic elements of a longwall system, decide about safety of people and machines working in a longwall face. Longwall powered roof supports, qualified as devices of increased hazard risk, require a special approach before their implementation into operation.

The second essential factor concerns functional requirements determined by users of powered roof supports. A necessity of meeting the requirements in this scope has stimulated a development of design form of individual assemblies of a powered roof support unit. This requirement has led to changes in a design form of advance rams of a powered roof support unit. A design change of advance rams has been caused by inconformity of the support unit increment with a web depth of a shearer. In the result of such changes bush bars have appeared.

Due to a collaboration of different types of powered roof supports in one longwall some changes in the design form of advance system beams have been introduced. A change in the length of the advance

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system (in the result of applying additional bush bars), enables a correction of the width of the face roof path. However, this solution has generated big costs and that is why bush bars have been applied.

Assemblies of intermediate bush bars, facilitating both a change in the length of the advance system beam and a proper connection of the support unit with the armoured face conveyor pan, appeared.

One of available methods is a connection of the advance system beam with the armoured face conveyor pan with use of a vertical pin. Such bush bars have been subject to a repair process.

An application of bush bars enables an improvement of collaboration of different types of powered roof support units in one longwall and a collaboration with a given type of an armoured face conveyor.

Intermediate bush bars are commonly used and they constitute an element of a powered roof support unit. An application of a given support unit in the following longwall (connected with a change of configuration of its equipment), causes a necessity of using intermediate bush bars. Their length and form is usually selected individually.

An application of an adjustable beam length of the advance system is also an essential fact as in practice it eliminates a necessity of correcting the shape of the gob side shields to seal the support units from the gob side.

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