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NEW SOLUTIONS OF DIESEL MINE TRANSPORTATION MACHINES

NOVA REŠENJA ZA DIZEL MAŠINE ZA RUDNIČKI TRANSPORT

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Abstract: *Economic and social conditions force mine managements to reduce production costs as much as possible and to increase work safety. Significant potential is still in effective development of safe transportation systems. In the result of collaboration of KOMAG with producers of transportation machines, series of new innovative solutions, which enable the users to make rational choice, according to technical and economical conditions, have been developed.*

Key words: *Mine, Transport, Machines.*

Apstrakt: *Ekonomski i socijalni uslovi primoraju uprave rudnika da smanje troškove proizvodnje što je više moguće i da poboljšaju bezbednost na radu. Ipak značajan potencijal i dalje leži u efikasnom razvoju bezbednih sistema transporta. Kao rezultat saradnje KOMAG-a i proizvođača transportnih mašina, izrađen je niz novih inovativnih rešenja, koja omogućuju korisnicima da izvrše racionalan izbor, u skladu sa tehničkim i ekonomskim uslovima.*

Ključne reči: *Rudnici, transport, mašine.*

1 INTRODUCTION

Use of better and better transportation systems of new generation, which are adapted for transportation of machines, equipment and their components of heavy weight, as well as use of the same transportation means for transport of miners enable to increase production effectiveness of mining plants. Effective work time of teams employed in the faces, as well as of machines and equipment, which are periodically relocated due to an advancement of mining front, increases.

Transportation machines with diesel drive, due to their advantages, are of broader use in underground hard coal mines. Beside economical factors, improvement of work safety conditions, mainly by elimination of open

1. UVOD

Upotreba sve boljih transportnih sistema nove generacije, koji su prilagođeni za transport mašina, opreme i njihovih komponenata velike težine, kao i upotreba istih prevoznih sredstava za transport rudara omogućuju da se poveća proizvodna efikasnost rudarskih postrojenja. Povećava se efektivno vreme rada timova u otkopnim čelima, kao i mašina i opreme, koji se povremeno premeštaju zbog napredovanja u otkopavanju.

Mašine za transport na dizel pogon, zbog svojih prednosti, u široj su upotrebi u rudnicima kamenog uglja sa podzemnom eksploatacijom. Pored ekonomskih faktora, poboljšanje bezbednosnih uslova rada, uglavnom putem

rope used as the transportation system, as well as a possibility of direct observation of both the track and transported equipment, are significant advantages of these mobile machines. Implementation in hard coal mines of suspended monorails with diesel drive (more than 100 diesel locomotives) and recently floor-mounted railways with diesel drive as well as diesel locomotives for underground mine railway, in the last dozen or so years, reflects these trends.

Considering the users' expectations, new transportation machines have been developed and implemented in the result of collaboration between KOMAG's specialists and industrial partners.

In the result of collaboration, which started in 1994, between PIOMA Mining Machinery Factory, JSC in Piotrków Trybunalski and KOMAG Mining Mechanization Centre, the factory offers the mining industry suspended monorails with diesel drive. Modular design of the locomotive in the suspended monorail (Fig. 1) enables to apply a diesel-and-hydraulic unit of this monorail in other technical solutions.

Series of new solutions in transportation machines, developed by the RYFAMA Machine Factory in Rybnik, JSC, VACAT Ltd. and ENERGOMECHANIK Ltd. were also realized in the last years.

Several most important technical solutions of floor-mounted railway and underground locomotives are discussed in the paper.

2 FLOOR-MOUNTED RAILWAYS WITH DIESEL DRIVE

2.1 PIOMA-VACAT diesel floor-mounted railway

The PIOMA-VACAT diesel floor-mounted railway (Fig. 2) is a result of collaboration between KOMAG Mining Mechanization Centre, PIOMA Mining Machinery Factory, JSC and VACAT Ltd. from Rybnik. It is designed for transportation of heavy loads on routes inclined up to 30°. It operates on channel track, which is similar to the track of floor-mounted railway with a rope drive, but there is a vertical frictional bar installed along the track axis. When bigger

uklanjanja nezaštićenog užeta koje se upotrebljavalo u transportnom sistemu, kao i mogućnost direktnog posmatranja kako pruge tako i opreme koja se transportuje, predstavljaju značajne prednosti ovih pokretnih mašina. Primena viseće jednošinske jamske železnice sa pogonom na dizel (više od 100 dizel lokomotiva) i novijih vozova ugrađenih na podini sa pogonom na dizel kao i dizel lokomotive za podzemnu jamsku železnicu, u poslednjih 10tak i više godina, odražava ove trendove.

Imajući u vidu očekivanja korisnika, izrađene su i upotrebljene nove transportne mašine nastale kao rezultat saradnje između eksperata KOMAG-a i industrijskih partnera.

Kao rezultat saradnje, koja je započela 1994. godine, između Fabrike rudarskih mašina PIOMA, JSC-a u Pjotrkovu Tribunalskom i Centra za rudarsku mehanizaciju KOMAG, fabrika je dala rudarskoj industriji viseće jednošinske vozove sa pogonom na dizel. Modularni dizajn lokomotive kod visećih jednošinskih vozova (slika 1) omogućava primenu dizel-hidrauličkog uređaja ovih vozova u drugim tehničkim rešenjima.

Takođe je poslednih godina realizovan niz savremenih rešenja u oblasti transportnih mašina, koje su izradile kompanije RYFAMA, Fabrika mašina u Ribniku, JSC, VACAT Ltd. i ENERGOMECHANIK Ltd.

U ovom Radu je razmotreno nekoliko najvažnijih tehničkih rešenja za vozove ugrađene na podini i podzemne lokomotive.

2 VOZOVI UGRAĐENI NA PODINI SA POGONOM NA DIZEL

2.1 Dizel vozovi ugrađeni na podini PIOMA-VACAT

Dizel vozovi ugrađeni na podini PIOMA-VACAT (slika 2) su rezultat saradnje između Centra za rudarsku mehanizaciju KOMAG, Fabrike rudarske mehanizacije PIOMA, JSC-a i VACAT-a Ltd. iz Ribnika. Namenjeni su za prevoz velikog tereta na trasama sa nagibom do 30°. Rade na koritastoj pruzi koja je slična kao pruga za železnicu ugrađenu na podini sa užetnim pogonom, ali tu je i vertikalna frikciona prečaga postavljena duž ose pruge.

inclinations up to 30° occur, a double rack bar with horizontal teeth is used. Depending on requirements and conditions in workings, a frictional coupling or a rack coupling between driving wheels and driving bar installed between the rails can be used.

Kada se dogodi da ima većih nagiba od 30°, koristi se dvostruka zupčasta poluga horizontalnim zupcima. Zavisno od zahteva i uslova u jami, može se koristiti frikciona spojnica ili zupčasta spojnica između pogonskih točkova i pogonske poluge postavljenih između šina.

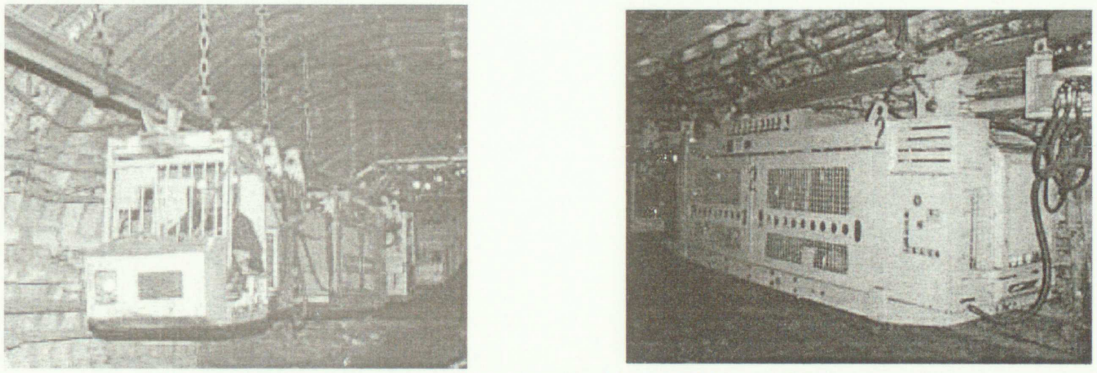

Figure 1 Diesel suspended monorail with PIOMA CS 80 locomotive
slika 1 Dizel viseća železnica sa lokomotivom PIOMA CS 80

Transportation possibilities of using frictional transmission of drive, known from a suspended monorail design, are sufficient for routes of inclination up to 20° and when there is no water in the working. Extension of frictional system by a rack drive enables to travel on locally wet transportation sections and on inclinations up to 30°. Type of the drive, used in a given moment, depends only on the type of rails put in a given section. Switching from one drive to the other is smooth, without stopping the rack-and-pinion locomotive.

Transportne mogućnosti u korišćenju frikcionog prenosa pogona, koji je poznat preko dizajna viseće železnice, dovoljne su za trase sa nagibom do 20° i kada nema vode u jami. Proširenje frikcionog sistema putem zupčastog pogona omogućava vožnju po lokalno vlažnim transportnim deonicama i pri nagibima do 30°. Vrsta pogona koji se koristi u određenom trenutku zavisi samo od vrste šina na datoj deonici. Prebacivanje sa jednog na drugi pogon je lako, bez zaustavljanja lokomotive na polužno-zupčasti pogon.

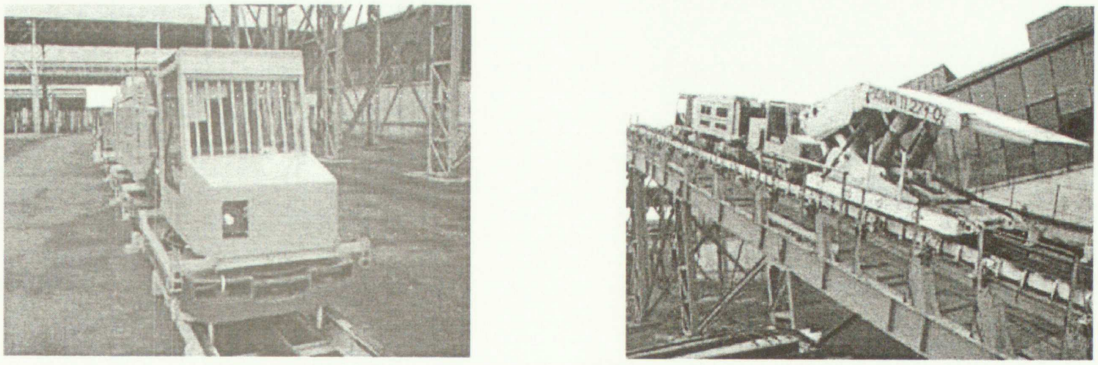

Figure 2 PIOMA-VACAT diesel floor-mounted railway
slika 2. Dizel železnica ugrađena na podinu PIOMA-VACAT

Actuating driving system consists of four repeatable driving modules-cars (Fig. 3), where the cabins and diesel-and-hydraulic units are installed. Articulated joints couple the modules with each other, and each joint is secured by two safety ropes. Each module has a driving system consisting of two hydraulic engines, which drive the frictional wheels and rack wheels as well as a shoe brake system, which

Izvršni pogonski sistem sastoji se od četiri pogonska modula-vagona koji se ponavljaju (slika 3), gde su postavljene kabine i dizel-hidraulične jedinice. Zglobni spojevi spajaju module jedan sa drugim, i svaki spoj je obezbeđen putem dva sigurnosna užeta. Svaki modul ima pogonski sistem koji se sastoji iz dva hidraulična motora, koji pokreće frikcione točkove i zupčaste točkove

uses a frictional bar located centrally between the rails. Due to the use of four driving modules (in spite of solutions of floor-mounted railways offered in the market so far), total pulling force of rack-and-pinion locomotive is always transmitted to more than two track segments, what significantly reduces the load of each track segment, especially its bolting components and driving bar. Double-sided rack of 50 mm pitch has smaller teeth and is made of metal sheet of 15-mm thickness. Also the force generated by the brakes is distributed on several track segments, therefore, practically there is no risk of tearing the track segment out of bolting during emergency braking at transportation of heavy weight.

WESOŁA Colliery is the first user of the PIOMA-VACAT diesel floor-mounted locomotive.

kao i nožni kočioni sistem, koji koristi frikcionu prečagu smeštenu u sredini između šina. Zbog upotrebe četiri pogonska modula (uprkos rešenjima za železnicu ugrađenu na podini koje se do sada nudilo na tržištu), ukupna vučna snaga lokomotive na polužno-zupčasti pogon se uvek prenosi na više od dva segmenta pruge, naročito njene zaptivne komponente i pogonska poluga. Dvostrana zupčasta poluga sa navojem od 50 mm ima manje zupce i napravljena je od lima debljine 15 mm. Takođe, snaga koju stvaraju kočnice se raspoređuje na nekoliko segmenata pruge, pa stoga skoro da nema rizika od habanja segmenta pruge kod zaptivnih delova prilikom naglog kočenja pri transportu velikog tereta.

Rudnik uglja WESOŁA je prvi upotrebio dizel lokomotivu ugrađenu na podini PIOMA-VACAT.

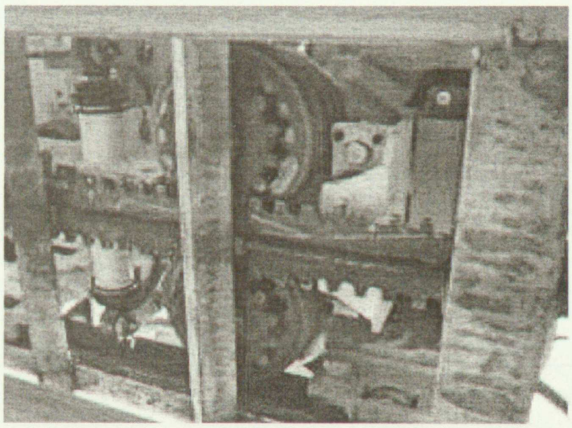

Figure 3 Bottom view of operating single module drive
Slika 3 Pogled odozdo na radni pogon sa jednim modulom

Main technical data of PIOMA-VACAT rack-and-pinion locomotive

Table 1

Name of machine	PIOMA-VACAT
Power of diesel engine	81 kW
Pulling force of frictional driving system	80 kN
Pulling force of rack driving system	90 kN
Speed (maximal) for frictional system	2 m/s
Speed (maximal) for rack system	1.6 m/s
Maximal track inclination for frictional system	±20°
Maximal track inclination for rack system	±30°
Type of track	channel-shaped, floor-mounted
Distance between track channel bars	900 mm
Horizontal turn radius	4 m
Vertical turn radius	10 m
Machine length /width/height	8.84/1.18/1.65 m
Unit weight	10 t

Glavne tehničke osobine lokomotive na polužno-zupčasti pogon PIOMA-VACAT

Tabela 1

Ime mašine	PIOMA-VACAT
Snaga dizel motora	81 kW
Vučna sila frikcionog pogonskog sistema	80 kN
Vučna snaga zupčastog pogonskog sistema	90 kN
Brzina (maksimalna) za frikcioni sistem	2 m/s
Brzina (maksimalna) za zupčasti sistem	1.6 m/s
Maksimalni nagib pruge za frikcioni sistem	±20°
Maksimalni nagib pruge za zupčasti sistem	±30°
Vrsta pruge	Koritastog oblika, ugrađena na podini
Razdaljina između koritastih pragova pruge	900 mm
Poluprečnik horizontalnog zaokretanja	4 m
Poluprečnik vertikalnog zaokretanja	10 m
Dužina/širina/visina mašine	8.84/1.18/1.65 m
Širina jedinice (uređaja)	10 t

2.2 SKZ-81 floor-mounted railway system with a dual driving unit

New solution of SKZ-81 diesel railway system, operating at the BIELSZOWICE Colliery (Fig. 4), has been developed in the result of collaboration between KOMAG Mining Mechanization Centre and RYFAMA Machine Factory in Rybnik, JSC.

2.2 SKZ-81 Sistem železnice ugrađen na podini sa dvojakom pogonskom jedinicom

Savremeno rešenje SKZ-81 dizel železničkog sistema, koji se upotrebljava u rudniku kamenog uglja BIELSZOWICE (slika 4), nastalo je kao rezultat saradnje između Centra za rudarsku mehanizaciju KOMAG i Fabrike mašina RYFAMA u Ribniku, JSC.

Figure 4 SKZ-81 rack-and-pinion locomotive with dual driving unit
slika 4 SKZ-81 Lokomotiva na polužno-zupčasti pogon sa dvojakom pogonskom jedinicom

The main development objective for this railway system has been a possibility of transportation of loads (including complete powered-roof support units) directly from the shaft bottom to the longwall face without reloading. A reduction of track construction costs, use of already existing mine railway tracks, with an option of adding a rack bar on inclined sections, have been taken into consideration. To meet these objectives the railway system has been equipped with the following two driving units:

- frictional system for travelling on practically horizontal track sections of inclination up to 4°,
- rack system for travelling in workings inclined up to 30°.

A design of dual driving unit has been developed in such a way that diesel engine system and pumping system are common for both actuating systems, i.e. for rack drive and rail drive. System of planetary gear, integrated with high-speed hydraulic engine, is used in the rack drive system, installed between two wheel sets. Due to the fact that these gears are offered in several types of gear ratio, there is a possibility to choose a gear ratio for individual customers. The gear is fitted directly to the driving bolted wheel, which cooperates with the rack mounted along the track

Glavni cilj izrade ovog železničkog sistema bila je mogućnost transporta tereta (uključujući kompletne hidraulične podgrade) direktno sa dna okna do širokog čela bez pretovaranja. Tom prilikom u obzir je uzeto smanjenje troškova izgradnje pruge, korišćenje već postojećih jamskih železničkih pruga, uz opciju dodavanja zupčaste poluge kod deonica pod nagibom. Kako bi se postigli ovi ciljevi, železnički sistem opremljen je sa sledeće dve pogonske jedinice:

- Frikcioni sistem za prevoz po praktično horizontalnim deonicama pruge sa nagibom do 4°,
- Zupčasti sistem za prevoz po otkopima sa nagibom do 30°.

Dizajn dvojne pogonske jedinice je izrađen na takav način da sistem dizel motora i pumpni sistem budu zajednički za oba izvršna sistema, tj. za zupčasti pogon i šinski pogon. Sistem planetarnog pogona, spojen sa hidrauličnim motorom velike brzine, koristi se u sistemu zupčastog prenosa, koji je postavljen između dva para točkova. Zbog činjenice da se ova vrsta prenosa može naći u nekoliko varijanti prenosnog odnosa, postoji mogućnost da vrstu prenosnog odnosa izaberu sami kupci. Prenos se uklapa direktno u pogonski zaptiveni točak, koji je u sprezi sa zupčastom polugom postavljenom duž

axis. Two smaller gear assemblies of such a type, where each of them drives one wheel set in one of two turning cars, being the components of rack-and-pinion locomotive driving car, are used in the rail driving system.

Arrangement of both driving systems within one rack-and-pinion locomotive body has required an implementation of many unconventional solutions, e.g. moveably fastened rack-driving system. Taking into consideration predicted track curves of R = 4 m in the horizontal plane and of R = 15 m in the vertical plane, a team of designers implemented a solution, which enables to change the height of rack driving system in relation to the rail wheel sets. For example, when the distance between the axes of rail drive wheels equals l = 1950 mm, the axis of driving wheel, installed between them, changes its distance from the rails on the convex and concave track in the range between +35 and –35 mm. Vertical guides, which cooperate with special supporting rollers, fixed to the rack driving wheel set, are used. In this way one degree of freedom of the wheel in relation to the rack-and-pinion locomotive body in the vertical direction has been obtained. It enables an adjustment of the wheel to changeable position of the rack in the vertical plane due to using the ram – Fig. 5. This function is also useful when rack-and-pinion locomotive operates on a horizontal track as a typical locomotive. The rack-and-pinion system is then situated in maximally elevated position, which is important for an elimination of potential collisions of this system on track junctions.

ose pruge. Dva manja sklopa prenosa tog tipa, gde svaki od njih pokreće jedan par točkova u jednom od dva vagona koja zaokreću, pošto predstavljaju komponente lokomotive na polužno-zupčasti pogon, koriste se u šinskom pogonskom sistemu.

Raspoređivanje oba pogonska sistema u okviru jednog tela lokomotive na polužno-zupčasti pogon je zahtevalo primenu mnogih nekonvencionalnih rešenja, npr. pomerljivo pričvršćen sistem na zupčasti pogon. Uzimajući u obzir predviđene krivine na pruzi od R = 4 m u horizontalnoj ravni i od R = 15 m u vertikalnoj ravni, tim projektanata je primenio rešenje koje omogućava da se promeni visina sistema na zupčasti pogon u odnosu na parove šinskih točkova. Na primer, kada razlika između osovina šinskih pogonskih točkova iznosi l = 1950 mm, osovina pogonskog točka, koji je postavljen između njih, menja razdaljinu u odnosu na pragove na ispupčenoj i udubljenoj pruzi u rasponu od +35 do –35 mm. Koriste se vertikalne vođice, koje su u sprezi sa posebnim potpornim valjcima, pričvršćenim za par zupčastih pogonskih točkova. Na ovaj način se dobija jedan stepen slobodnog prostora između točka i tela lokomotive na polužno-zupčasti pogon u vertikalnom pravcu. To omogućava podešavanje točka na promenljivu poziciju zupčaste poluge u vertikalnoj ravni zbog korišćenja držača - slika 5. Ova funkcija je takođe korisna kada se lokomotiva na polužno-zupčasti pogon upotrebljava na horizontalnoj pruzi kao obična lokomotiva. Polužno-zupčasti sistem se tada postavlja na maksimalno podignutu poziciju, što je bitno za otklanjanja mogućnosti sudara u okviru ovog sistema na raskršću pruga.

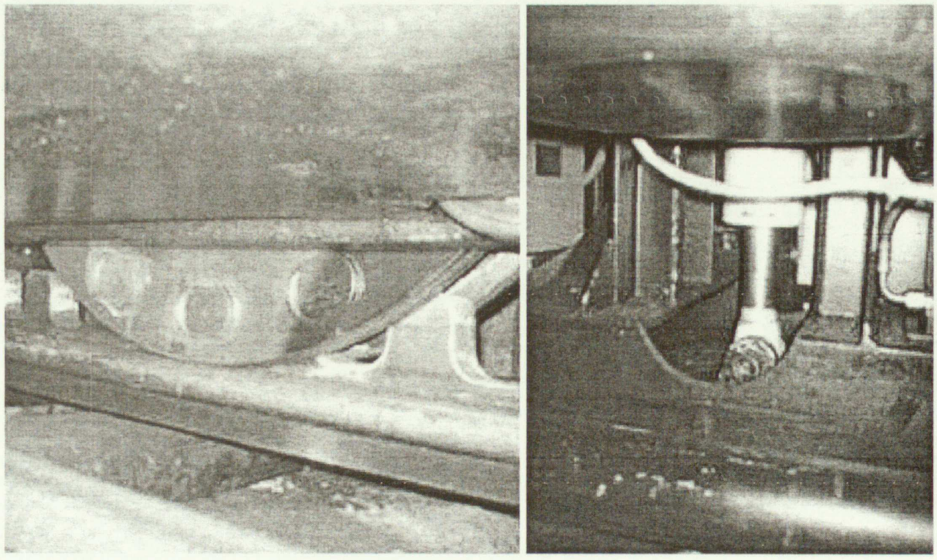

Figure 5 View of rack driving system and of ram for its elevation
slika 5 Slika sistema na zupčasti pogon i držača za njegovo podizanje

Other solutions of floor-mounted railway systems, used before, require a special track made of channel bars, which enable a cooperation with rolling keeps protecting the rack-and-pinion locomotive and transportation platforms on inclinations. In the case of SKZ-81 design solution, the rail tracks equipped with racks are used on the inclined track sections. The racks with vertical teeth of the pitch equal to 150 mm are equipped with welded additional side bars. Side disks of the driving wheel roll on the upper surfaces of these bars and they determine a proper cooperation area between the wheel bolts and rack teeth. The keeps of rack-and-pinion locomotive are hydraulically activated and on the inclined track they cooperate with lower surfaces of rack bars.

Main technical data of SKZ-81 rack-and-pinion locomotive

Table 2

Name of machine	SKZ-81
Power of diesel engine	81 kW
Pulling force of rail driving system	21 kN
Pulling force of rack driving system	270 kN
Speed (maximal) for rail system	4 m/s
Speed (maximal) for rack system	1.34 m/s
Maximal track inclination for rail system	±4°
Maximal track inclination for rack system	±30°
Type of track	Rail track with rack
Distance between track rails	750, 900, 1100 mm
Horizontal turn radius	4 m
Vertical turn radius	15 m
Machine length/width/height	7/1.2/1.65 m
Unit weight	15 t

3 UNDERGROUND LOCOMOTIVES WITH DIESEL DRIVE

3.1 Lds-100k-em and Lds-100k-ema underground diesel locomotives

The Lds-100K-EM and Lds-100K-EMA locomotives manufactured by ENERGOMECHANIK Company in Strzelce Opolskie are one-body locomotives with mechanical transmission of torque from diesel

Druga rešenja železničkih sistema ugrađenih na podini, koja su ranije korišćena, zahtevaju posebnu prugu sačinjenu od koritastih pragova, koji omogućavaju da sprega sa kretanjem pri nagibu štiti lokomotivu sa polužno-zupčastim pogonom i transportne platforme. U slučaju projektnog rešenja SKZ-81, pragovi opremljeni zupčastim polugama se koriste na deonicama sa nagibom. Zupčaste poluge sa vertikalnim zupcem na navoju od 150 mm opremljene su zavarenim dodatnim bočnim prečagama. Bočni diskovi pogonskog točka prelaze preko gornjih površina ovih prečaga i određuju odgovarajuće područje sprege između zavrtnja i zubaca poluge. Zadržavanje lokomotive na polužno-zupčasti pogon se aktivira hidraulično i pri nagibu stavljaju se u spregu sa donjim površinama zupčastih poluga.

Glavni tehnički podaci za lokomotivu na polužno-zupčasti pogon SKZ-81

Tabela 2

Ime mašine	SKZ-81
Snaga dizel motora	81 kW
Vučna sila šinskog pogonskog sistema	21 kN
Vučna sila zupčastog pogonskog sistema	270 kN
Brzina (maksimalna) za šinski sistem	4 m/s
Brzina (maksimalna) za zupčasti sistem	1.34 m/s
Maksimalni nagib pruge za šinski sistem	±4°
Maksimalni nagib pruge za zupčasti sistem	±30°
Vrsta pruge	Pruga sa zupčastom polugom
Razmak između šina	750, 900, 1100 mm
Poluprečnik horizontalnog zaokretanja	4 m
Poluprečnik vertikalnog zaokretanja	15 m
Dužina/širina/visina mašine	7/1.2/1.65 m
Težina jedinice	15 t

3 PODZEMNE LOKOMOTIVE NA DIZEL POGON

3.1 Podzemne dizel lokomotive Lds-100K-EM i Lds-100K-EMA

Lokomotive Lds-100K-EM i Lds-100K-EMA koje proizvodi kompanija ENERGOMECHANIK iz Strzelce Opolskie (Poljska) su jednodelne lokomotive sa mašinskim prenosom obrtnog momenta od dizel motora do točkova (slika 9).

engine to the wheels (Figure 9). Driving system of these locomotives is designed in such a way that torque from diesel engine is transmitted to the hydrokinetic torque converter and then to the reverse gear, which is connected with intersecting axis gears of wheel sets. The applied system: diesel engine – hydrokinetic gear enables a smooth start of mine cars in the train, especially on inclines.

Pogonski sistem ovih lokomotiva je projektovan na takav način da se obrtni moment prenosi od dizel motora na hidrokinetički konvertor obrtnog momenta a zatim na zupčanik za hod unazad, koji je povezan sa ukrštenim osovinskim zupčanicima parova točkova. Primenjeni sistem: dizel motor – hidrokinetički zupčanik omogućava lako pokretanje jamskih vagona u vozu, naročito pri nagibima.

The Lds-100K-EM locomotive (Figure 6) is designed for transportation operations carried out in underground ore, salt and other mines of minerals in the area which is not threatened by methane explosion. Low toxic compression-ignition engine with turbo-charging and charging air cooler, made by Cummins Company, is used in the driving system. Catalyst and exhaust gases diluter are installed in the exhaust system to improve a quality of exhaust gases and to reduce their arduousness.

Lokomotiva Lds-100K-EM (slika 6) je namenjena za transport koji se vrši u podzemnim rudnicima rude, soli i drugim rudnicima minerala u području kome ne preti opasnost od metanske eksplozije. U pogonskom sistemu se koristi motor sa paljenjem na kompresiju uz nizak nivo toksičnih materija sa turbo napajanjem i napajanjem za rashlađivač vazduha, koji proizvodi Cummins Company. Katalizator i razblaživač izduvnih gasova su smešteni u izduvnom sistemu u cilju razblaživanja izduvnih gasova i smanjenju njihovog dejstva.

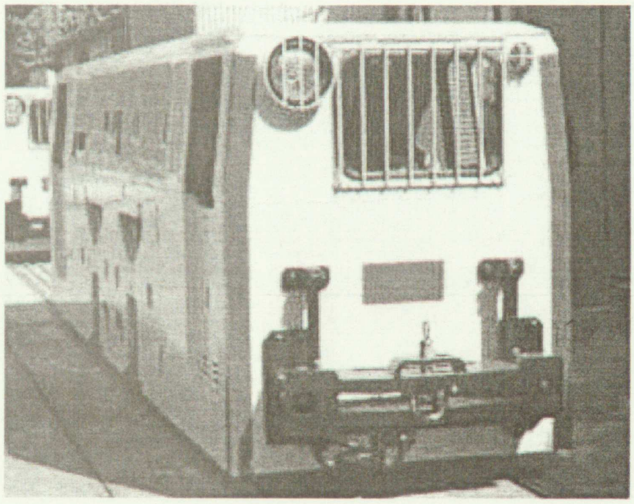

Figure 6 Lds-100K-EM underground diesel locomotive
slika 6 Podzemna dizel lokomotiva Lds-100K-EM

The locomotive is equipped with the manoeuvring brake, having a hydraulic drive as well as with hydraulically released emergency-and-parking brake.

Lokomotiva je opremljena manevarskom kočnicom, koja ima hidrauličan pogon kao i kočnicu sa hidrauličnim popuštanjem za preventivno-incidentno zaustavljanje i parkiranje.

Control of engine rotations, brakes, travelling direction and turning the sanders on is realized hydraulically. The start up of diesel engine is realized electrically. The locomotive is fitted with self-operating fire fighting system. The Lds-100K-EM locomotive can be optionally fitted with an electronic system to control its operational parameters (together with their recording).

Kontrola rotacija motora, kočnica, pravca vožnje i uključivanja uređaja za posipanje peska vrši se hidraulično. Pokretanje dizel motora se vrši električno. Lokomotiva je opremljena auto-pogonskim protivpožarnim sistemom. Lokomotiva Lds-100K-EM se može dodatno opremiti elektronskim sistemom u cilju kontrole njegovih radnih parametara (zajedno sa evidentiranjem istih).

Main technical data of Lds-100K-EM and Lds-100K-EMA locomotives

Table 3

Type of machine	Lds-100K-EM,Lds-100K-EMA
Power of diesel engine	81 kW
Pulling force	30 kN
Maximal speed	4 m/s
Smallest turn radius	12.5 m
Volume of fuel tank	60 l
Locomotive weight	12 000 kg
Distance between bumpers	6200 mm
Height from rail head	1650 mm
Locomotive width for s≤750 for s=750 for s=900	 1100 mm 1135 mm 1250 mm
Gauge	550÷900 mm

Glavni tehnički podaci lokomotiva Lds-100K-EM i Lds-100K-EMA

Tabela 3

Tip mašine	Lds-100K-EM,Lds-100K-EMA
Snaga dizel motora	81 kW
Vučna sila	30 kN
Maksimalna brzina	4 m/s
Najmanji poluprečnik zaokretanja	12.5 m
Zapremina rezervoara za gorivo	60 l
Širina lokomotive	12 000 kg
Razmak između branika	6200 mm
Visina od pretovarnog mesta	1650 mm
Širina lokomotive za s≤750 za s=750 za s=900	 1100 mm 1135 mm 1250 mm
Graničnik	550÷900 mm

The first Lds-100K-EM locomotives have been used in the KGHM Polska Miedź (Polish Copper), JSC. – RUDNA and POLKOWICE-SIEROSZOWICE Copper Mines.

Prve lokomotive Lds-100K-EM su korišćene u rudnicima bakra KGHM Polska Miedź (Poljski rudnik bakra), JSC. – RUDNA i POLKOWICE-SIEROSZOWICE.

The Lds-100K-EMA locomotive (Fig. 7) is designed for transportation and manoeuvring operations carried out in underground coal, ore, salt and other minerals mines, in the areas of "a", "b" and "c" level of methane explosion hazard and "A" and "B" class of coal dust explosion hazard. Low toxic compression-ignition engine with turbo-charging, made by Volvo Penta Company, is used in the driving system.

Lokomotiva Lds-100K-EMA (slika 7) je namenjena za transport i manevrisanje koji se obavljaju u podzemnim rudnicima uglja, rude, soli i drugih minerala, u oblastima u kojima je opasnost od metanske eksplozije "a", "b" i "c" nivoa, a opasnost od eksplozije ugljene prašine "A" i "B" klase. U pogonskom sistemu je korišćen motor sa paljenjem na kompresiju uz nizak nivo toksičnih materija sa turbo napajanjem, proizveden od strane Volvo Penta Kompanije.

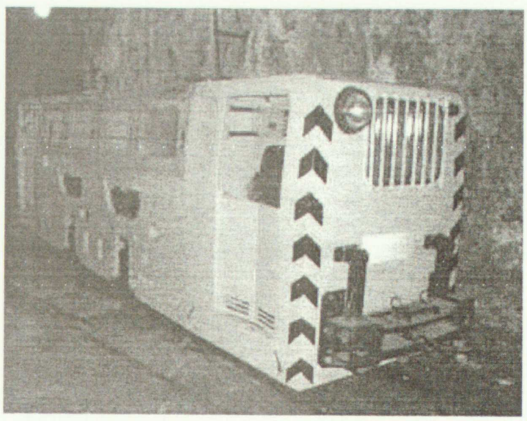

Figure 7 Ld-100K-EMA underground diesel locomotive
slika7 Podzemna dizel lokomotiva Ld-100K-EMA

The locomotive is equipped with manoeuvring brake having a hydraulic drive as well as with hydraulically released emergency-and-parking brake. Control of engine rotations, brakes, travelling direction and turning the sanders on is realized electro-hydraulically. The start up of diesel engine is realized hydraulically.

Lokomotiva je opremljena manevarskom kočnicom koja ima hidraulični pogon kao i kočnicu sa hidrauličnim popuštanjem za hitno zaustavljanje i parkiranje. Kontrola rotacija motora, kočnica, pravca vožnje i uključivanja uređaja za posipanje peska vrši se elektro-hidraulično. Pokretanje dizel motora se vrši hidraulično.

The Lds-100K-EMA locomotive is fitted with an electronic system for a control of operational parameters. The system stops the engine in the case of pressure decay of oil lubricating the engine, in the case of lack of pressure in the brake system or in the case of exceeding the following temperatures: of fluid cooling the engine, of exhaust gases, of oil in the hydraulic system. Apart from the central self-operating fire fighting system each cabin is equipped with a portable dry powder or carbon dioxide extinguisher.

The locomotive is equipped with a microprocessor system to control an operation of subassemblies. All the electric components as well as inlet-outlet diesel engine system have the certificates for conformity with the requirements of the ATEX Directive.

The first Lds-100K-EMA locomotives have been implemented in BORYNIA and JANKOWICE Collieries.

3.2 PIOMA LDS 80 underground diesel locomotive

The PIOMA LDS 80 locomotive (Figure 8), the result of collaboration between KOMAG Mining Mechanization Centre and PIOMA Mining Machinery Factory, JSC, is a machine with hydraulic transmission of diesel engine torque to the wheels. The locomotive has been designed on the basis of the subassemblies of PIOMA CS 80 suspended monorail locomotive. At the weight of 15 t, the locomotive can pull trains, whose weight exceeds 150 t. Derailing of the locomotive together with mine cars is the main hazard, which can occur during transportation of heavy loads. Thus, a development of a design of locomotive drive system, which will maximally reduce derailing possibility, has been the main objective.

The locomotive consists of the three following main subassemblies connected together to enable mutual movement in relation to axis of the joints:

- a driving car, made of frame, two gear boxes, engines, hydraulic brakes and wheels,
- two operator's cabins with fixed bumpers, where each cabin is flexibly connected to a driving car with rubber supporters.

Lokomotiva Lds-100K-EMA je opremljena elektronskim sistemom za kontrolu radnih parametara. Sistem zaustavlja motor u slučaju pada pritiska ulja kojim se podmazuje motor, u slučaju nedovoljnog pritiska u kočionom sistemu ili u slučaju povišene temperature tečnosti koja hladi motor, temperature izduvnih gasova ili ulja u hidrauličnom sistemu. Osim auto-pogonskog protivpožarnog sistema, svaka kabina je opremljena prenosivim aparatom za gašenje požara sa suvim prahom ili ugljen-dioksidom.

Lokomotiva je opremljena mikroprocesorskim sistemom za kontrolu rada podsklopova. Sve električne komponente kao i ulazno-izlazni sistem dizel motora imaju potvrde da su u skladu sa zahtevima Direktive ATEX (Smernice za zaštitu od eksplozije u industriji).

Prve lokomotive Lds-100K-EMA bile su upotrebljene u rudnicima kamenog uglja BORYNIA i JANKOWICE.

3.2 Podzemna dizel lokomotiva PIOMA LDS 80

Lokomotiva PIOMA LDS 80 (slika 8), koja je rezultat saradnje između Centra za rudarsku mehanizaciju KOMAG i Fabrike za rudarske mašine PIOMA, JSC, je mašina za hidraulični prenos obrtnog momenta dizel motora na točkove. Lokomotiva je projektovana na osnovu podsklopova viseće jednošinske lokomotive PIOMA CS 80. Pošto ima težinu od 15 t, lokomotiva može da povuče vozove čija težina prelazi 150 t. Iskliznuće lokomotive iz šina, zajedno sa jamskim vagonima predstavlja glavnu opasnost, do koje može doći za vreme transporta velikih tereta. Prema tome, glavni cilj je bio razvoj dizajna pogonskog sistema lokomotive, koji bi maksimalno umanjio rizik od iskliznuća iz šina.

Lokomotiva se sastoji od sledeća tri glavna podsklopa koji su međusobno povezani u cilju omogućavanja uzajamnog kretanja u odnosu na osovinu spojeva:

- Pogonskog vagona, sastavljenog od okvira, dva menjača brzina, motora, hidrauličnih kočnica i točkova,
- Dve kabine za mašinistu sa fiksiranim branicima, pri čemu je svaka kabina fleksibilno povezana sa pogonskim vagonom gumenim podupiračima.

- an internal combustion-and-hydraulic compartment installed on the slide base, which rests on a driving car by its joints.

- Unutrašnjeg ložno-hidrauličkog odeljka, postavljenog na kliznoj osnovi, koja naleže na pogonski vagon putem svojih spojeva.

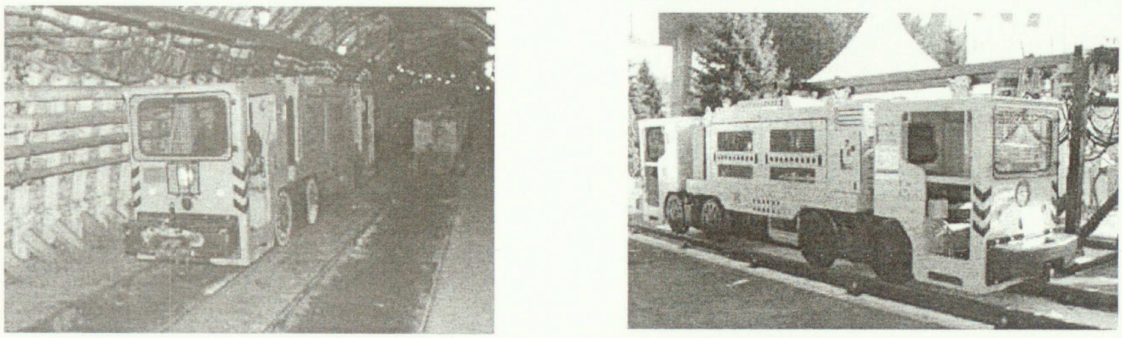

Figure 8 PIOMA LDS 80 underground diesel locomotive
slika 8 Podzemna dizel lokomotiva PIOMA LDS 80

The drive is transmitted from hydraulic engines through gears to a pair of wheels connected with them. The gears are fixed to the car frame in a swinging way by sleeves. Such a method of gear connection ensures even distribution of locomotive weight on all the driving wheels.

Hydrostatic gear, which at the same time plays a role of the manoeuvring brake, is used in the driving system. Each release of the travel control lever causes an automatic braking of the locomotive. Multi-disk brakes, controlled hydraulically, play a role of a parking brake. The brakes act on the driving wheels through a gear. They are activated after putting the travel control lever to „0" position or after exceeding the speed of 4.8 m/s. These brakes are a separate sub-system used to stop the locomotive, which doubles the hydrostatic gear.

Design solutions described above give the following advantages:

- the locomotive, despite of its significant length, overcomes the curves in a much better way than one-body locomotive and it does not show derailing tendency,
- the cabins, which turn together with the modules, significantly limit their track outline overlapping on turns, what reduces the hazard to people, who can accidentally appear near the track,
- the locomotive pulling force, transmitted to mine cars through the couplings, is in the track symmetry axis, what significantly protects the locomotive against pushing it out of the track by the weight of mine cars, during braking on turns,

Pogon se prenosi sa hidrauličnih motora preko zupčanika do para točkova koji je povezan sa njima. Zupčanici su pričvršćeni za okvir vagona na vibracioni način putem čaura. Ovaj način povezivanja zupčanika omogućuje ravnomerno raspoređivanje težine lokomotive na sve pogonske točkove.

U pogonskom sistemu se koristi hidrostatički zupčanik, koji u isto vreme ima ulogu manevarske kočnice. Bilo kakvo popuštanje poluge za kontrolu vožnje uzrokuje automatsko kočenje lokomotive. Kočnice sa više diskova, koje se kontrolišu hidraulično, imaju ulogu kočnice za parkiranje. Kočnice deluju na pogonske točkove preko zupčanika. One se aktiviraju nakon što se poluga za kontrolu vožnje postavi na poziciju „0" ili nakon što brzina bude veća od 4,8 m/s. Ove kočnice su poseban podsistem koji se koristi za zaustavljanje lokomotive, što predvostručuje hidrostatički zupčanik.

Projektna rešenja koja su ranije opisana pružaju sledeće prednosti:

- Lokomotiva, uprkos svojoj znatnoj dužini, savladava krivine mnogo bolje nego lokomotiva iz jednog dela i ne pokazuje tendenciju ka isklizavanju iz šina,
- Kabine, koje se okreću zajedno sa modulima, značajno ograničavaju spoljne ivice pruge da se preklope na zavojima, što smanjuje rizik po ljude, koji se mogu slučajno naći blizu pruge,
- Vučna snaga lokomotive, koja se prenosi na jamske vagone putem spojeva, je u osovini simetrična sa prugom, što znatno štiti lokomotivu od ispada iz koloseka zbog težine jamskih vagona, za vreme kočenja na zavojima,

- an even distribution of the locomotive weight to all the eight wheels improves the locomotive braking efficiency.

- Ravnomerno raspoređivanje težine lokomotive na svih osam točkova povećava efikasnost kočenja lokomotive.

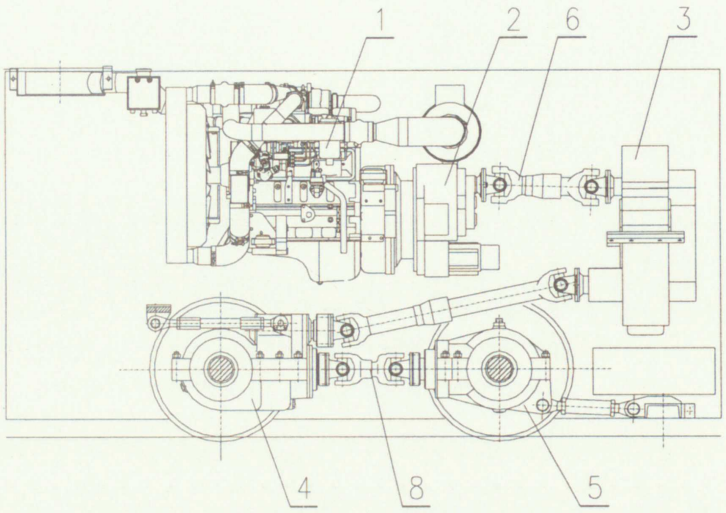

Figure 9 Diagram of drive transmission in Lds-100 locomotives
1 – diesel engine; 2 – hydrokinetic gear (torque converter); 3 – reverse gear; 4 – front angle gear; 5 – rear angle gear; 6, 7, 8 – driving shafts
slika 9 Grafikon prenosa pogona u lokomotivama Lds-100
1 – dizel motor; 2 – hidrokinetički zupčanik (konvertor obrtnog momenta); 3 – zupčanik za kretanje unazad; 4 – prednji ugaoni zupčanik; 5 – zadnji ugaoni zupčanik; 6, 7, 8 – pogonska vratila

A prototype of the locomotive has successfully overcome operational tests in LW BOGDANKA Colliery. The tests have verified design assumptions as regards effective transportation of long (even up to 50 full 5-ton cars) and heavy load transportation in the main workings as well as fast transportation of men.

Prototip lokomotive je uspešno prošao radne testove u rudniku kamenog uglja LW BOGDANKA. Testovi su proverili projektne pretpostavke u pogledu efikasnog transporta dugačkih kompozicija (čak do 50 punih 5-tonskih vagona) i velikog tereta u glavnim jamama kao i brzo prevoženje ljudi.

Main technical data of PIOMA LDS 80 locomotive

Table 4

Type of machine	PIOMA LDS 80
Power of diesel engine	81 kW
Pulling force	40 kN
Maximal speed	5 m/s
Smallest turn radius	12 m
Diameter of wheels	560 mm
Locomotive weight	15500 kg
Distance between bumpers	7250 mm
Height from the rail head	1650 mm
Locomotive width	1100 mm
Gauge	600÷900 mm

Glavni tehnički podaci o lokomotivi PIOMA LDS 80

Tabela 4

Tip mašine	PIOMA LDS 80
Snaga dizel motora	81 kW
Vučna sila	40 kN
Maksimalna brzina	5 m/s
Najmanji poluprečnik zaokretanja	12 m
Prečnik točkova	560 mm
Težina lokomotive	15500 kg
Razdaljina između branika	7250 mm
Visina od pretovarnog mesta	1650 mm
Širina lokomotive	1100 mm
Graničnik	600÷900 mm

4 SUMMARY

The first design solutions of transportation machines have already been implemented in hard coal mines and in copper ore mines. At present, groups of specialists from the KOMAG Mining Mechanization Centre and from manufacturers, basing on users remarks and suggestions, carry out further research work to improve the design of these machines aimed at increasing their operational reliability and safety.

The certification processes of SKZ-81 and PIOMA-VACAT railway systems have revealed some interpretation problems associated with the regulations, which are in force in Poland. Especially SKZ-81 railway system, which can operate as the rack-and-pinion railway and typical railway, has to meet both regulations in this respect. Use of innovative design machines in underground mines is possible only when the requirements included in the regulations, are fully met.

An increase of work effectiveness and safety by an elimination of labour consuming and dangerous load transfer operations on transportation routes is the main objective of the projects under realization at present as regards transportation machines. The projects are aimed at designing innovative transportation machines, which meet both the requirements of regulations and the expectations of the users.

4 ZAKLJUČAK

Prva projektna rešenja za mašine za transport su već primenjena u rudnicima kamenog uglja i rudnicima bakra. Danas, grupe stručnjaka iz Centra za rudarsku mehanizaciju KOMAG i iz proizvodnih preduzeća, na osnovu primedbi i sugestija korisnika, obavljaju napredna istraživanja u cilju poboljšanja dizajna ovih mašina koja imaju za cilj da se poboljša njihova radna pouzdanost i sigurnost.

Procesi sertifikacije železničkih mreža SKZ-81 i PIOMA-VACAT su pokrenuli neke probleme u tumačenju propisa, koji su trenutno na snazi u Poljskoj, Naročito železnički sistem SKZ-81, koji može da radi kao polužno-zupčasta železnica i obična železnica, mora po ovom pitanju da se pridržava propisa vezanih za oba tipa. Upotreba mašina inovativnog dizajna u podzemnim rudnicima je moguća samo ako se u potpunosti ispune zahtevi koji su navedeni u propisima.

Povećanje radne efikasnosti i sigurnosti putem otklanjanja mogućnosti prekomernog rada i prenosa opasnog tereta na transportnim trasama je glavni cilj projekata koji su trenutno u toku u pogledu mašina za transport. Projekti imaju za cilj izradu inovativnih mašina za transport, koje ispunjavaju kako propisane zahteve tako i očekivanja kupaca.

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