

JERZY GAS

## Innovative solutions in the products of SAG Sp. z o.o. (LLC)

*The article presents the origins and implementations of innovative solutions in the construction of balance ropes that have provided a new quality in the transport of men and materials using mining hoisting devices. In the article the new technical solutions are discussed and the advantages of operation of the SAG type steel rubber coated balance ropes are indicated. A short historical overview of the founding of SAG Company is presented on this background with years of successful experience, which resulted in the implementation of innovative solutions in the offered products ensuring the effectiveness and reliability of their operation.*

Key words: SAG type balance rope, steel ropes, rollers, rope requirements

### 1. INTRODUCTION

---

*“Tradition and modernity”* – this motto encapsulates the strategy of the company’s operations since the founding of SAG Sp. z o.o. In 2021 the company will celebrate 30 years of operations, with 1991 marking the moment when the idea was formulated to found a company manufacturing innovative and unknown at that time steel rubber coated flat balance ropes in Nikiszowiec, a district of the city of Katowice.

The company began its business activities as the SAG Steel-Rubber Coated Rope Manufacturing Company. The name was created as an acronym of the following Polish words – *stal*, *antykorozja*, *guma* (steel, anticorrosion, rubber). Originally 51% of company shares belonged to an Austrian company Trade-pol, the remaining 49% of the shares being taken over by the “Wieczorek” Coal Mine. The Katowice Coal Holding, Joint Stock Company became a legal successor of the mine and in 1997 the Austrian shares became the property of Marchart & Lackner GmbH Company. In 2008 the Austrian shares were purchased by Fabryka Taśm Transporterowych Wolbrom S.A. (conveyer rubber belt manufacturers) who thus became the new co-owner. In 2012 SAG changed its name to SAG Sp. z o.o. (LLC). In 2019 Spółka Re-

strukturyzacji Kopalń S.A. (mine restructuring company) took over the SAG shares from the Katowice Coal Holding, Joint Stock Co. as the result of the organizational transformation of Polish coal mining.

### 2. SAG STEEL RUBBER COATED FLAT BALANCE ROPES

---

#### 2.1. Historical overview

A pioneering product in the years 1980–1990 were steel-rubber coated flat balance ropes, and these became the principal product of the company. Looking back, one can clearly state that the dynamic development of the company was triggered solely by this modern rope. Innovative solutions in the construction of balance ropes developed in the 1970’s and 80’s at the Academy of Mining and Metallurgy in Krakow (AGH) constituted a revolution in the transport of men and materials in shafts using mining hoisting devices. The impulse to undertake work in this field were the results of investigations of the causes and results of accidents in mine shafts, which were performed in the 1970’s by AGH together with the Energy and Mechanical Departments of the State Mining

Authority in Katowice and the Ministry of Mining. As a result of the investigations it was discovered that the most unreliable element of mining hoisting devices were steel balance ropes, both flat and round ones. During the analysed period, an average of 1–2 steel flat balance ropes broke in a given year. Each such event threatened the safety of the mine and resulted in very large material losses. One of the principal causes of the steel flat balance ropes breaking (stitched manually and riveted) was the lack of any opportunity to reliably assess their technical condition. On the other hand, the round balance ropes had to be replaced rather frequently because they became distorted due to rotating around their axis during operation cycles. The SAG steel rubber coated balance ropes are free from these faults. The research – implementation work commenced at AGH in 1974 and lasted a dozen or so years before the production of the SAG ropes was organized and the ropes were approved for common use in under-ground mining works. Dozens of experts were employed to solve the problems relat-

ed to this project (mechanics, chemists, electricians, miners, underground mining supervisors, etc.). The date of completion of the scientific-implementation proceedings is considered to be 3 July 1990, which is the date of approval by the State Mining Authority in Katowice of the SAG ropes for applications in the shaft hoisting devices in Poland concerning the transport of both men and materials. Therefore, this date marks the end of many years of scientific research, design, construction-assembly works etc. and which resulted in the manufacture of the SAG ropes. Also the conditions were created for their common application in mining hoisting devices without any limitations [1].

## 2.2. Rope construction

Steel rubber coated flat balance ropes are made from an even number of steel ropes (left lay and right lay), vulcanized in rubber along their entire length (Fig. 1).

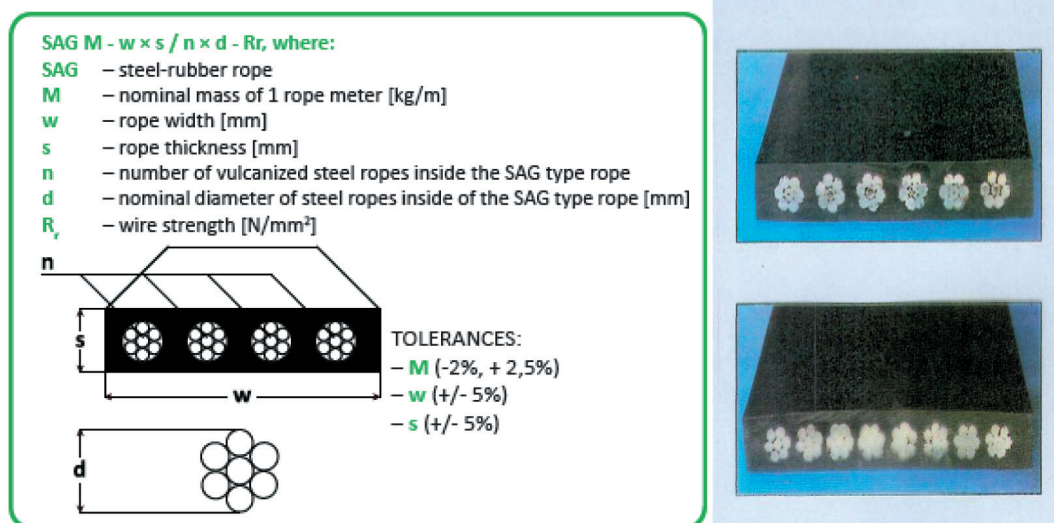


Fig. 1. Construction of SAG-type steel rubber coated flat balance rope [2]

The rope range developed already in 1978 comprises steel rubber coated ropes, in which from 2 to 8 steel wire ropes are vulcanized, featuring diameters 12, 14, 16, 20, 22 and 24 mm and strength of 1370, 1570, 1670 and 1770 MPa. Thanks to this, all the demands are fulfilled that are placed for balance ropes, concerning weight of meter of the rope and values of rope actual complete breaking loads (requested safety factors), which are applied in mining shaft hoisting devices of any technical parameters [1].

### 2.3. Technical advantages of the operation of sag ropes

The SAG-type ropes feature an average useful life at least 3–4 times longer than the useful life of steel balance ropes, and are in the opinion of many experts a significant international accomplishment of the AGH scientists and Polish engineers.

After 41 years of experience in the exploitation of steel rubber coated ropes produced by SAG Sp. z o.o. (since the end of 1989), it can be stated that all the advantages of the SAG-type ropes declared by their inventors have been fully confirmed. The application of the SAG-type ropes in Polish mines completely eradicated breakdowns related to the breaking of balance ropes (Fig. 2). Usage of the SAG-type ropes facilitates reduced costs of vertical transport and work safety improvement not only in mines in Poland but also in many other countries where the SAG-type ropes have been exported.

The advantages of the SAG-type steel rubber coated balance ropes primarily comprise:

- 1) The feature of complete non-rotation, which was accomplished by the application of an even number of steel wire ropes with two directions of lay, featuring round strands, vulcanized in rubber along their entire length. One half of the number of the steel wire ropes is of the right lay whilst the second half is of the left lay.
- 2) Vary large resistance to corrosion – thanks to the vulcanization of the galvanized steel wire ropes in rubber. The inner rubber coating features large adhesion to the wires while the outer rubber layer, which is made from flame retardant rubber, features large electric conductivity and resistance to abrasion.
- 3) Wide range of SAG-type rope unit weights and rope breaking loads – a relevant unit weight and demanded breaking load are obtained using

different even numbers of steel wire ropes with a relevant diameter (ropes made from wires with a specific resistance) and the application of determined amount of rubber filling.

- 4) Operational reliability – accomplished by the application of at least a couple of steel wire ropes bearing axial loads. The probability of their simultaneous damage (breaking) is a probability calculation product of the damaging of a single rope. Breaking one steel wire rope in a SAG-type rope does not result in the breakdown of the hoisting device.
- 5) High reliability of rope fixing in the attachment – accomplished thanks to a large friction factor between contacting rubber coated surfaces, which are tightened with steel clamps and a new SADEX-type attachment solution.
- 6) Large durability and resistance to mechanical damage – obtained due to the above advantages, but primarily thanks to the large resistance to wear from corrosion, and the fact that the external rubber layer protects the steel ropes against mechanical damage.
- 7) Small radius of rope bending in the shaft sump – thanks to the application of a large number of steel wire ropes with small cross rigidity.
- 8) Possibility of magnetic testing – allowing the qualitative assessment of the SAG-type ropes. It was obtained thanks to the development of a wide range of magnetic heads and a new magnetic testing methodology [1].

The technical-operational advantages of the SAG-type ropes were awarded the Gold Medal at the 41st World Fair for Invention Research and Industrial Innovation Eureka'92 in Brussels.

Many years of the use of SAG-type ropes made in compliance with patent PL 150321, demonstrated the full utility of these ropes for operation in shaft mining hoists. This statement is confirmed by the SAG-rope 177x35/4x18 installed on 30.11.1991 in the skip section of the production shaft of Janina III at Mining Company Janina Tauron Wydobycie S.A. in Libiąż, Poland. This rope, which was made in compliance to patent PL 145595 (with vulcanized calibration elements) was used until 2018, i.e. after almost 26.6 years of operation, and performed approximately 1,800,000 operations. The record holding rope, however, is the SAG-type balance rope 118x29/4x18, which has already been in operation for over 29 years at the Mining Company Brzeszcze – Tauron Wydobycie S.A.



*Fig. 2. SAG-type steel rubbercoated flat balance rope [2]*

Thanks to their large resistance to corrosion, the potential to monitor their technical condition on an ongoing basis using NDT tests and the possibility of repair directly in the shaft of the hoist (without taking the rope out) in the event of damage to the rubber coating, the SAG-type balance rope has become a symbol of quality, effectiveness and a guarantee of safety.

SAG-type balance ropes have been used in mining shaft hoisting devices (including the transport of men) in coal mines, metallic ore mines, salt and other usable mineral mines in Poland and abroad. By the end of 2020, the company had sold a total of 660 SAG-type steel-rubber coated balance ropes, of which 128 were exported to mines in the Czech Republic, Russia, Ukraine, Kazakhstan, Germany, Morocco and Vietnam. In Poland there are still over 200 SAG-type balance ropes in operation.

Among the manufactured ropes, the longest one is 1,600 m, the heaviest weighed 28,990 kg and the largest number of operations performed was approximately 3.2 million cycles.

### **3. SAG ROLLERS FOR BELT CONVEYERS**

Recognition from the mining industry was a triggering factor to expand and diversify the product offer of the SAG company. These products have found their application not only in the mining sector, but in other branches of industry as well.

The product offer comprises i.a. different types of rollers, from standard to special ones tailored to the particular demands of the customer (Fig. 3).



*Fig. 3. SAG-make rollers [3]*

The ECO-rollers developed by SAG deserve a special mention in this regard. As a long-time partner of the mining industry, SAG has gained expertise in conveyer transport, a fact confirmed by its certificates, references and numerous awards. Operating conveyer belts in the exceptionally demanding environment of underground mines led the company to initiate work on a product with superior quality, one not only featuring durability and reliability but safety of use as well. Considering the fact that the rollers constitute the most numerous elements of a conveyer belt, with their construction and efficiency influencing the power consumption of the drive, as well as the correct running of the belt and its durability, SAG developed a new method for the construction of rollers.

Thanks to the application of high quality materials and innovative construction solutions, the SAG ECO-rollers have become an exemplary product in respect to the minimization of belt conveyer operation costs, a fact confirmed by laboratory testing at technical universities and exploitation testing in mines.

The innovative solutions applied in the energy saving ECO-rollers have allowed us to achieve the following effects:

- 1) The rollers installed in one of the Gwarek 1200 type conveyer belts at the “Mysłowice-Wesoła” Coal Mine in hard operation conditions resulted in a power consumption drop of 8.1%, both at start up as well as during stabilized operations of the conveyer. The testing was performed by the Silesian University of Technology after 10 months and then 3 years of their operation. Measurements of the radial run out demonstrated the very high precision of the SAG ECO-rollers, and testing the static and dynamic resistance of rotations confirmed its low level. Moreover, testing showed that after three years the roller construction had not lost its exploitation properties and they could be still operated at the mine [4, 5].
- 2) The rollers tested in laboratory conditions by the Wrocław University of Science and Technology confirmed low resistance of rotation within the whole range of operation loads, at minimal temperature increase of bearing nodes of the rollers, low radial run out and the durability guaranteed by the manufacturer i.e. 3 years [6].
- 3) The low level of the vibrations of the rollers installed in two supporting structures of the coal feeding conveyer at Jaworzno II Power Plant allowed for the reduction of vibration of the supporting structure by 30% and a reduction of power supply necessary for the conveyer. At the same time, a small temperature increase was confirmed at the bearing nodes, which directly influenced safety of work and which was documented by the Somar Company [7].
- 4) The rollers with polyurethane rings, which were applied in innovative conveyer belts at KGHM Polska Miedź S.A. copper ore mine featured rotation resistance not exceeding 1.23 N (the norm is 3 N). Also no significant temperature increases were noticed at the bearing nodes, which is very important for the safety reasons in conveyer belt transport, because in many cases the belt conveyers work in zones with explosion risk [6].
- 5) The rollers with flexible bearing nodes tested by the AGH Technical University in Krakow confirmed that the application of rubber inserts not only allowed to obtain higher roller strength, but helped lower noise emission during roller operation as well. Laboratory testing confirmed good exploitation features resulting from diminishing dynamic forces burdening the ECO-SAG roller bearings [8].

The SAG offer also comprises rollers that are produced on the basis of a new production process and the selection of relevant materials, using innovative sealing of the bearing node, relevant hubs, machining, assembly, production precision and materials with confirmed strength and that can last during 5 years of operations.

HEAVY DUTY (Fig. 4) rollers feature superior durability in hard working conditions of the belt conveyers and they find applications in underground mine conveyor belts with large extraction volumes – high output. This roller, which is especially resistant to reacting to dust and water, features a shell tube wall thickness of 6.3 mm, bearings 6306–6308 and innovative sealing of bearing nodes, which allows for efficient protection against reacting of the factors causing roller wear, i.e. water, dust penetrating the bearing nodes, etc.



*Fig. 4. Construction of HEAVY DUTY a roller [9]*

#### 4. SAG CONSTRUCTIONS

SAG is also a manufacturer of steel constructions for such industrial branches as mining, railways, construction, power generation, recycling, etc. Since 2015

SAG has supplied the middle sections of tram cars for the Tramwaje Śląskie S.A. Company, featuring lowered floors and adapted to the needs of disabled people (Fig. 5). Examples of steel constructions executed for definite orders of customers show Figures 6–9.



*Fig. 5. Construction of the middle section of a tram car [3]*



*Fig. 6. Construction of a drum screen [3]*

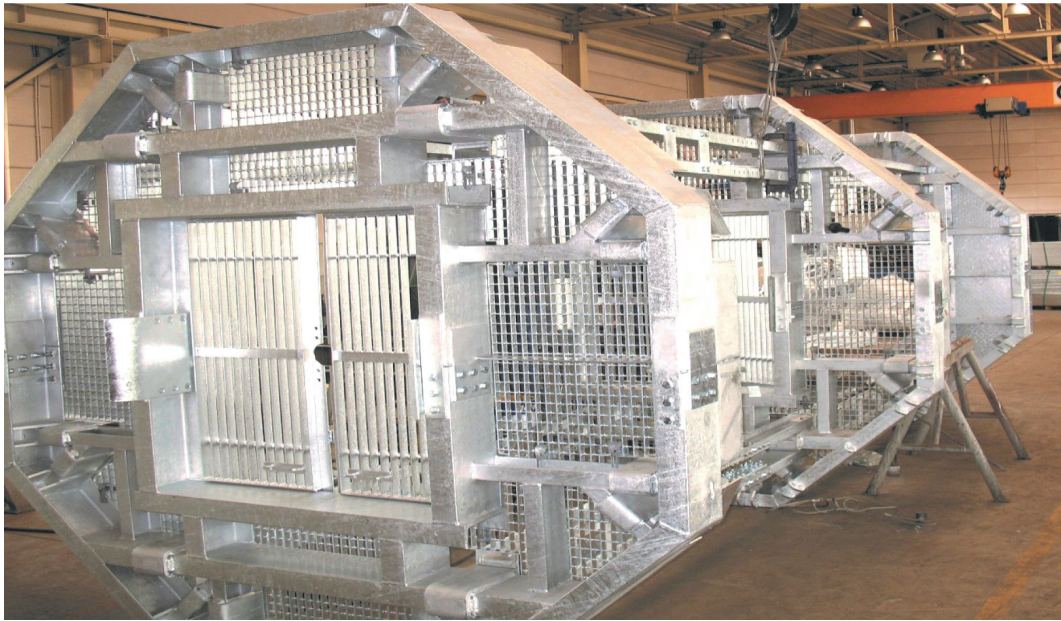


Fig. 7. Suspended platform construction [3]



Fig. 8. Conveyor belt construction [3]

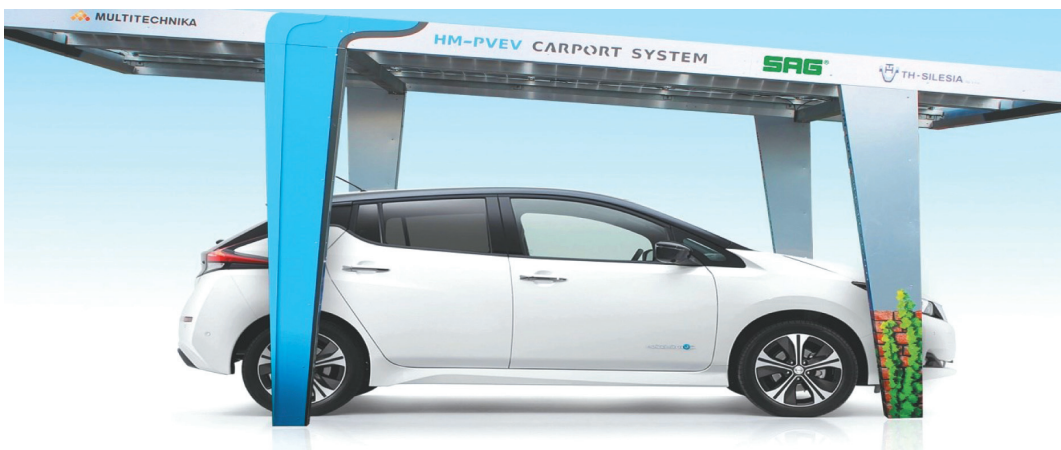


Fig. 9. Supporting structure for the Chameleon PVEV Carports modular photovoltaic system [10]

## 5. HOISTING ROPES AND SERVICES

In 2018, to meet customer demand, the SAG offer was amended with steel hoisting ropes made by *WDI* Westfälische Drahtindustrie GmbH – a leading steel rope manufacturer from Germany (Fig. 10).

WDI specializes in the production of highly efficient steel hoisting ropes, of which the whole production process starting from drawing of wires is executed at WDI owned factories, including the most modern steel wire manufacturing plant in Europe in Rothenburg. The registered brand of steel wire ropes WDI – “PYTHON” was launched in the market in the 60-ties of the previous century and nowadays is a world-wide reputed brand of steel ropes featur-

ing high quality and fulfilling ever growing industry demand in respect of steel wire ropes with the construction optimized in respect of costs, durability and strength. Production of ropes is performed in compliance with the quality management system ISO 9001:2008. The company is certified i.a. by Germanischer Lloyd, Lloyd’s Register of Shipping, Russian GOST and China Mining Products Safety Approval and Certificate.

In addition, SAG also renders services in the scope of overhauling shaft rope attachments, special welding services, including robotized welding, steel plate flame cutting, machining and mechanical forming of steel elements using modern CNC machines.



Fig. 10. WDI Company Logo for PYTHON Brand [11]

## 6. SUMMARY

Having automated production machines and constantly investing in their modernization, SAG Sp. z o.o. is now entering the market of the most advanced technologies, i.a. in the scope of electro mobility, recycling and rail rolling stock. Its experience and qualified personnel, close cooperation with science-research centres, competent technical support, position SAG in the segment of manufacturers – pioneers in respect to innovation, taking care for safety and high quality of the offered products and create a strong and stable position of the company in the domestic market and abroad. It has been reflected by the prizes and awards awarded to SAG.

By the decision of the Management of the Silesian Association of Managers, SAG Sp. z o.o. was recognized as 2018 Company of the Year in Silesia, in the category of medium size manufacturing companies. Also the company has been repeatedly awarded for the quality and innovativeness of its products (three times recognized by IPH in Krakow with the T. Baranowski Diploma for innovative activities in respect to the SAG-type steel rubber coated balance rope, SAG

ECO-roller and a product – a tram car middle section with a lowered floor; it received a Gold Badge for a QI Product a part of the Top Quality International program in 2019). The production quality is assured with certificates of management and safety and cooperation with the science centres in Poland. The company was also awarded the honourable Diamond title by Forbes 2020. This award is not only a prize for excellent financial results and the growth of the company’s value, but proof of a guarantee of reliability and transparency of the particular company.

Maintaining and strengthening its market position in Poland and abroad is one of the objectives of the company in the years to come.

### References

- [1] Hansel J., Gas J.: *Liny wyrównawcze stalowo-gumowe SAG*. XX International Conference Investigation, Production and Use of Steel Ropes, Conveyors and Hoisting Machines, Koszycze 2018.
- [2] Product data sheet SAG: “Liny”, <http://www.sag.pl/> [10.09.2020].
- [3] Photographs by SAG.
- [4] Łazarz B., Opasiak T., Pypno C., Peruń G.: *Badanie krążników firmy SAG Sp. z o.o. po 10 miesiącach eksploatacji w KWK Mysłowice-Wesoła*. Wydawnictwo Politechniki Śląskiej, Katowice 2014.



- [5] Opasiak T., Gas J.: *Badanie krążników firmy SAG Sp. z o.o. po 3 latach eksploatacji w KWK Mysłowice-Wesoła*. Wydawnictwo Politechniki Śląskiej, Katowice 2018.
- [6] Król R., Kisielewski W., Kaszuba D., Gładysiewicz L.: *Badanie krążników ECO-SAG w warunkach laboratoryjnych*. Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław 2016.
- [7] Szczyrba K.: *Bezprzewodowy system diagnostyki technicznej i przeciwpożarowej przenośników taśmowych*. Rynek Inwestycji 2016, 11: 102–105.
- [8] Furmanik K., Kulinowski P., Kasza P., Zarzycki J., Vasina S., Gawlik W.: *Opracowanie krążnika z uelastycznionymi węzłami łożyskowymi*. Akademia Górniczo-Hutnicza, Kraków 2014 [unpublished].
- [9] Product data sheet SAG – ROLLERS: STANDARD, ECO-POWER, HEAVY DUTY.
- [10] MULTIECHNIKA: [http://woltaika.com/index.php?page\\_id=3](http://woltaika.com/index.php?page_id=3) [10.09.2020].
- [11] Catalogue WDI Westfälische Drahtindustrie GmbH.

JERZY GAS, M.Sc.

SAG Sp. z o.o.

ul. Szopienicka 58a, 40-432 Katowice, Poland

[j.gas@sag.pl](mailto:j.gas@sag.pl)