

LESZEK ŻYREK  
WOJCIECH ZASADNI  
JAN LUBRYKA  
DAWID JENDROSKA

## Mobile lighting of passenger and material monorails stations

*In this article, the authors present the Becker-Warkop company innovative technology development of mobile lighting for passenger and material stations as well as routes during the passage of a suspended monorail. As part of the paper, a technical solution was presented along with its configuration options. The paper also includes standard requirements along with a description of the experiences and good practices obtained during the implementation of this technology.*

Key words: *mobile lighting, suspended monorail, experience, practice*

### 1. INTRODUCTION

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The innovative solution proposed by Becker-Warkop is a direct response to the specific needs of our customers in the area of lighting for mobile and material stations. The mobile lighting of the station gives the possibility of eliminating standalone lighting by using lamps mounted on passenger cabins and transport sets of suspended monorail machines [1]. The use of this lighting technology and the possibility of using it not only at the stations but also during the length of the entire driven routes significantly increases the safety as well as the economic and energy efficiency of the mine. This solution is protected by a patent. Below, we present its details and best practices.

### 2. SOLUTION DESCRIPTION

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Standard standalone lighting of material and personal stations requires constant rebuilding as work progresses. An additional aspect in favor of mobile lighting is the fact that, after the installation of stationary lighting, it works all of the time (not only when it is actually needed), which is the reason for generating

increased costs for energy and the consumption of lighting lamps.

The use of the mobile lighting of suspended monorails with their own drives eliminates the use of electrical devices and power lines from mining routes at risk of explosion, thus increasing the level of anti-explosive safety. To obtain the functionality of mobile lighting for a suspended monorail, the following devices are needed:

- UZOD-02 additional lighting supply system,
- type ŚWIT-14 / MOD [2] lamps (lighting for passenger stations) and type OLR-1-18 / MOD [3] (lighting for material stations) lamps,
- KS-01/1/5 control box in cabins,
- flameproof connectors of PC220 series.

Thanks to these devices, it is possible to implement changes to the power supply system of the machine and add an optional supply of UZOD-02 lighting, thanks to which we obtain the effect presented in Figure 1.

The functionality that is obtained through the use of this solution is to illuminate passenger and/or material stations as well as selected places on the route of the monorail through the mine. Figure 2 shows the placement of an additional UZOD-2 system on the motor part of a suspended monorail.

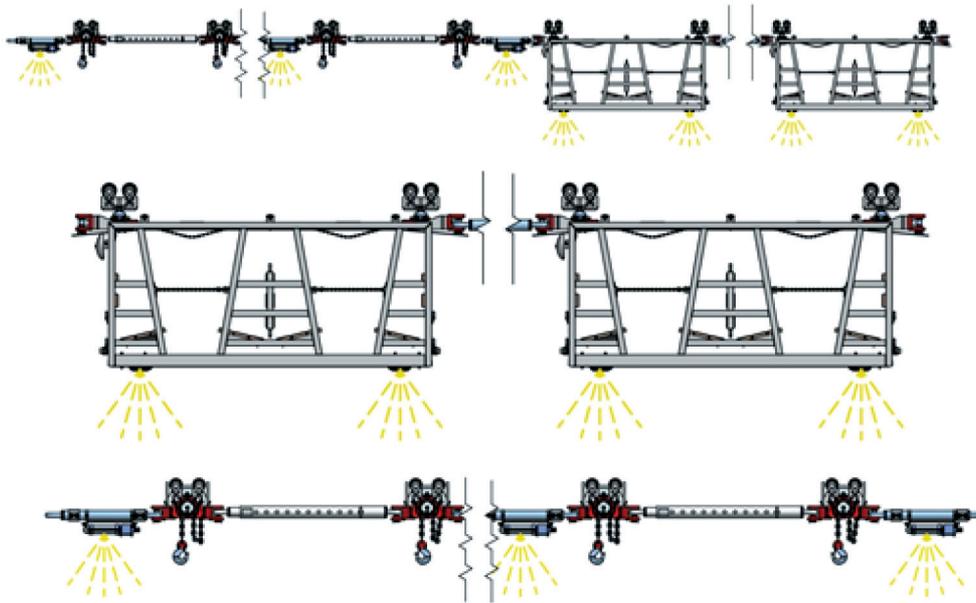


Fig. 1. Example of lighting installation on passenger cabins and transport sets [4]

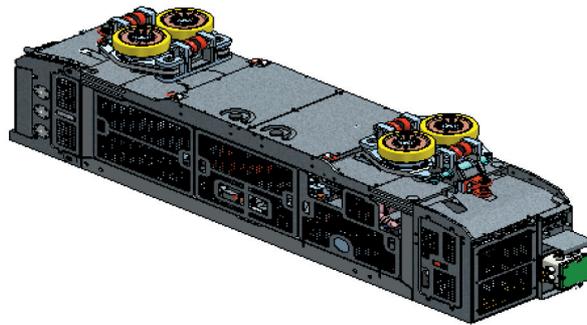


Fig. 2. Example of UZOD-02 power supply system installation on motor part [1]

The remaining elements of the mobile lighting can be installed in cabins suitable for this purpose, having the appropriate approvals of the President of the State Mining Authority; e.g., UIK KO-8-A passenger cabins, UIK KOS-A sanitary cabins, or also built on dedicated adapters serving as hanging lamps on a transport set. Figure 3 presents an example of the SWIT lamps for passenger cabins. Due to their location, the lamps must be properly attached to the cabin, taking into account their dimensions. Placing lamps in passenger cabins is the result of many months of work and testing of the lighting parameters. Another important aspect are vibrations, which are largely eliminated by shock absorbers. Thanks to the applied springs, the effect of retracting the lamps in the cabin is obtained when it comes in contact with the platform, which in combination with the metal cover of the lampshade lamps (from metal rods) results in increased resistance to mechanical damage [3].

In the case of lamps used on transport sets, it is very important to place the lamp under the rod itself so that the emitted light is not limited by the transported load nor by the hydraulic and electrical lines. In addition, special brackets should be used to support the PC220 quick couplers that enable the quick reconfiguration of the sets. The additional power cord of the lamp should be guided through the designated clamps for the hydraulic and electrical lines. An exemplary solution is demonstrated in Figure 4.

The number of lighting sources is limited by the power of the alternator feeding the monorail control system, which is 240 W for the KP-95 and KP-148 monorails. The following values should be used for the calculations:

- two lamps of ŚWIT-14/MOD type for one personal cabin ( $2 \times 10$  W),
- one OLR-1-18/MOD lamp for one pull rod of the transport set ( $1 \times 10$  W).

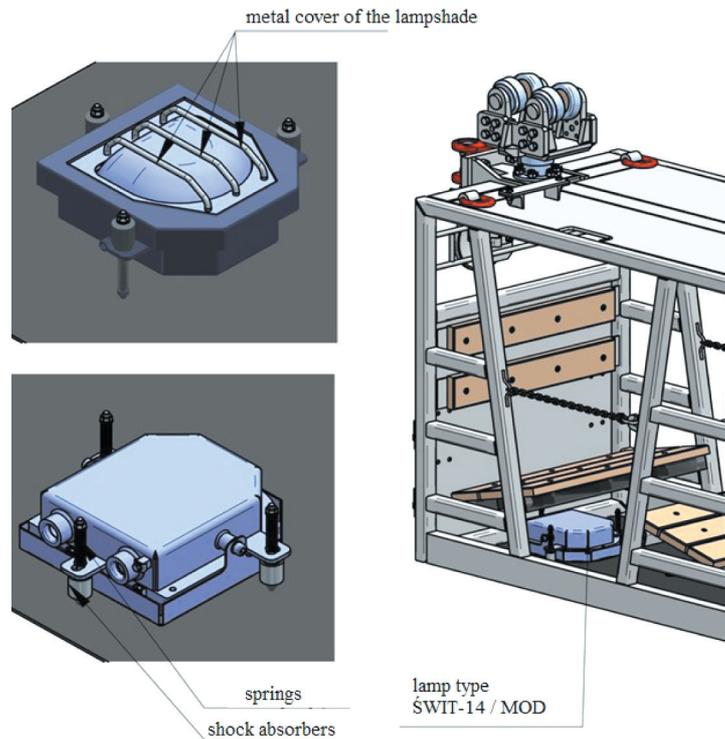


Fig. 3. Sample installation of SWIT lamps in passenger cabin

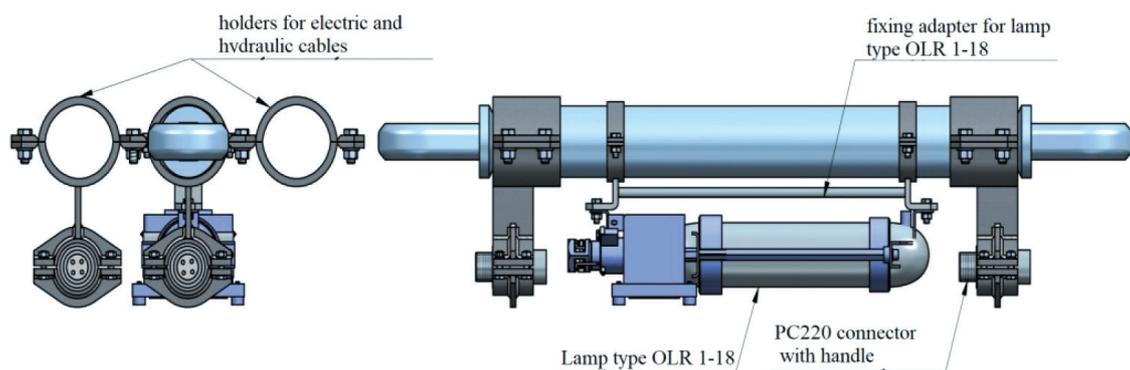


Fig. 4. Exemplary installation of OLR lamp on transport set

The UZOD-02 additional lighting supply system ensures the required performance program for switching LED lights on and off with the KS-01/1/5 control box; i.e., switching lamps intended for lighting passenger stations (ŚWIT-14/MOD lamps) or switching lamps for lighting material stations or lamps intended for simultaneously switching lamps on or off for lighting passenger and material stations. An example of the arrangement of the KS-01/1/5 cassette in the operator's cabin is shown in Figure 5.

If the insulation resistance is lower than 10 kΩ, a warning message will be generated by the monorail control system. The device controlling the insulation condition is a standard protection of the monorail installation built into the ZUSD-01 power supply unit.

After connecting additional devices (lamps), this circuit is also controlled by this protection.

Additional level of protection built into the supply system for the UZOD-02 additional lighting is protection that controls the continuity of the grounding on its outflows. Any disturbance in the electrical system (i.e., short circuiting, opening, a too high resistance of the loop, or the incorrect termination of the earth continuity monitoring circuit or other defects) are additionally monitored by the monorail's control system, and the appropriate messages are displayed on the WLM-01 (Fig. 7) or MSPM-01 or 04 displays (Fig. 6). The termination of the earth continuity monitoring circuit is done by a male protective cover (BM-PC220) or a diode built into the lamp.

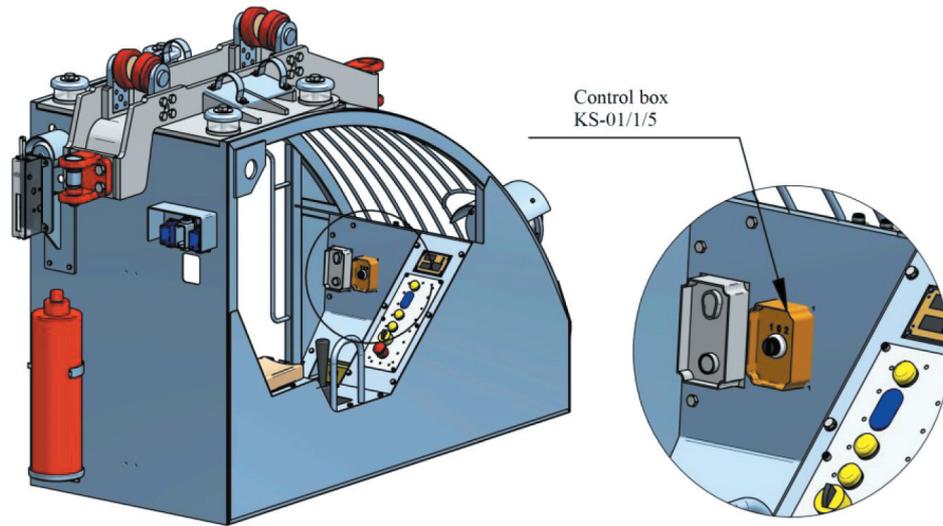


Fig. 5. Placement of KS-01/1/5 box in operator's cabin [3]



Fig. 6. Machine status monitor type MSPM-01



Fig. 7. Driver's display type WLM-01

The sets between themselves and the motor part are connected via PC220-series quick connectors. Figure 8 shows an example configuration of a human transport monorail equipped with a PC220-series connector system.

It is allowed to make connections between cabins and transport sets using cable – cable glands to reduce costs.

Up until July 2017 (before each lighting system replacement of the lighting of passenger and material stations), it was necessary to measure the intensity of the lighting, uniformity factor, and inventory ratio by qualified personnel with appropriate qualifications.

During the implementation of this solution, the measurements of the personal and material stations at the JSW SA and KWK Krupiński mine were made in 2016 by OPA-ROW Sp. z o.o. (Environmental Research Laboratory) included in the reports confirmed that the lighting installation built under the passenger cabins and under the tie rods of the transport sets met the requirements of PN-G-02600 “Lighting of underground mining plant operations” [5].

The Polish standard in Point 2.4.1 explicitly defined that, in the excavation corridors, the smallest allowable average illuminance, uniformity of lighting, and inventory factor should correspond to the values in Table 1.

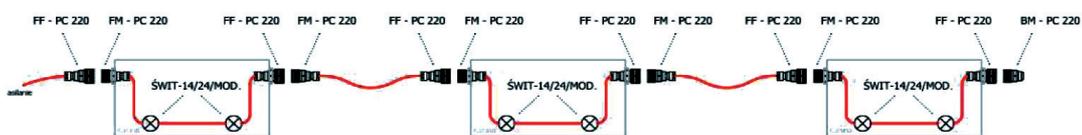


Fig. 8. Examples of electrical connection of lighting between cabins [2]

**Table 1**  
**Required illumination according to PN-G-02600**

No.	Illuminated area	Illuminated surface	Factor inventory	Parameters lighting	
				intensity lighting $E_{Wed}$ [lx]	uniformity lighting $\delta_{sr} = \frac{E_{min}}{E_{sr}}$
1	2	3	4	5	6
1	Shaft bottom	bottom	1.5	thirty	0.4
2	Shaft bottom – entrance to the cage, workstation for the signaller	bottom, heights with signaling equipment	1.5	thirty	0.3
3	Passenger station with rail transport	bottom on the side of the entrance to the carts	1.5	thirty	0.4
4	Passenger station with tire transport	bottom	1.5	20	0.4
5	Platforms for getting on the conveyor and getting off the conveyor	bottom	1.5	20	0.3
6	Pier, horizontal or sloping footpath for pedestrian traffic	bottom, transition for people	1.5	5	0.2
7	The route of the queue and other means used for transporting people (without pedestrian traffic)	bottom	1.5	2	0.2
8	Turnouts, forks, intersections, narrowing, intersection of pedestrian crossings with the conveyor route on major roads	bottom	1.5	10	0.3
9	Dams (on both sides) on the main transport routes	bottom	1.5	10	0.3
10	Station material, loading, transfer	edge car, trellis	2.0	10	0.3
11	Station borders	bottom	2.0	5	0.2
12	Other workplaces and places of installation of machines and devices, communication means, etc. in sidewalks and trenches	bottom or other work surfaces	1.5	10	0.3

According to the latest ordinance of the Minister of Energy from November 23, 2016, regarding the detailed requirements for the operation of underground mining in Annex 4, Section 4.9. Rope transport and self-propelled transport sets are defined as:

“4.9.7. Illuminates:

- 1) (...);
- 2) stations during loading or unloading;
- 3) passenger stations when people are boarding or disembarking”.

In addition, when driving a monorail, the road can be additionally illuminated (which increases the level of safety).

### 3. SUMMARY

The simple and at the same time innovative solution proposed by Becker-Warkop presented above has been developed as a solution resulting from the specific needs of our clients. It provides not only technological and economic benefits in the area of lighting for passenger and material stations but also improves the safety of the crew working near the suspended railway route at

the time of a particular threat (that is, during monorail movement). This is one of the examples of cooperation between Becker-Warkop and our clients, who are our inspiration and partners.

### References

- [1] Annex no. 6 to the Instruction Manual of a suspended monorail type KP-95 – applicable to mobile lighting of mobile and material stations.
- [2] User's manual for the ŚWIT-14 / MOD type lamp from Elektrometal S.A.
- [3] User's manual for OLR-1-18 / MOD type lamps from Elektrometal S.A.
- [4] Datasheet of Becker-Warkop mobile lighting.
- [5] Annex no. 6 of the Service Manual of a KP-148 suspended type tractor mobile lighting station of the KP-148 railway station – applicable to mobile lighting of passenger and material stations

*LESZEK ŻYREK, Eng.*  
*WOJCIECH ZASADNI, Ph.D., Eng.*  
*JAN LUBRYKA, M.Sc., Eng.*  
*DAWID JENDYSKA, M.Sc., Eng.*  
*Becker-Warkop Sp. z o.o.*  
*ul. Przemysłowa 11, 44-266 Świerklany, Poland*  
*{l.zyrek, w.zasadni, j.lubryka, d.jendroska}*  
*@becker-mining.com.pl*