U. S. Department of Labor
Mine Safety and Health Administration

"Better Lighting for Metal-Nonmetal In-Mine Preblast Operations"

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ABSTRACT

Accidents in metal-nonmetal mines have occurred that indicate the need for improved lighting while performing preblast loading operations. An engineering study was conducted to determine the feasibility of installing supplemental lighting on underground mining lift equipment used in blast hole loading operations. The study identified two types of lighting systems that could be installed on lift equipment to significantly improve the ability of miners to judge the integrity of the mine roof and back.

DISCLAIMER

The mention of any company or product in this report does not constitute endorsement by MSHA.

INTRODUCTION

An engineering study was undertaken to determine what additional lighting could be provided to improve the illumination of the area to be loaded with explosives. The effectiveness of supplemental lighting added on elevated lift platforms used in the preblast loading of explosives was the focus of this in-mine study. Recommendations are made from this study for the installation of additional lighting to achieve more effective illumination of preblast areas.

LIGHTING REGULATIONS

Federal regulations address illumination for underground metal-nonmetal mines in Title 30, Code of Federal Regulations (30 CFR). Part 57, Subpart P- Illumination, Section 57.17010, Electric Lamps (Ref. 1), requires that "individual electric lamps shall be carried for illumination by all persons underground". No other illumination requirements are provided in 30 CFR for metal-nonmetal mines. Therefore, additional lighting in an underground metal-nonmetal mine is at the mine operator's discretion.

It is the mine operator's responsibility, however, to examine each working place as specified in 30 CFR Part 57, Subpart Q-Safety Programs, Section 57.18002, Examination of Working Places (Ref. 1). The mine operator is required to examine each working place at least once each shift for conditions which may adversely affect safety or health and promptly initiate appropriate action to correct such conditions. To meet this requirement for examination of working places, it is essential for the mine operator and the miners to be able to clearly see hazardous conditions.

The electric lamps used to meet the requirements of 30 CFR Part 57.18002, in most cases, are miner's cap lamps. The cap lamp was originally designed for use in coal mines where the mine roof is usually no higher than 8 to 12 feet. Approved according to 30 CFR Part 19-Electric Cap Lamp requirements (Ref. 2), the cap lamp meets specific illumination requirements for angle of illumination and illumination intensity at specific distances. The illumination capability of the MSHA approved cap lamp is marginal at best for observing details in the rock formations of mine roofs or backs that are 25 feet or higher from the mine floor.

IN-MINE LIGHT STUDY

Five (5) underground hardrock mines participated in the MSHA preblast lighting study. A list of these mines is presented under the Acknowledgement section. The operators of the 5 mines understood the need for supplemental illumination for examination and/or production purposes. Each mine in the study used additional lighting on equipment or used portable hand-held lights for spot inspections. These mine operators recognize the electric lamp used by each miner is not adequate for all their lighting needs.

The results of this preblast lighting study have shown that supplemental lighting added to equipment benefits in making detailed observations of the mine roof and back. Low cost halogen lights and higher cost high intensity discharge (HID) xenon lights were used on various elevated lift platforms in the 5 mines that participated in the study. A typical elevated platform is shown in Photograph 2. Detailed specifications and cost of the halogen and HID lights used in this study are provided in the following sections.

Description of Halogen Lights

Round and rectangular halogen lights used in this study incorporated a diffuse lens and a replaceable 12-volt, 100-watt halogen bulb. These lights are primarily used as supplemental lighting for the off-road commercial truck market and are available in auto parts stores. These lights cost approximately $50 per light and a replacement bulb costs less than $6. These lights offer a low cost solution for supplemental lighting in preblast operations.

A typical beam pattern for a 100-watt halogen lamp is shown in Photograph 3. The spectral output and illumination intensity of these type of lights are listed as follows:

<u>Round lens</u>
Operating spectral color temperature, 3200^0K yellow light
Light intensity, 60.9 lux @ 20 feet, 14.1 lux @ 40 feet

<u>Rectangular lens</u>
Operating spectral color temperature, 3200^0K yellow light
Light intensity, 132.4 lux @ 20 feet, 38.0 lux @ 40 feet

Description of High Intensity Discharge (HID) Lights

The high intensity discharge (HID) lights used in this study incorporated a diffuse lens and a replaceable 12-volt, 35-watt xenon bulb. The 35-watt HID bulb is shown in Photograph 4. These lights are used for primary or supplemental lighting for heavy duty, off-road construction and mining equipment. The lights were purchased from an industrial lighting distributor. Each light costs approximately $400 and a replacement bulb costs approximately $20. Typically, the HID lights for heavy-duty equipment meet the vibration standard, International Electrotechnical Commission (IEC) Standard 60068-2-64 (Ref 3). Although higher in price than the halogen lights, the HID lights offer

a light quality that is noticeably superior for illumination in the underground mine environment.

A typical beam pattern for a 35-watt HID lamp is shown in Photograph 5. The spectral output and illumination intensity of the HID lights are listed as follows:

Operating spectral color temperature, 4000 ^{0}K white light
Light intensity, 69.82 lux @ 20 feet, 20.95 lux @ 40 feet

A comparison of the illumination from a halogen light to a HID light is shown in Photograph 6. Several different types of halogen and a high intensity discharge (HID) light were tested for light output in the Engineering & Testing Division's Light Laboratory. The results of the tests are shown in Table 1. Although the light intensity for the halogen rectangular light is almost twice the light intensity as the HID rounded square, the area of light at 12 feet is much larger for the HID light as shown in Table 1. Typical examples of halogen and HID lights used in this study are shown in Photographs 7, 8, and 9.

Both the halogen and the HID lights will provide additional illumination to identify the integrity of the roof and back. However, the HID light as reported by blasters working on the elevated work platform will supply effective lighting that is easier to work near than the halogen light. The HID light also provides more light output with more efficient use of power than the halogen light. Compared to the halogen light, the HID light provides 3 to 4 times the light per watt of power. The 35-watt, 12 volt HID light will draw approximately 3 amps from the equipment generator/battery electrical power source. The 100-watt, 12-volt halogen light will draw approximately 8 amps from the equipment's power source. Where multiple lights are installed, the total power demands from the source must be considered, as well as wire size and overload protection.

Also by comparison, the operating life of the HID light is 3 to 8 times longer than a halogen light. However, the cost of a halogen light is much less expensive as compared to a HID light.

Installation of Lights

The lights were installed on the lift platforms as follows: (1) on the cab roof, (2) at the base of the telescoping boom, (3) at the lift platform's knee rail, and (4) on the edge of lift platform's canopy. Some of these installations are shown in Photographs 10, 11, and 12. The roof or back heights were as much as 25 to 27 feet.

In all installation locations, the additional lighting increased the illumination of the ribs and face compared to cap lamps only. Photograph 13 shows the illumination from a miner's camp lamp as compared to the illumination from two HID lights on a lift platform shown in Photograph 14.

Lights installed at the knee rail of the lift platform were too bright for the blasters to work effectively in their vicinity. Lights installed on the edge of the lift platform canopy did not illuminate the back to any beneficial level. Lights installed on the base of the boom and

on the equipment cab roof provided the greatest illumination of the back as shown in Photographs 15 and 16. The greatest effect was accomplished when the lights were directed toward the back.

The quality of light projected by the HID lights was recognized by personnel at each mine in this study. The brightness and clarity of the HID lights increased the ability to see the detailed rock features of the roof, back and rib. The blasters on the elevated platforms or ground workers in the area could easily identify detailed features in the rock. Both blasters and scalers reported that they observed and scaled down more loose rock while using the high quality light from the HID fixtures.

The halogen lights used in the study also enhanced the ability of miners to observe the detailed rock features of the roof, back and rib formations, provided they were appropriately oriented. The illumination provided by the halogen lights was sufficient enough to highlight the loose rock that blasters and scalers needed to scale down.

However, the miners preferred the HID lights to the halogen lights. There was less glare emitted from the HID lights and the miners found it easier to look toward a HID light without becoming temporarily blinded by its light. The glare of the halogen lights adversely affected the vision of miners, even though the lights were not pointed directly at them.

An area of concern was the heating of the lens of the halogen and HID lights. It was determined through test, that the halogen and HID lights used in the study generated lens surface temperatures of approximately 290 ^{0}F and 190 ^{0}F, respectively. Additionally it required approximately 8 minutes for the halogen light and 3.5 minutes for the HID light for the lenses to cool to the safe temperature limit of blasting agents (150 ^{0}F) when power was removed. **Caution must be exercised when using blasting agents in the vicinity of these lights.** Based on this study, best practices for use of these lights would be to de-energize them and let them cool for at least 15 minutes prior to the use of blasting agents in their vicinity or to guard or physically locate the lights to prevent contact with blasting agents. It is specified in 30CFR, Part 57, Subpart E-Explosives, Section 57.6905(a) (Ref. 4) that “explosive material shall be protected from temperatures in excess of 150 degrees Fahrenheit.

Some of the manufacturers and suppliers of halogen and HID lights are provided in the Appendix.

RECOMMENDATIONS

It is recommended that supplemental lighting be added to elevated lift equipment to improve the illumination in preblast areas, especially in high back situations. With increased illumination, it is expected that blasters and ground crews will better identify loose and hanging rock on the roof or back. The loose rock could then be scaled down before the blaster and others in the immediate presence of the blaster ascend on the lift platform to load blast holes.

Specific recommendations are as follows:

1. Supplemental lighting should be added to the super structure of the elevated work platform near the cab roof or at the base of the telescoping or articulating boom. The supplemental lights should be aimed at either the mine roof or back directly above the elevating platform and boom or the mine roof or back above the platform while following the inclination of the elevating platform.

2. Lights designed for use on off-road equipment should be selected for this application. Lights for off-road vehicles are designed to withstand the rigors of a harsh environment. Halogen and High Intensity Discharge (HID) lights of the off-road type are commercially available in various voltages and wattage to meet most lighting needs (see Appendix). Twelve (12) volt, 100-watt halogen lights and 35 watt HID lights have been shown in this study to provide adequate supplemental lighting by in-mine tests with roofs or backs as high as 27 feet. Higher wattage lamps may be needed to illuminate mine roofs or backs of greater heights.

3. When adding supplemental lighting on mining equipment, attention must be given to the use of the proper conductor sizes, overload protection, protection of cabling against damage and power demands on the equipment's electrical power supply.

4. The conductive parts of the lights must have continuity of the ground/bonding system. As an example, the conductive parts of the lights need to be grounded and bonded to the loading equipment and the loading equipment must be bonded and grounded and the grounding must not be made to other potential sources of extraneous electricity. In addition, lead wires and blasting lines must be isolated and insulated from power conductors, pipelines, tracks, and must be protected from sources of stray or static electricity. An external bonding strap between exposed conductive parts of the lights and the equipment frame would allow a visual inspection. Bonding straps help to maintain grounding, even if the light fixture was to lose its ground.

5. **Caution must be taken when supplemental lighting is installed on equipment where blasting agents are handled due to the potentially high surface temperature of the lens when a light is energized.** Lights must be located where inadvertent contact with blasting agents is not possible.

6. Supplemental lighting systems that are to be used in a mine that has been place into one of the categories defined in 30 CFR, Subpart T—Safety Standards for Methane in Metal and Nonmetal Mines must meet the applicable permissibility requirements

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Better Materials, Connellsville, PA
Cool Spring, Uniontown, PA
Greer Limestone, Morgantown, WV
Hanson Aggregate's Whitney Mine, Latrobe, PA
Latrobe Construction Materials, Latrobe, PA

REFERENCES

1. Title 30, Code of Federal Regulations, Part 57, Subpart P- Illumination, Section 57.17010 and Subpart Q-Safety Programs, Section 57.18002, July 1, 2001.

2. Title 30, Code of Federal Regulations, Part 19, Electric Cap Lamps, July 1, 2001.

3. International Electrotechnical Commission (IEC) Standard 60068-2-64 (1993-05), Environmental testing, Part 2: Test methods—Vibration, broad-band random and guidance, 85 pgs. and Sylvania-Osram Technical Product Information, Italy.

4. Title 30, Code of Federal Regulations, Part 57, Subpart E-Explosives, Section 57.6905(a), July 1, 2001.

APPENDIX

List of Manufacturers and Suppliers of Off-Road Equipment Lights:

<u>Halogen</u>

Advanced Auto Parts
Pep Boys
NAPA
Checker
Reliable
Keystone

<u>High Intensity Discharge</u>

United Group, Inc., Telephone 847-816-7100
Phoenix Products Company, Inc., Telephone 414-438-1200
Nordic Lights, Finland, Telephone +358 6 781 5138

Note: These lists are provided as an informational source of vendors. They are not a complete list of possible vendors. MSHA does not endorse the businesses listed.

TABLE 1

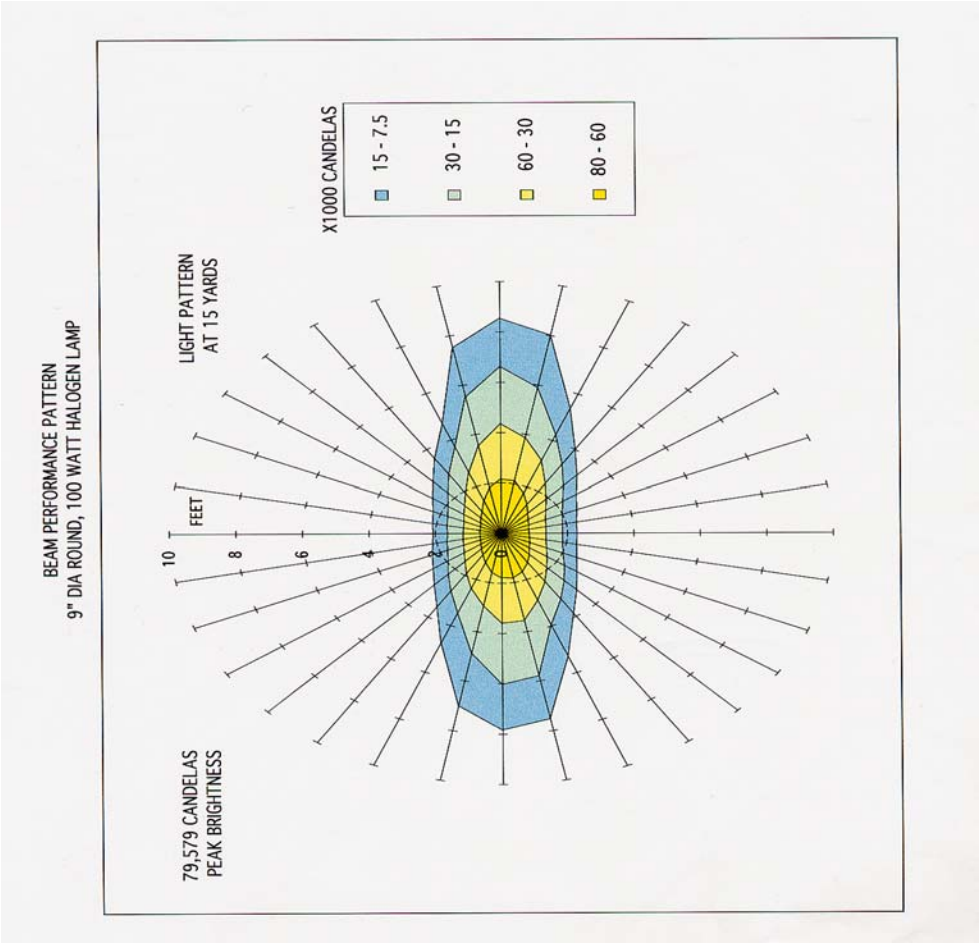
ETD Darkroom Light Output Tests

Fixture and Type	Current In	Output 5 ft.	Output 20 ft.	Output 40 ft.	Spot@12 ft. (W x H)
Rectangular 12VDC 100W Halogen	5.8 amps	3.02K lux	132.4 lux	38.03 lux	5ft. x 3ft.
Round 12VDC 100W Halogen	5.7 amps	1.003K lux	60.90 lux	14.1 lux	14ft. x 5ft.
Round 12VDC 150W Spotlight, Halogen	8.7 amps	42.06K lux	3.142K lux	820.4 lux	3ft. x 1ft.
Rounded square 12VDC 35W, HID	3.5 amps	2.007K lux	69.82 lux	20.95 lux	5ft. x 16ft.

Photograph 1 – Fallen Slab from the Back of Stope at a Fatal Accident Scene

Photograph 2 – Typical Elevated Platform

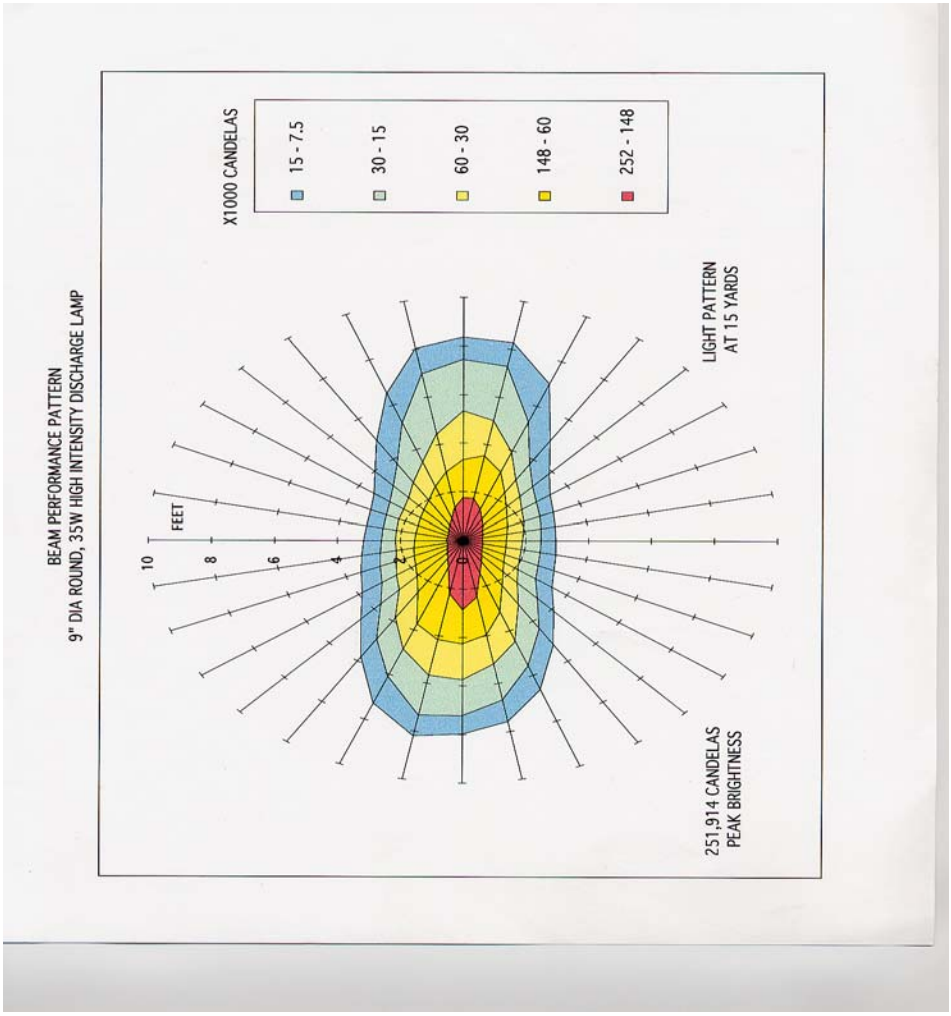
Photograph 3 – Typical Beam Pattern for a 100 Watt Halogen Bulb



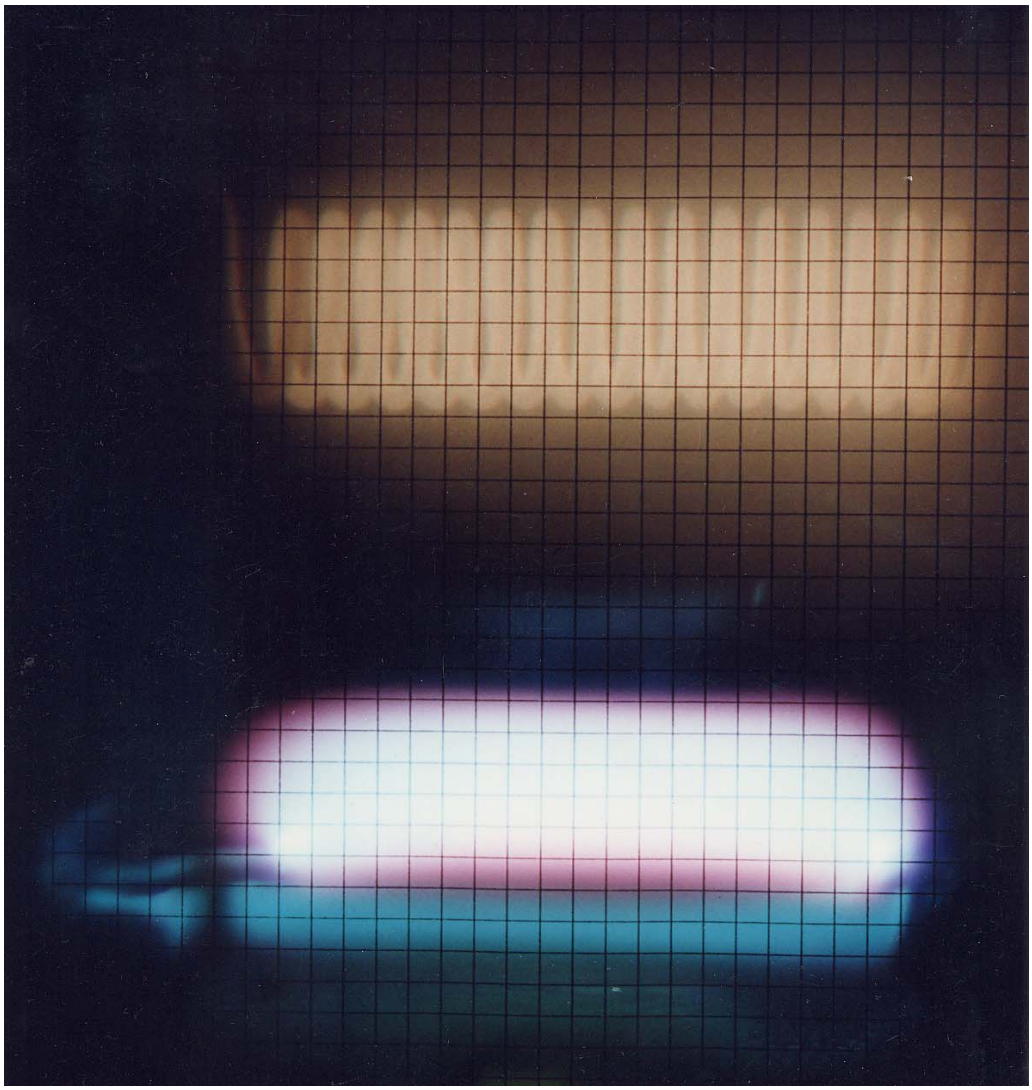
Photograph 4 –Typical HID 35-Watt Bulb

D2L "Super Long Life" Gasentladungslampe

Photograph 5 – Typical Beam Pattern for a 35 Watt HID Bulb



Photograph 6 – Illumination Comparison of a Halogen to HID Light



Photograph 7 – Round 100-Watt Halogen Light

Photograph 8 – Rectangular 100-Watt Halogen Light

Photograph 9 – 35-Watt High Intensity Discharge (HID) Light

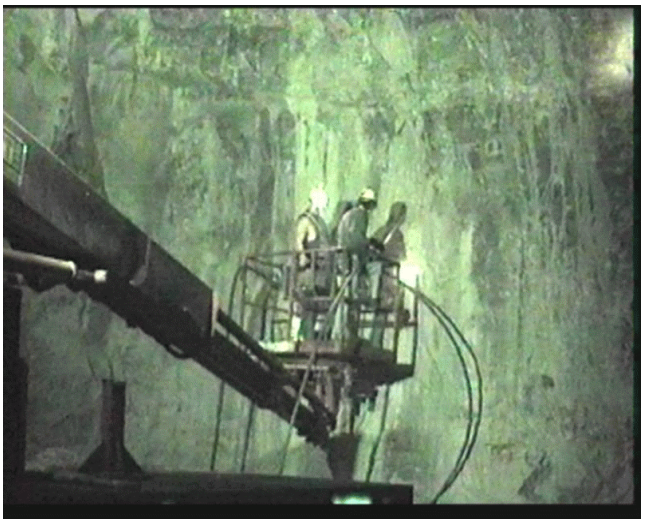
Photograph 10 – Lights Installed on a Canopy of a Lift Platform

Photograph 11 – Lights Installed on a Boom of an Elevated Lift

Photograph 12 – Lights Installed on a Cab Roof of an Elevated Lift and Directed to the Mine Roof

Photograph 13 – Illumination of the Back by only a Miner's Cap Lamp

Photograph 14 – Illumination of a Back by Two HID Lights on a Lift Platform



Photograph 15 – Illumination of the Back and Roof with Two Halogen Lights Installed on the Cab Roof of a Lift

Photograph 16 – Illumination of the Back and Roof with Two HID Lights Installed at the Base of the Lift Boom