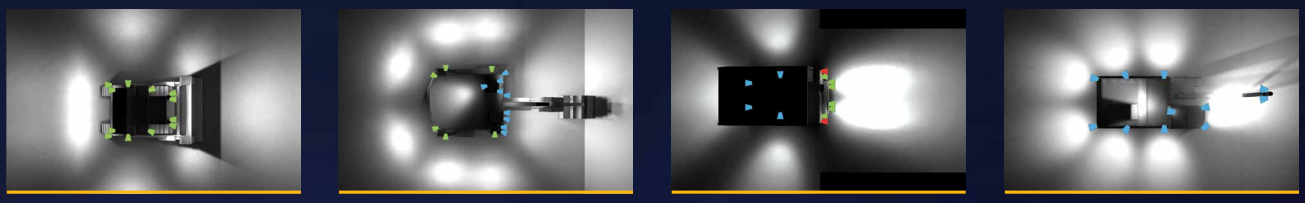
PHOENIX®
DURABILITY X DESIGN™

eBook

Safety First, Performance-Centric Lighting Designs

How to Optimize LED Lighting for Mobile Equipment



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With its advantages becoming more apparent by the day, mining operators are increasingly upgrading to LEDs to safeguard lives and improve mining output. But the switch to LED is only one part of the equation. Of bigger concern should be where and how LED fixtures are mounted, particularly on mobile mining equipment.

It pays for mining operators to re-examine and optimize the lighting designs of their mobile fleet. The specific designs and optics of LEDs mean that a high-quality fixture, in the wrong place, often results in sub-par light that compromises operator safety and performance. An optimal lighting design isn't just nice-to-have – it's key to reaping the full benefits of LEDs.

This e-book taps into years of LED experience and best practices from mining operations around the world, to provide a clear idea of what constitutes an optimal but practical lighting design. In it you'll find:

- Optimized lighting designs for five different types of mobile equipment, tried-and-tested for safety and productivity
- Recommended beam optics (flood, spot, elliptical) that help each equipment carry out their roles in the field
- A comprehensive five-step lighting audit to evaluate the efficiency and effectiveness of a lighting design

With the right guidance and proper procedures, it's easy to implement the ideal lighting design for all of your mobile equipment. Mine sites around the world that have done so are directly reaping the benefits. With the knowledge in this e-book, your operations could tap into those same gains.

The anatomy of good lighting design

A good lighting design maximizes the performance of LED fixtures, by placing them where they can aid the safety and productivity of mobile operators. What results is clean and uniform light, by design, that improves operator visibility, productivity and efficiency. This, in turn, allows mobile operators to work confidently around heavy machinery and fully focus on the job at hand.

Among other things, it should have:

- Strategically positioned fixtures to provide uniform light to key areas, enabling operators to work confidently and minimize mistakes
- Fixtures positioned around the equipment's perimeter, providing safety and visibility around dangerous areas of the machine
- Fixtures equipped with the right optics to create the appropriate beam pattern for the task at hand
- Fixtures aimed at the right angle to minimize fixture glare that could blind operators, mining crew or incoming equipment at night
- Fixtures spaced out to avoid bright spots that contrast sharply with surrounding darkness, resulting in eye fatigue during long night shifts

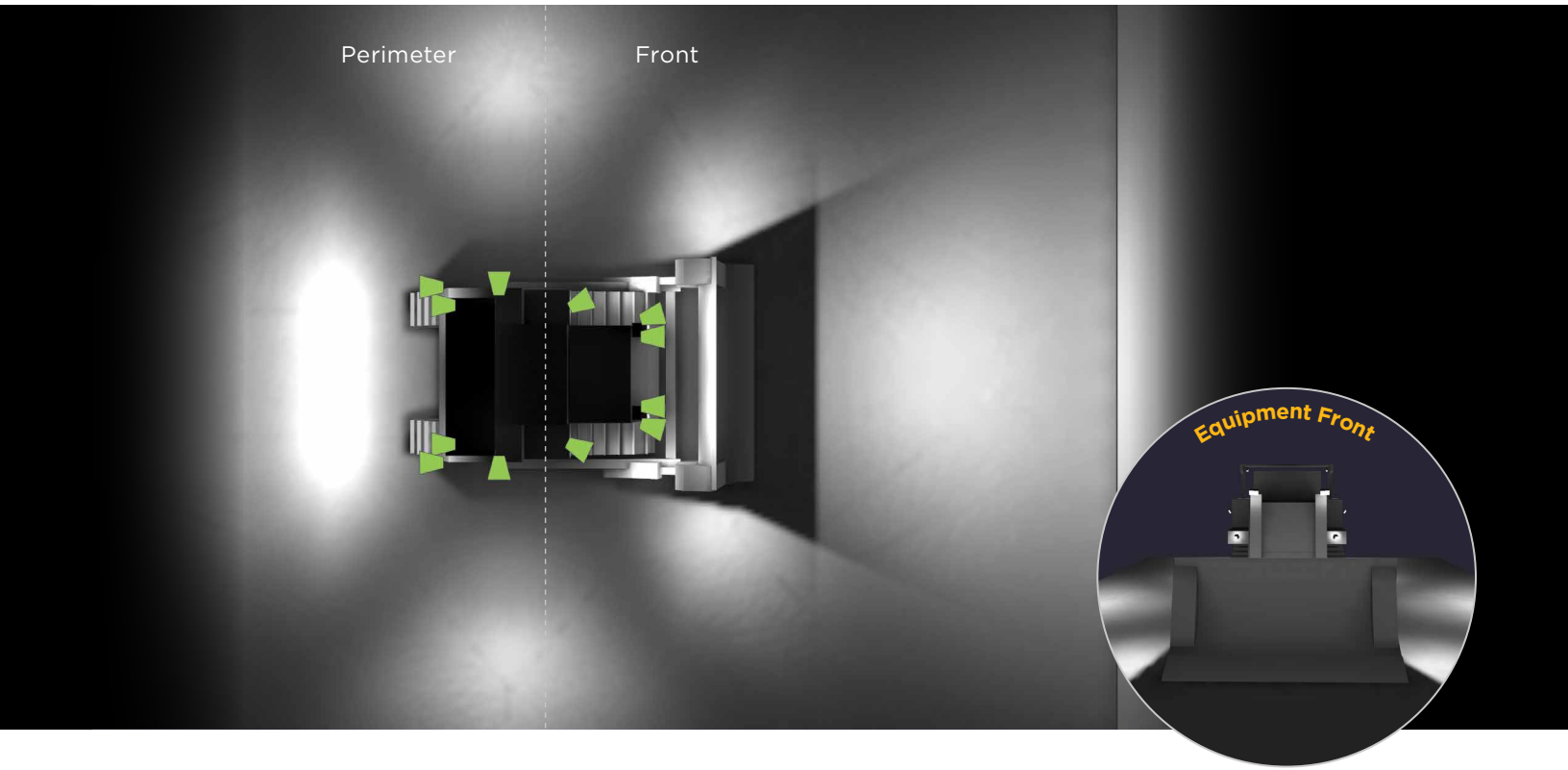
During busy periods, it's not uncommon for maintenance crews to replace broken fixtures with any available light in their inventory – even if their specifications don't match. This creates lighting inconsistencies that slow mobile operators down, as their eyes struggle to adjust. Worse, it could even lead to worker injuries or costly accidents, due to limited visibility or overly bright glare.

That means mining operations must proactively evaluate and consider lighting designs for all types of mobile equipment, no matter what. To do this effectively, they must first understand the optimal LED layout and lighting best practices for each piece of mobile equipment in their fleet.

Quick Note: The lighting and visual designs in this e-book are based on the specifications and field-tested performance of our best-in-class Sturdilite® Master Series fixtures. Results may vary according to your choice of LED fixture.

1 Lighting Designs for Dozers

The workhorse of any mine, dozers work day and night, building ramps and laying the foundation for future operations. Working so close to the ground, dozers rely on well-placed lights to illuminate their uneven and debris-filled surroundings. It's the only way to keep themselves – and others around them – safe as they move the earth through dust and darkness.



Equipment Section	Recommended Number of Fixtures	Color Temperature
Front	6 to 8 with Elliptical Optics	5000- 5500K (clear conditions) / 2200 - 2500K (inclement weather)
Sides	2 with Elliptical Optics	5000- 5500K
Rear	4 with Elliptical Optics	5000- 5500K

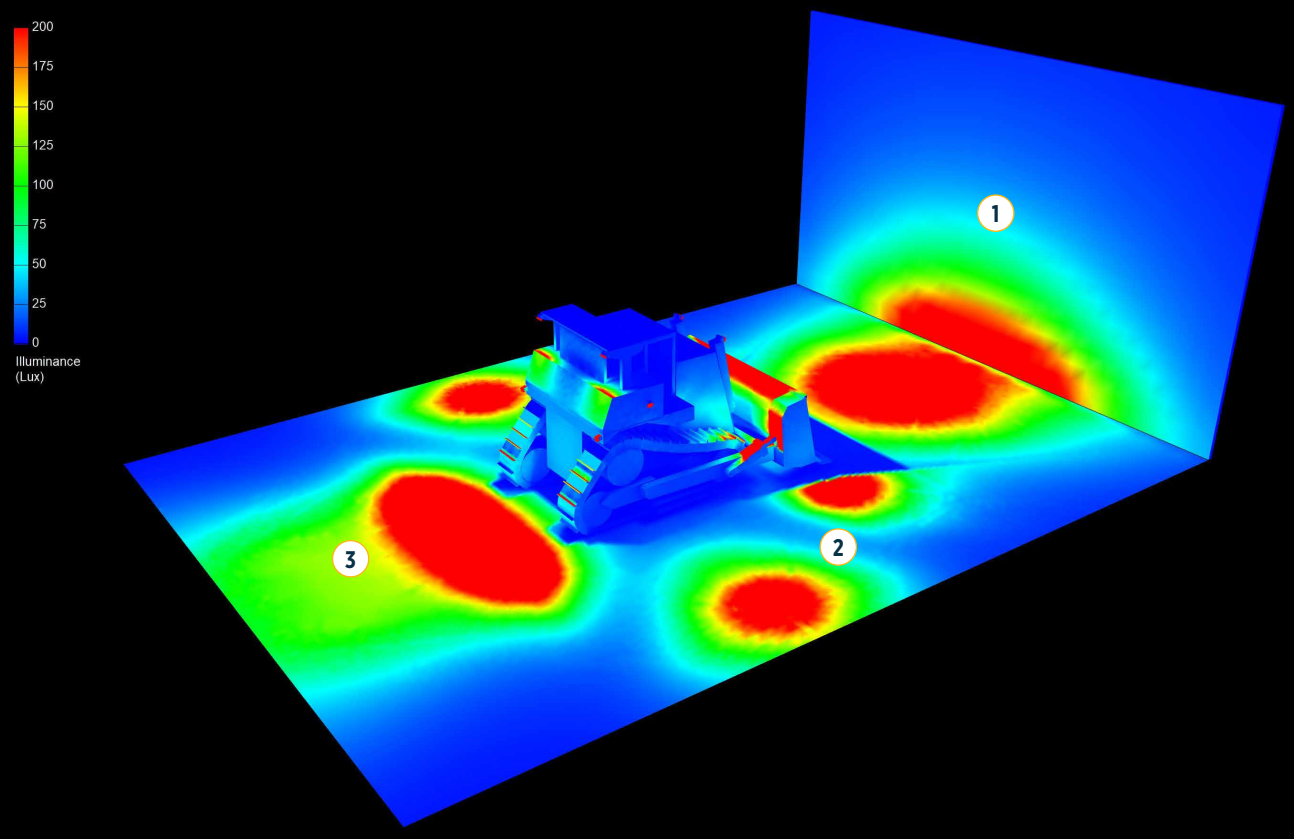
Elliptical Optics

Lighting Designs for Dozers

Lighting Best Practice

1. Provide uniform elliptical light at the front of the blade, where the action takes place. Illuminating this work area allows the equipment's operator to work with greater precision while remaining aware of potential hazards ahead.

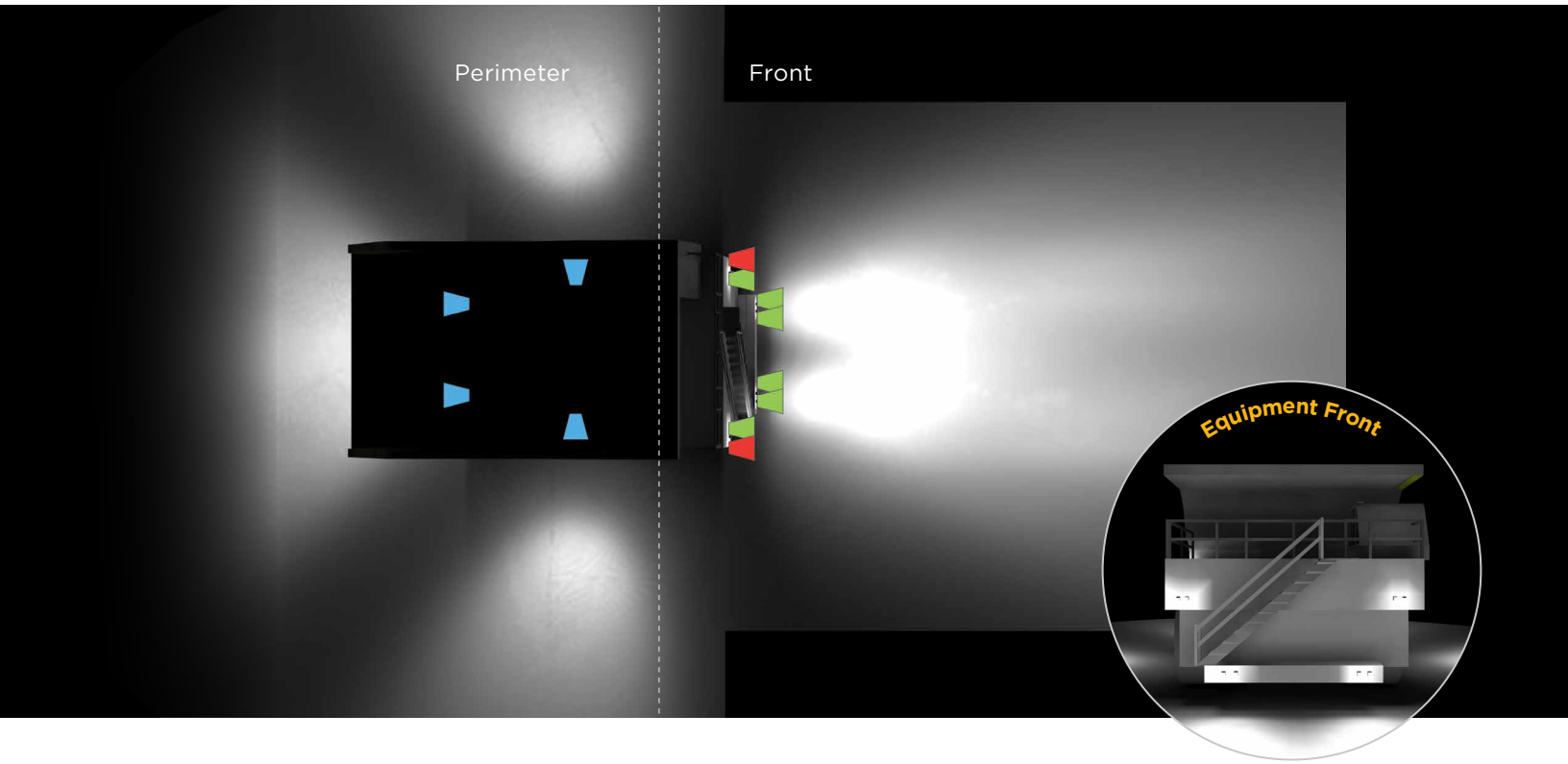
2. Fixtures with elliptical optics on either side provide the visibility that operators need for safe ingress or egress. It also highlights the dozer's profile to nearby equipment in low-visibility conditions, without the glare that usually occurs when using fixtures with spot or flood optics.



3. Dozers reverse frequently as they work, making rear lights essential. To aid these maneuvers, some dozers even come installed with rear cameras. To avoid fixture glare on the camera lens – and the operator's vision – use elliptical fixtures that provide smooth, uniform light.

2 Lighting Designs for Haul Trucks

As they haul material across mining sites, these lumbering behemoths depend on high performing fixtures to light the way ahead. A good lighting design will help haul truck operators safely navigate through rugged terrain, heavy rain or thick fog. It should also alert oncoming equipment of the haul truck's position, preventing collisions.



Equipment Section	Recommended Number of Fixtures	Color Temperature
Front	2 with Spot Optics 6 with Elliptical Optics	5000- 5500K (clear conditions) / 2200 - 2500K (inclement weather)
Sides	2 with Flood Optics	5000- 5500K
Rear	2 with Flood Optics	5000- 5500K

Spot Optics Elliptical Optics Flood Optics

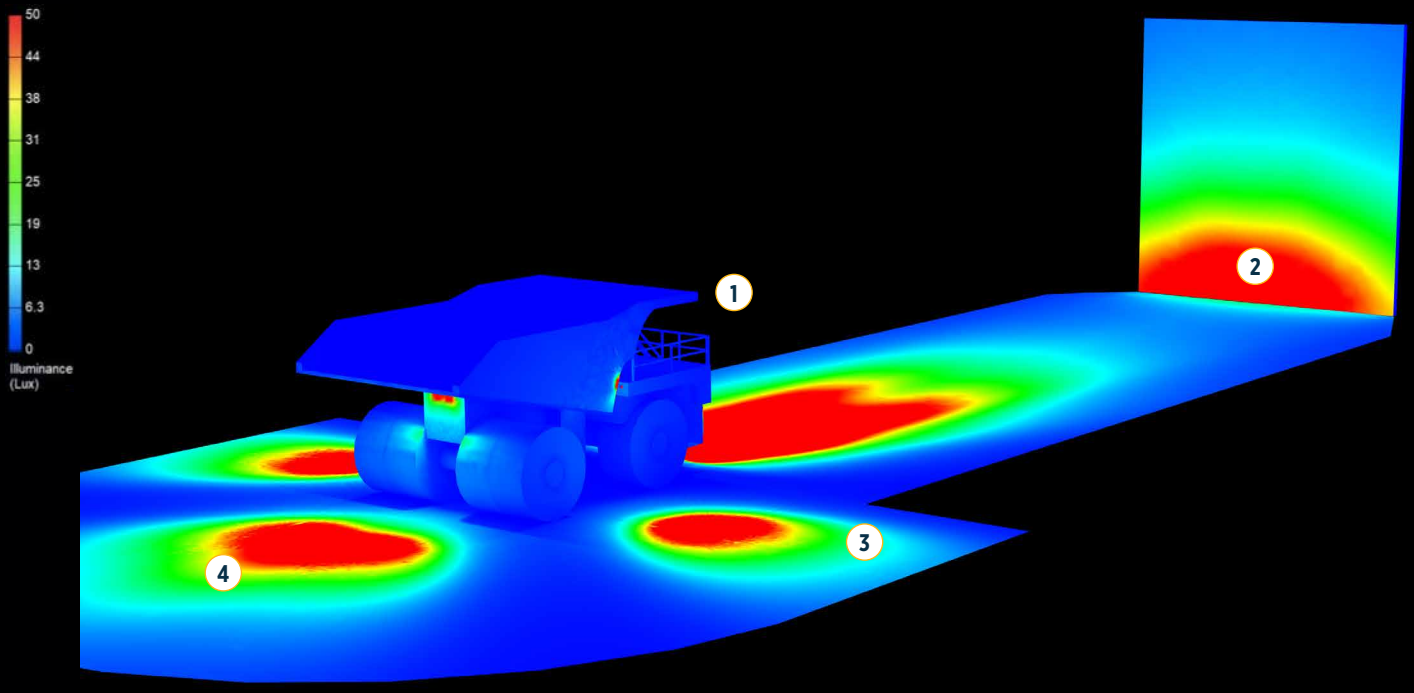
Lighting Designs for Haul Trucks

Lighting Best Practice

1. As the haul truck travels, it will depend on its 'driving lights' – typically four to six fixtures with elliptical optics aimed at the ground. These fixtures will illuminate blind spots six to seven meters in front of the truck, allowing its operator to drive safely.

   They also provide smooth, even illumination that contrasts minimally with the surrounding darkness. This minimizes operator eye strain while driving and reduces glare and interference to a truck's crucial front and side camera systems.

2. During particularly bad weather or at night, haul truck operators would also depend on two fixtures with spot optics mounted near the driving cab. These fixtures create twin beams of high-intensity light that can pierce through thick fog, rain and dust. Combined with fixtures with elliptical optics, this helps operators maintain visibility in inclement weather.

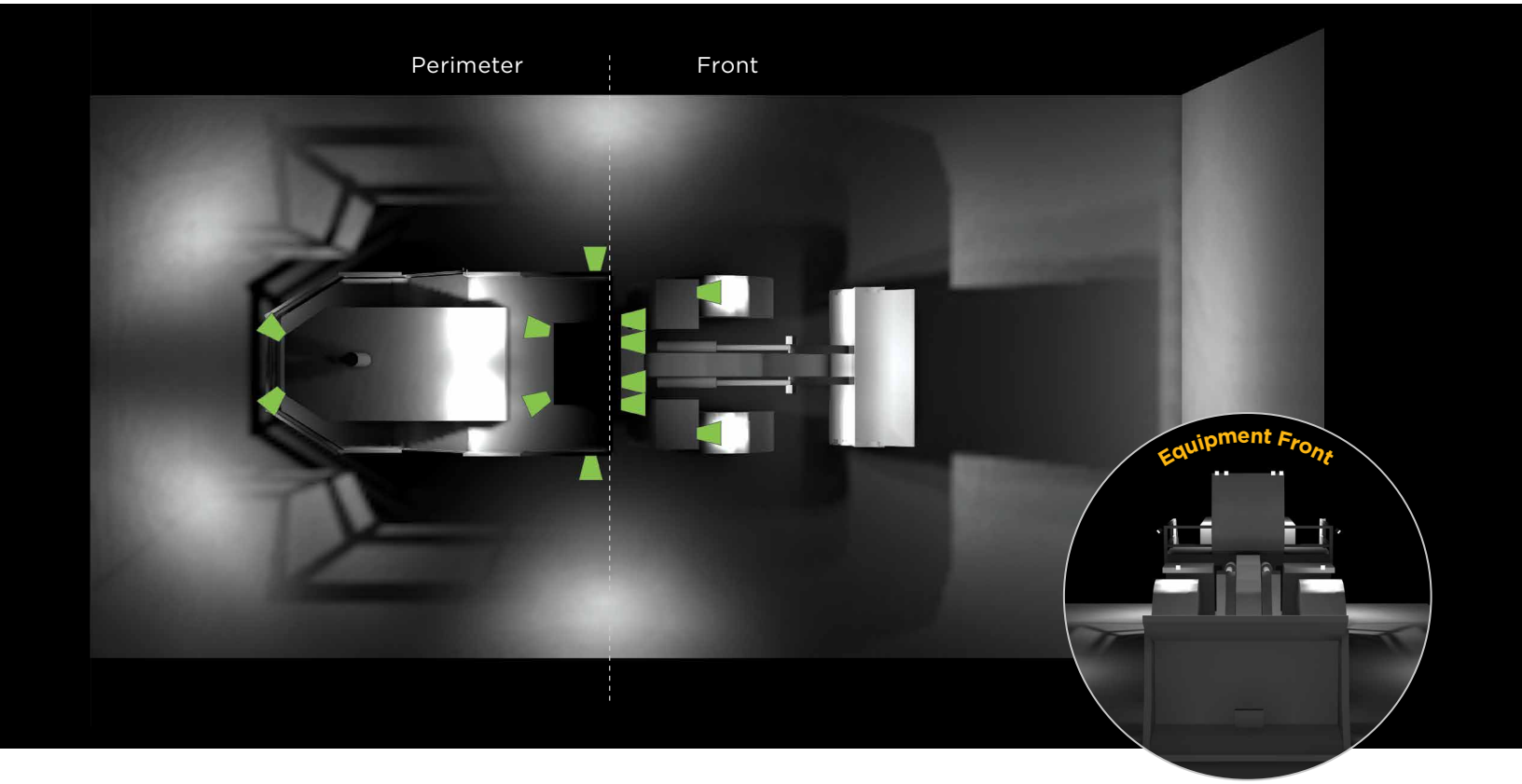


3. Flood fixtures on the side are usually only turned on when the haul truck is backing up to deposit its load or during low visibility conditions. Because a haul truck's sides are also its blind spots, the floods here serve as a warning to other equipment or workers.

4. The fixtures on the rear of a haul truck provide illumination for its operator and other workers near the equipment as it reverses into a space. The truck's rear camera systems will also be able to function optimally, if fixtures with flood optics and a natural 5000-5500K color temperature are used.

3 Lighting Designs for Wheel Loaders

The lights on a wheel loader are there to help protect workers in the machine's vicinity as much as its own operator, through added visibility. Highly mobile and adaptable, wheel loaders benefit from good lighting as they shovel, move and scrape the earth from dawn to dusk. For any fast-expanding mining operation, a well-lit and safe wheel loader is a worthy long-term investment.



Equipment Section	Recommended Number of Fixtures	Color Temperature
Front	6 to 8 with Elliptical Optics	5000- 5500K (clear conditions) / 2200 - 2500K (inclement weather)
Sides	4 with Elliptical Optics	5000- 5500K
Rear	2 with Elliptical Optics	5000- 5500K

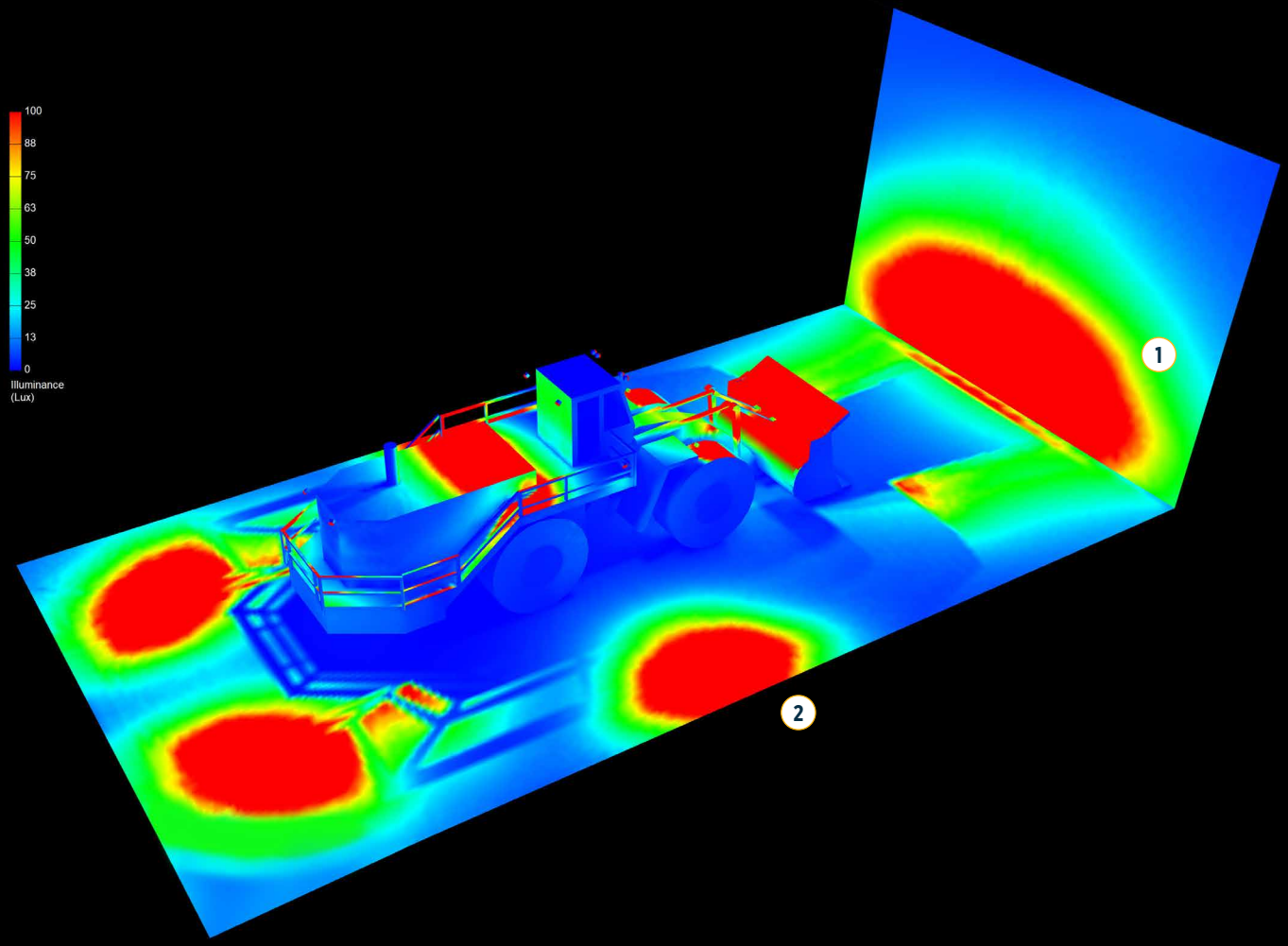
Elliptical Optics

Lighting Designs for Wheel Loaders

Lighting Best Practice

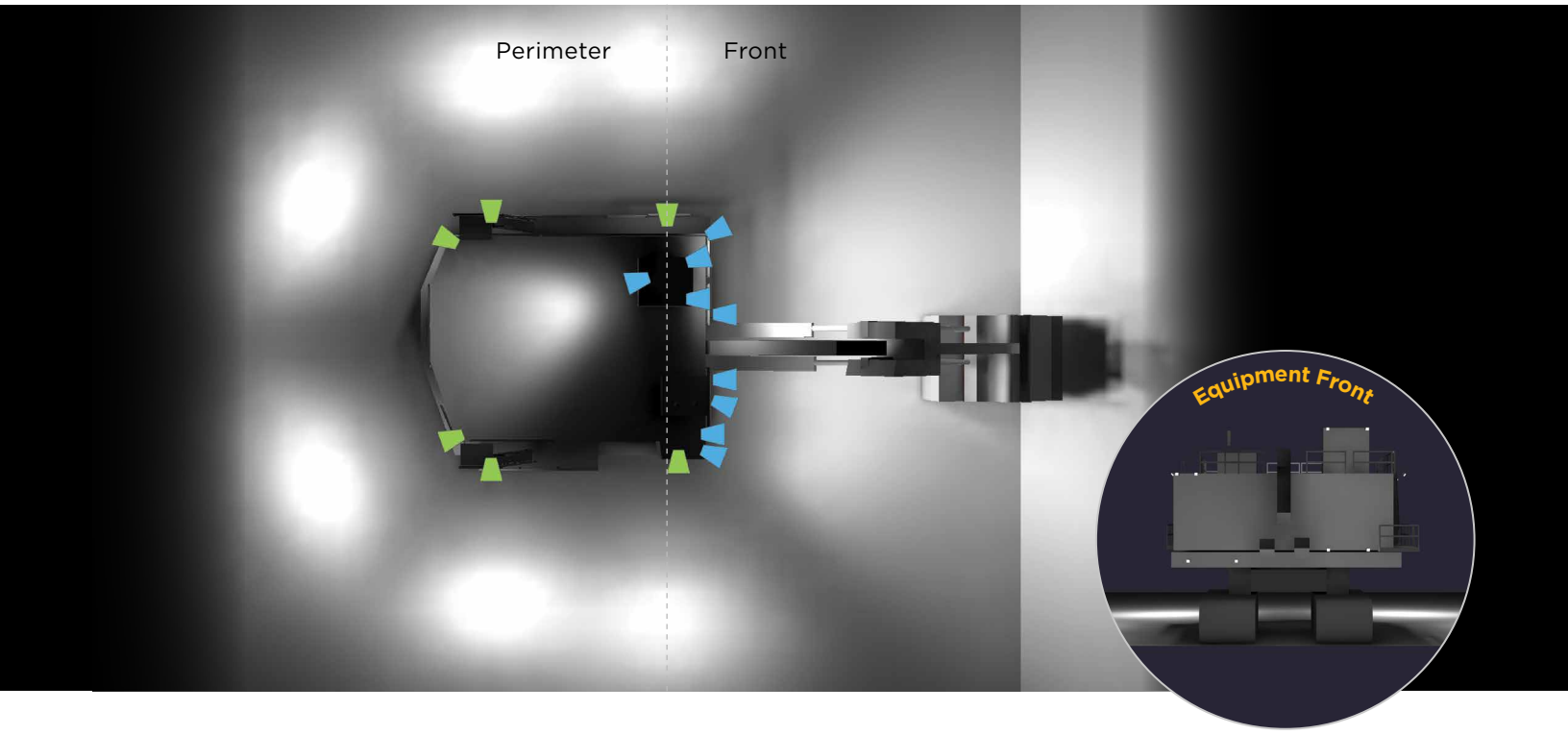
1. As they work on a bench face, wheel loaders need clean, uniform lighting that only elliptical optics can provide. This even light distribution prevents light 'hot spots' that can cause eye strain over the duration of a night shift, while reducing glare to other equipment operators in the vicinity.

2. The perimeter of a wheel loader is best lit with ellipticals to minimize glare to the operators of dozers or excavators, which typically work alongside the wheel loader. If possible, provide a fixture for the equipment's cab to keep its operators safe as they move about the equipment.



4 Lighting Designs for Hydraulic Excavators

The punishing work of a hydraulic excavator requires high levels of awareness and accuracy. Only with a well-planned lighting design can equipment operators work confidently and precisely at night. And although an excavator is largely stationary, its lights serve to warn nearby equipment of its movements, keeping accidents at bay.



Equipment Section	Recommended Number of Fixtures	Color Temperature
Front	8 to 12 with Flood Optics	5000- 5500K (clear conditions) / 2200 - 2500K (inclement weather)
Sides	1 with Flood Optics 4 with Flood Optics	5000- 5500K
Rear	2 with Elliptical Optics	5000- 5500K

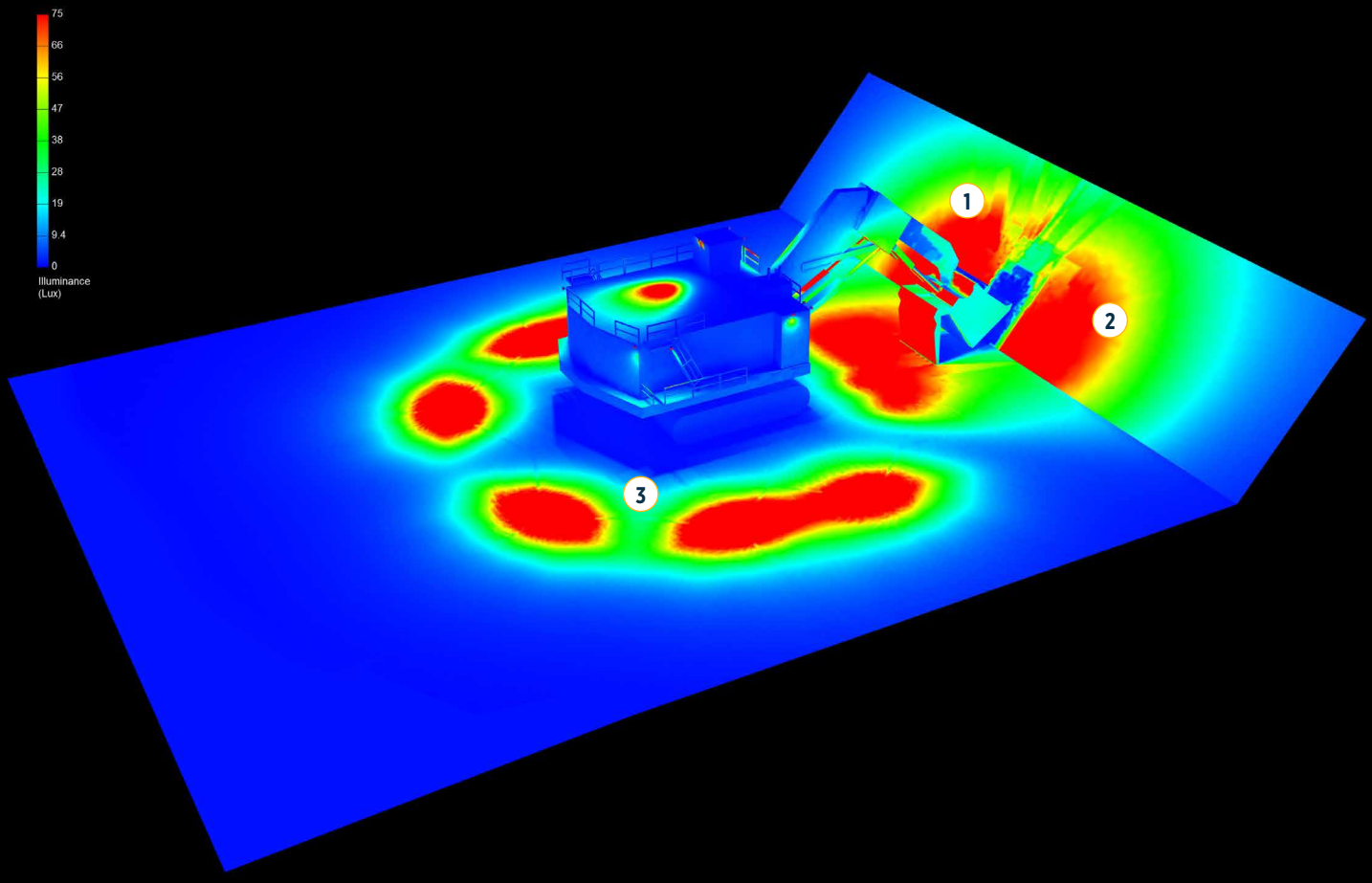
Elliptical Optics Flood Optics

Lighting Designs for Hydraulic Excavators

Lighting Best Practice

1. Excavators need uniform lighting on the bench or work area, particularly if the surface is highly reflective. Depending on the excavator's size and the height of the bench, flood fixtures often suffice.

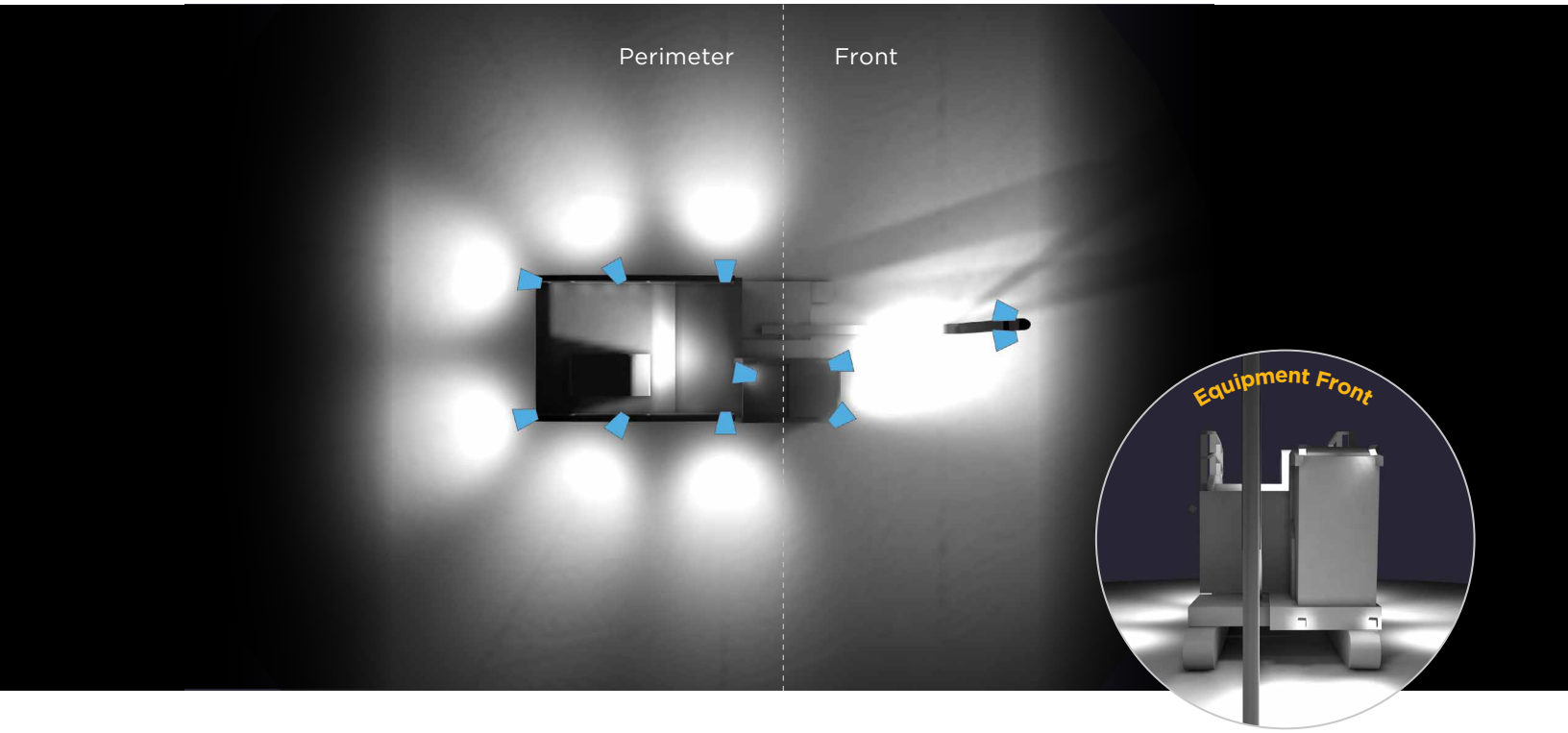
2. Certain mining operators may install fixtures with optics that aren't wide enough on their excavators, but this isn't ideal. The vibrations of the equipment will cause the fixture's beam to constantly shake, distracting and causing eye fatigue for operators.



3. Because hydraulic excavators often work in tandem with haul trucks and wheel loaders, aim to minimize the glare and brightness of their perimeter lighting. Elliptical fixtures – and in some cases flood fixtures – aimed at the ground, work particularly well. This prevents distracting or blinding flashes of light as the excavator turns, thus keeping accidents at bay.

5 Lighting Designs for Blasthole Drills

What follows the deployment of a blasthole drill is extreme shock and vibration as its drill bit bores through tough rock. Highly durable and shock-resistant lights are required to illuminate the machine's work area and perimeter. And due to the machine's bulk and heavy moving parts, quality lighting is also needed to keep its operator safe as they inspect the equipment at night.



Equipment Section	Recommended Number of Fixtures	Color Temperature
Front	4 with Flood Optics	5000- 5500K (clear conditions) / 2200 - 2500K (inclement weather)
Sides	3 with Flood	5000- 5500K
Rear	2 with Flood Optics	5000- 5500K

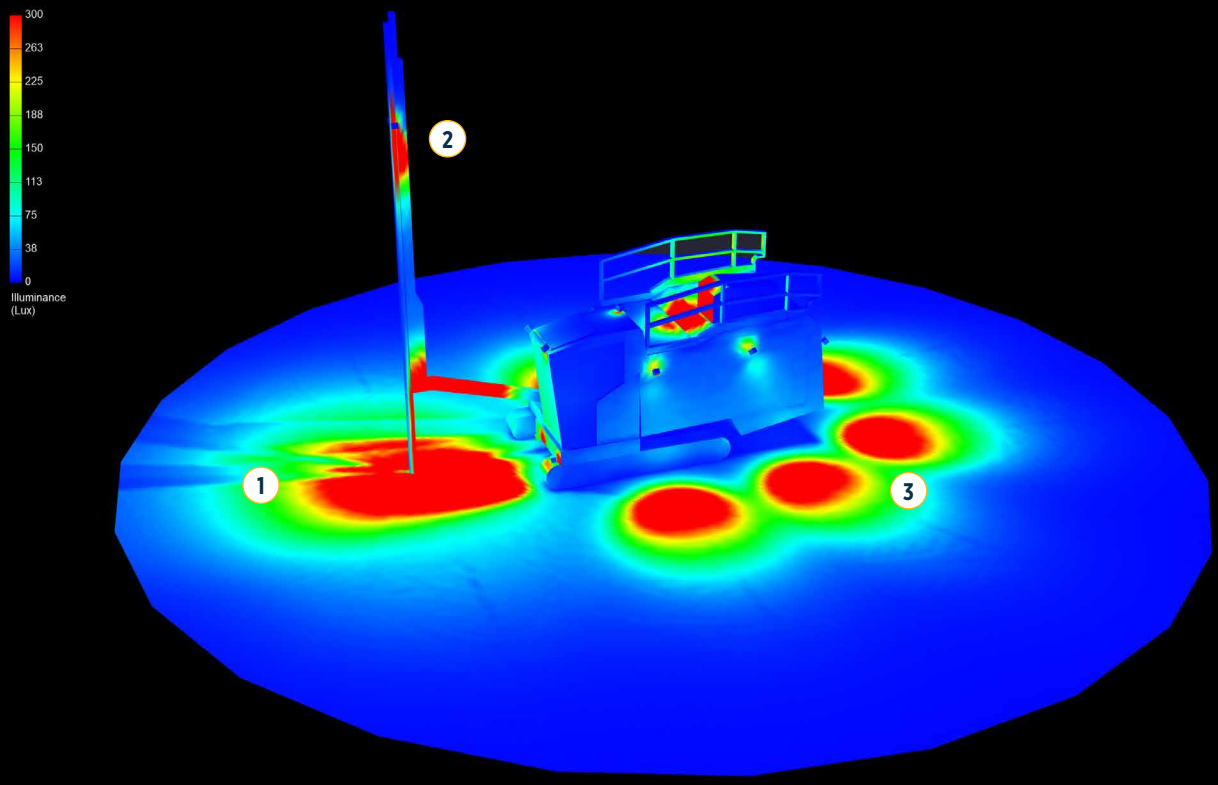
Flood Optics

Lighting Designs for Blasthole Drills

Lighting Best Practice

1. The work area must be well illuminated to ensure that the blasthole drill's bit is properly aligned with the marked drilling area. Smaller drills will need multiple flood fixtures at the front. For larger rotary drills, place additional flood fixtures on the equipment's frame, mast and underside.

2. For added safety, some mining operators may also mount several flood fixtures at the top of the drill's mast. This provides illumination in a large radius around the equipment and drill site. It also provides comfort to a blasthole drill's operator, who typically works alone at night, far from other equipment.



3. Although blasthole drills are stationary when operating and possess a low top speed, perimeter lighting is still crucial to minimize the threat of accidents or collisions.
The lights also notify the drill's operator of any potential hazards – like large debris – that may have become dislodged while drilling. They also keep the operator safe and aware of the equipment's heavy machinery, as it slowly bores its way into the earth.

Next Steps: Conduct A Five-Step Lighting Audit

Put your newfound knowledge to use by conducting a quick lighting audit. This can be done as part of routine maintenance or incorporated into your daily safety inspections. Done well, it will reveal any lighting inconsistencies – and areas of improvement – that could impact the safety and productivity of your mobile workforce.

Let's say a haul truck just rolled in for routine checks. To begin your lighting audit:

1	Walk around the equipment and inspect its fixtures. Count the number of working fixtures and note where they are aimed at.
2	Check if the number of fixtures meets minimum safety requirements. In general, you want to achieve uniform lighting around the equipment. Cross-check with maintenance records or original equipment schematics to identify if there are fewer or more fixtures. Adding additional fixtures above the OEM schematics is common practice, even recommended if there's a clear need. If additional fixtures were added, ensure existing circuitry and wiring will support the additional amperage.
3	Determine if working fixtures have the right optics and angles. Are the fixtures thoughtfully selected and installed for the tasks performed by the equipment?
4	Perform a lighting test by switching on all fixtures on the equipment. Are there any dark or underlit areas that could become safety risks? Check to ensure all lighting fixtures are clean. If not, wash down the lens with water. An excessively dirty fixture will not provide adequate light and could even lead to premature failure.
5	Check for fixture glare by standing a ways in front of the equipment. Check for uneven lighting around the equipment. Both could distract or cause eyesight fatigue for your mobile operators.

Finally, create a new lighting design

The findings of your lighting audit, coupled with the information in this e-book, should serve as a good foundation towards improving the lighting around your equipment and will make your mine site safer and more efficient. If you need a more customized design for unique mining applications or environments, it would be helpful to work with an experienced lighting expert.

Phoenix is one such expert. For over seven decades, we've helped mining operators across the world improve the lighting – and safety – of their equipment. Alongside our free lighting design and consultation services, we also recommend best-in-class LED fixtures – like our Sturdilite® Master Series – as part of the solution. What you'll get: well-lit equipment, with made-for-mining fixtures optimally placed to provide quality and most importantly, safe light at sunrise or sundown.

That's the Phoenix promise. In the market for an optimal lighting design or made-for-mining lighting solutions?

Tell us about your project and let's talk.

PHOENIX®
DURABILITY X DESIGN™

We've been manufacturing durable lighting fixtures for well over a century and installing them on draglines and various mining equipment for the past 77 years. You'll find our fixtures in mines across the US, in over 6 continents and at over 3,000 large mine sites – some have been in the field for over a decade.

Our latest offering – the Sturdilite® Master Series – draws from our years of mining experience and is engineered to keep mobile operators safe and focused on the job at hand. Phoenix also manufactures fixtures that are durable enough for the needs of marine, aviation, ports and dock loading applications in the US and around the world.