



# VOLATILE ORGANIC COMPOUNDS (VOCs)

## *Minimizing the Effects of VOC and Reactive Gas to LEDs*

Dialight Corporation is the world leader in LED Industrial Lighting technology. Dialight's rugged and dependable fixtures are designed and manufactured to survive in Industrial and Hazardous lighting applications. The industry tends to focus on drive current and LED temperatures within the fixtures but run the risk of missing other factors that can directly affect the performance of the LEDs over time. Two of these factors that can effect performance are VOCs and Reactive Gases.

Volatile Organic Compounds (VOCs) and reactive gases are everywhere and are harmful to LED lighting. Neither contaminant can be prevented or eliminated, and both are difficult and expensive to detect.

VOCs are organic chemicals that easily vaporize at room temperature and atmospheric pressure. They are emitted as gases from certain solids or liquids. Concentrations of many VOCs are consistently higher indoors (up to ten times higher) than outdoors. VOCs are emitted by a wide array of industrial products numbering in the thousands. Examples include – rubbers, silicones, greases, paints and lacquers, paint strippers, cleaning supplies, pesticides, building materials and furnishings. They are even present within typical office equipment such as copiers and printers, correction fluids and carbonless copy paper, graphics and craft materials including glues, adhesives, permanent markers, and photographic solutions.

VOCs can easily permeate through silicone-based LED encapsulations. Heat and photonic energy cause changes in chemical bond structure of VOCs. VOC compounds discolor, resulting in a thin dark layer on the LED die surface. In the case of discoloration caused by VOCs, the substance that discolors is itself a VOC, decreasing light output and causing the color to shift towards blue. Color shifts caused by a VOC will make the luminaire output to appear blue or purple and additionally result in loss of light from the luminaire. Since the VOC is the root cause for the loss of performance, the change is reversible. The LED device will revert to normal performance if the VOC escapes a ventilated luminaire.

Reactive gases, such as hydrogen sulfide (H<sub>2</sub>S), are environmental contaminants sometimes present within industrial sites that can also contribute to premature LED failure. Like VOCs, reactive gases can permeate through the silicone encapsulation. However, unlike VOCs the damage caused by reactive gases is corrosive and irreversible. Reactive gases are byproducts of a wide array of common industrial processes, which include power generation, rubber manufacturing, pulp and paper processing, wastewater treatment, battery production, and data server rooms. Reactive gases such as Hydrogen Sulfide, Sulfur Dioxide (SO<sub>2</sub>), Chlorine (Cl<sub>2</sub>) and others, react with metallic conductors causing corrosion.

In the case of reactive gases, the loss of performance is due to the damage within the LED or sensitive electronic device. Since the electronic device was damaged due to corrosion, the change is irreversible. All sensitive electronic devices will fail at a rate proportional to gas concentrations, temperature, and humidity. Condensing humidity levels are especially damaging in the presence of reactive gases.

The quality and reliability of lighting in industrial sites is critical to ensure safe operations. OSHA has identified poor lighting as a leading cause of injuries caused by slips, trips, falls and contact with objects and equipment. Over the past decade alone, these types of accidents have cost industrial workplaces billions of dollars in medical and worker compensation expenses. Worse yet, thousands of these accidents have resulted in loss of life, which could have been prevented through better lighting. While VOCs and reactive gases are ever-present within industrial sites, it is imperative that they do not create unsafe conditions by affecting light output. Component manufacturers have not implemented protections to prevent these failure modes, prompting Dialight to engineer advanced solutions to protect our fixtures from the impacts of VOCs and reactive gases.

Dialight's material science group conducted a detailed review of several corporate and Instrument Society of America (ISA) specifications. The published literature defines the limits of environmental contaminants such as reactive gases and VOCs according to health and safety guidelines. *The results of Dialight's review found the conditions that cause premature failure of the electrical components within the LED Light Fixtures are far below human health and safety thresholds. Even at low concentrations, both classes of atmospheric pollutants are damaging to electrical components.* The level of concentration of gases necessary to cause electronic failure can be deceiving. For example, gas concentrations of H<sub>2</sub>S in the parts per billion (ppb) range may quickly lead to electronic failure, while the human perception is that the environment is very benign. Once a person perceives that there is an environmental problem, it is usually past the damage threshold for corrosion of electronic modules, especially in the hot and humid areas common in industrial settings. This increases the difficulty of detecting reactive gases and VOCs that may affect the LED fixture. Expensive and sensitive testing is needed to identify even small amounts of these contaminants.

IP sealed luminaires can only minimize the concentrations of atmospheric pollutants that originate from outside the luminaire. Even when LED drivers are enclosed to protect the sensitive electronic components from all environmental contaminants, the LEDs and the wire and cable connections are exposed and susceptible to failure.

Dialight has developed technology to protect LED components from harmful environmental contaminants. Through extensive research the Dialight materials team has come up with the ideal protection method for specific industrial applications. The findings proved that the only temperature independent solution is to create a shield that isolates the VOC, or reactive gas, from the sensitive electronics, such as the LEDs.

Dialight's long term testing has proven that sensitive electronic areas coated with the appropriate chemistry are significantly better protected than uncoated areas. The shield is required to be an appropriate chemistry that does not allow reactive gas or VOC to permeate. Further, the shield will not outgas VOCs that would contribute to reduced LED performance. Since it is imperative that the shield material not create damaging VOCs, Dialight's engineering team optimized the coating, testing multiple shielding chemistries to study performance and tradeoffs. The team started with ten chemistries, short-listed, and extensively tested three, and finally selected the best performing variant.



*Dialight has determined that, in order to protect the electrical components within LED lighting fixtures from damaging environmental contaminants, the following LED fixture construction methods should be taken.*

- Internal power contacts shall be made of suitably noble metals.
- Protective chemistry must fully cover all exposed conductive joints.
  - » The protection shall be an appropriate chemistry that does not allow reactive gas or VOC to permeate through.
- LEDs must be coated with the shielding chemistry.
  - » The shield shall be an appropriate chemistry that does not allow reactive gas or VOC to permeate through.
  - » The shield must not outgas VOCs that would contribute to reduced LED performance.

In conclusion, Dialight understands the criticality importance of lighting quality within industrial lighting applications and has a solution to protect LEDs chemistry from severe environmental contamination that shortens useful fixture life and light output. Dialight has expertise in heavy industrial lighting design and manufacturing of fixtures for robustness in harsh and hazardous lighting applications. Dialight's technology will maintain the quality of illumination and improve the durability of the luminaire, for customers within power generation, rubber manufacturing, pulp and paper processing, wastewater treatment, battery production, and data server rooms where VOCs and reactive gases are commonly present.

*To learn more about this and Dialight's complete line of industrial LED lighting solutions, visit [www.dialight.com](http://www.dialight.com).*

