

RESILIENT

TOUGH LIGHT

WHITE PAPER

Key Considerations for Lighting Industrial Facilities

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INTRODUCTION

Industrial facilities need high quality lighting to keep workers safe and factories productive. Lighting solutions not only need to be durable enough to withstand harsh environmental conditions, including high temperatures, humidity, corrosive atmosphere, dirty power, and vibration, but also must comply with applicable fire, safety, and material codes. In addition to these requirements, the luminaires should require only minimal maintenance and be energy efficient.



Because of recent advances in LED technology, industrial facility managers now have other options than just the traditional high intensity discharge (HID) lamps of yesterday, and can achieve substantial savings in energy and lighting maintenance LED. Today's LED systems use 2–3 times less energy and require up to 90% less maintenance compared with traditional Metal Halide and High Pressure Sodium High-intensity discharge lamps—bringing lighting to the forefront of sustainability and cost reduction initiatives. Factories and plants are upgrading mission critical lighting applications to achieve rapid payback on investment with significantly better light quality and control. This white paper describes the major lighting applications within the Industrial sectors and key points to consider when upgrading to LED lighting.

Major applications within the industrial sector include:

- Manufacturing and Warehousing
- Food and Beverage processing and
- Heavy Industrial

Industrial facilities each have their own unique lighting and luminaire specifications: from optimum light levels, to controlling individual lights. Targeted specifically at these applications, Resilient's lighting solutions provide industrial facilities with a productive work environment, all while meeting the stringent environmental and safety standards.

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APPLICATION AREAS

MANUFACTURING & STORAGE

Manufacturing and warehouse facilities represent a major section of indoor or covered real estate in the industrial sector. The types of work performed in these areas vary tremendously from production to machining to storage; therefore every lighting solution needs to be customized to the function of the space and the complexity of the task being performed.

Maintained Illumination: Illumination, measured in lux or foot candles, is the measure of the amount of light that falls onto a surface. The level of illumination required depends on the task being performed. Organizations like OSHA and IESNA recommend minimum lighting levels for performing specific tasks based on the frequency of activity and the inherent danger present. 'Maintained' refers to light level from a luminaire not at the beginning of its life, but rather at the end of its life; therefore light decay must be factored into the equation when calculating minimum illumination. It has been proven time and again that accidents and productivity can be directly linked to adequate lighting, and therefore, it is imperative to provide a minimum level of maintained lumens. Since LED luminaires do not have replaceable 'lamps', the maintained lumens are calculated at the end of its life.

LM80 and Lumen Maintenance for LEDs

Lumen maintenance is defined as the percentage of initial lumens that a light source maintains over a time period. Specific to LEDs, LM80 is a methodology defined by the IESNA (Illumination Engineering Society of North America) for measuring the decline in an LED's output over a specific period of time. LM80 standardizes the performance of LEDs across different manufacturers. The major factors that affect lumen maintenance in LEDs are drive current and operating temperature. High temperatures and high drive currents can adversely affect the efficiency of the chip and the diode material. Using the LED LM80 data, manufacturers can extrapolate the expected lumen maintenance curve for different operating temperatures. The lumen maintenance curve then shows facility managers how long they can expect the light from a luminaire will meet specified illumination requirements.



KEY CONSIDERATIONS FOR LIGHTING INDUSTRIAL FACILITIES

APPLICATION	MAINTAINED ILLUMINANCE TARGETS (LUX)
General¹	
Working Spaces where visual tasks are only occasionally performed	100
Performance of visual tasks of high contrast or large scale	300
Performance of medium contrast of small size	500
Performance of visual tasks of low contrast or very small size	1,000
Assembly/Inspection²	
Simple	300
Exacting	3,000
Difficult	1,000
Emergency & Safety¹	
Low hazard environment/low activity	5.4
Low hazard environment/high activity	11
High hazard environment/low activity	22
High hazard environment/high activity	54
Machining²	
Rough bench or machine work	300
Medium bench or machine work	500
Fine Grinding	3,000
Fine Bench or machine work	300
Warehousing & Storage^{2,3}	
Inactive	50
Active: bulky items, large labels	100
Active: bulky items, large labels	300
Forklift operation	20

Figure 1. Light Requirement table.

1. "Lighting for office and industry." SAIF. SAIF Corporation, Dec. 2011. Web.

2. DiLaura, David, et al. *The Lighting Handbook: 10th Edition*. New York: Illuminating Engineering Society of North America, 2011. Print.

3. Ryan, John, and L.D. Ryan. *The Forklift Manual*. Donegal Bay Inc. Publishing, Jan. 2006. Print.

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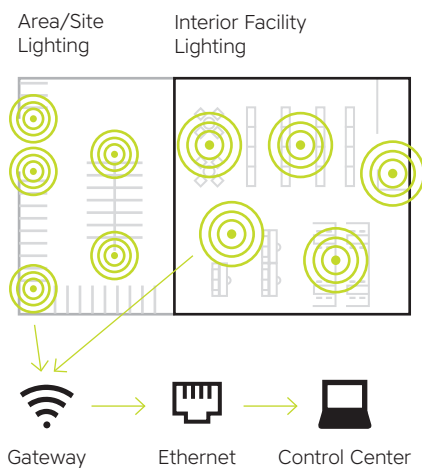


Figure 2.
Wireless Controls Network for
Facility Lighting

Control Systems: The instant dimming and turn on-off capabilities of modern day LED systems allow for a more efficient utilization of electricity, not possible with HID lamps. In addition to standard analog dimming, lighting can be made adaptive to the environment based on foot or vehicle traffic via occupancy sensors, daylight using photocells or timers, and peak electricity costs utilizing advanced lighting controls. These controls use wireless or power line communication, and can also provide facilities managers with real time usage and maintenance data. Resilient luminaires are compatible with wired and wireless control methods depending on the specific need of the facility.

FOOD AND BEVERAGE PROCESSING

In food and beverage processing facilities, lighting equipment is subjected to 'tough' performance and durability standards. Due to the chemical processes used in the manufacturing, the

light fixtures used in these facilities need to be constructed to withstand elements such as water, oil, steam, dust, and biohazards. Several agencies including the USDA and IESNA set or recommend minimum illumination levels for food handling facilities. Organizations like NSF International also certify lighting equipment to meet the stringent requirements set forth by the Federal Food, Drug and Cosmetics Act. To comply with all these requirements, it is important to consider the following aspects of lighting:

Vertical and Horizontal Illumination:

Illuminance levels play a vital role in worker and food safety. There are two types of illumination, horizontal and vertical. Horizontal illumination is the light that shines on horizontal surfaces, such as work benches or conveyor belts, while vertical illumination is the light that shines on vertical surfaces such as signs on a wall or labels on vertical storage rows. The USDA specifies minimum horizontal illumination in meat and poultry plants, while IESNA (Illumination Engineering Society of North America) recommends the illuminance levels for other food and beverage plants sites. Typically, vertical illumination should be 25-50% of the horizontal illumination and free of shadows in critical areas to create a safe working environment.

Color Rendering: Color rendering is the ability of a light source to represent the true colors of an object, and the Color Rendering Index (CRI) is a scale that measures this ability. A CRI of a 100 indicates that a light represents color perfectly (sunlight represents a CRI of 100). In food and beverage processing

Why LEDs are more controllable than HID

High-pressure sodium and metal halide lamps used for HID lighting are optimized to operate at full power. While these types of lamps are capable of being dimmed, the drawbacks significantly outweigh the benefit of any energy savings achieved through dimming. When dimmed, HID lamps are not able to maintain a sustaining voltage in the dimmed mode, leading to a shorter life and premature lamp failure. They also experience a change in color during dimming, which negatively affects their color rendering ability. The dimming capabilities of HID lamps are also very limited in terms of timing and range. HPS and MH lamps respond to dimming settings substantially slower than LED, typically over a few minutes. They also must be fully warmed up to full power before being able to dim. When HID lamps are dimmed below 50% of the rated power, issues, such as the rated life, efficacy, and color, are even more exaggerated.

KEY CONSIDERATIONS FOR LIGHTING INDUSTRIAL FACILITIES

facilities, a high CRI light sources allows workers to see colors accurately and perform their jobs safely and correctly. Most importantly, high CRI light sources allow workers to discern the quality of food products in processing and inspection areas, impacting the safety of the food. In general food processing areas, a CRI of 70 is desired, whereas in inspection areas, a CRI of at least 85 is required.

Durability and Watershed Design

—NSF Requirements: The sanitary conditions of a food and beverage processing facility are a critical part of its operations. Facilities are mandated by the FDA to implement thorough cleaning regimens, such as daily high-pressure wash downs of all processing

areas. This process, which involves using hot water or sanitation chemicals at pressures between 1000–1500 PSI, ensures that processing areas are kept free of bacteria and other contaminants. Therefore, light fixtures must be designed to be leak-free and corrosion resistant at wash down pressures of 1500 PSI. The watershed design of luminaire prevents water from pooling in the crevasses of the housing and allows water to easily flow off with the fixture when being washed. These factors are crucial for meeting the NSF requirements for light fixtures in a Splash Zone. For lighting in Non-Food zones, luminaires must be constructed with easily cleaned, non-toxic materials that will not chip or break on impact causing potential food hazards.

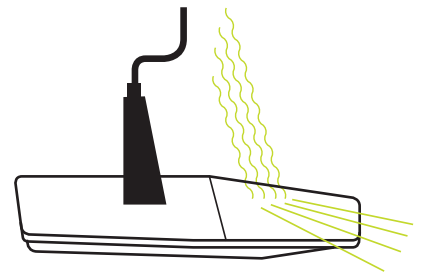


Figure 3. Watershed Design of Resilient Fixtures

NSF CERTIFICATION	DESCRIPTION	LIGHTING APPLICATIONS
Non-Food Zone	<p>Exposure:</p> <ul style="list-style-type: none"> no direct contact with food products Cleaning solvents <p>Considerations:</p> <ul style="list-style-type: none"> Material resistance (lens, finish, etc.) to cleaning solvents Lamp glass breakage 	<ul style="list-style-type: none"> Kitchens Food storage Dry process areas Damp process areas
Splash Zone	<p>Exposure:</p> <ul style="list-style-type: none"> High pressure wash downs No direct contact with food products <p>Considerations:</p> <ul style="list-style-type: none"> Durability & watershed design Material resistance to cleaning products Lamp glass breakage 	<ul style="list-style-type: none"> Wet or damp process areas High purging or decontamination used in the process Areas using hose wash down
Food Zone	<p>Exposure:</p> <ul style="list-style-type: none"> Direct contact with food products Full sanitation required 	N/A

Figure 4. NSF Zone Classification Chart

KEY CONSIDERATIONS FOR LIGHTING INDUSTRIAL FACILITIES

HEAVY INDUSTRIAL

Heavy industrial locations, such as foundries, steel mills, casting and welding facilities, pose as challenging environments to illuminate. In these harsh environments, one finds vibration from large machinery, caustic chemicals, extreme temperatures, and dirty power, making it difficult to find lighting solutions that are powerful and tough enough. Lighting at such facilities needs to provide ample illumination to create a safe workplace for intrinsically dangerous tasks while being able to handle the extreme conditions.

Dirty Power: Voltage and current fluctuations in the power line are a known problem in heavy industrial settings. Large temporary surges in power can be caused by lightning storms, but more often the facilities are impacted by smaller, dirtier surges from load switching, and the use of low power factor devices. Constant dirty power use over time will lead to premature lighting failures. Resilient's power solutions counteract and guard against this at the individual luminaire level by utilizing proprietary protective circuits to defend against various types of dirty power.

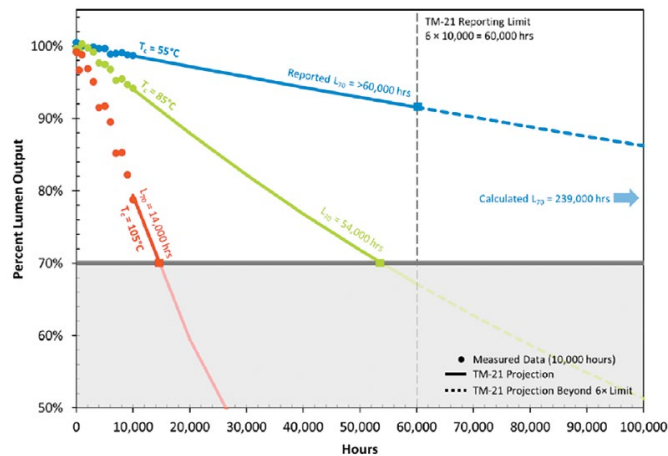
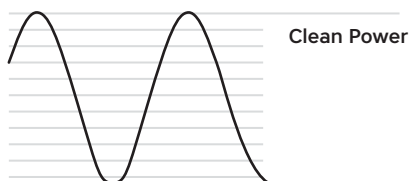
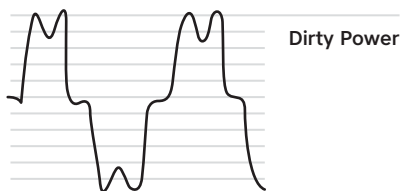


Figure 5. Lumen Depreciation Characteristics as Function of Temperature. *Lumen Maintenance and Light Loss Factors, Pacific Northwest National Laboratory, 2013 (www.pnnl.gov/main/publications/external/technical_reports/PNNL-22727.pdf)*

Light Penetration: Luminaires in heavy industrial sites are often hung at near ceilings exceeding 30 meters high and require at least 750 to 1000 lux in moulding, smelting and plating areas. In addition, the particulates in the air can accumulate on the luminaire lens exacerbating the need for powerful light output to penetrate to the facility work areas. Light fixtures in such areas should utilize long throw optics to reach the work floor, and a luminaire dirt depreciation factor of 0.65 should be used to calculate the level of light output and the number of luminaires needed to illuminate the workspace.

Extreme Temperatures: Heavy industrial plants produce extremely hot environments often exceeding average temperatures of 50°C (122 F). LED chips and driver electronics are extremely sensitive to high temperatures, which accelerate lumen decay and increase premature failure rates. Standard luminaires designed for outdoor area or commercial use will not survive in such conditions. Resilient luminaires utilize advance vapor chamber based cooling to ensure luminaires will operate continuously at a 55°C ambient temperature for over 100,000 hours.

DIRTY POWER



Resilient Luminaires can defend against two different types of dirty power:

lightning strikes and switching related transients. Lightning strikes can create huge, short-duration high-voltage transients. These surges can be up to several thousand volts in amplitude. Switching-related surges are lower in amplitude, but longer in duration and more frequent.

Most surge suppression devices are only designed and tested for the short duration impulses. But, it is equally, if not more important, for a long-lifetime LED luminaire in a heavy industrial environment to be able to withstand the longer duration oscillatory transients.

PRODUCTS



CRP0400—Plasma



FLL0400—LED



HBL1000—LED



HZL0250—LED



FZL0250—LED



ARL0100—LED

Resilient is focused on serving the lighting needs of industrial, ports and hazardous location sectors. We develop 'Tough Light' for tough environments with strict safety and compliance requirements. Together with our end users, we identify opportunities for energy and cost savings and tailor our product solutions to meet application specific needs. Please contact us for a site evaluation or consulting at info@resilientlighting.com.

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