Appleton®

Safely Lighting Hazardous Environments

An overview of hazardous environments and the lighting fixtures that protect them.

Whitepaper

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Lighting fixtures play a critical role in the safe, efficient and productive operation of any industrial facility or production process. Darkened, enclosed and round-the-clock operations rely on them exclusively for illumination. Daylight operations benefit from the additional and spot lighting they provide. However, facilities, such as petrochemical, food processing and grain storage, require more from their lighting fixtures. In addition to providing light, fixtures for these industries must address and overcome the inherent challenges of hazardous environments.

Hazardous environment lighting fixtures are designed to specifically handle the highly corrosive elements, combustible dusts and flammable gases and vapors that are endemic to these industries. This whitepaper examines the distinct hazardous environments defined by global electrical codes, which fixtures are suited for them and technologies that are on the way to help keep light fixtures operating longer and safer. This information provides the foundation for achieving optimal plant safety and efficiency through proper lighting, safe electrical installation and operation.

Around the world, hazardous locations are broken down into different categories. Each category defines the type of hazard present, its explosive force and if its exposure is part of normal or abnormal facility operations.

Class of threats

The National Electrical Code (NEC) and the Canadian Electrical Code (CEC) define hazardous environment combustible dusts and flammable gases and vapors into three separate Classes. Class I locations are categorized by the flammable gases and vapors present in industries such as natural gas, petroleum and chemical.

Class II locations contain combustible dusts. These dusts can be carried aloft during pulverizing processes or compacted in storage centers. Combustible dusts are found inside plastic, pharmaceutical, coal and flour processing locations.

Class III locations contain the igniteable fibers and flyings that are produced in the wood, cotton, and textile industries, among others.

Groups within each class

Class ratings are further broken down into groups, which identify the explosive pressure created by the gas, vapor or dust (Figure 1).

There are three distinct classes of flammable compositions. Class I locations consist of Groups A, B, C and D:

- Group A, acetylene, features the highest outward pressure during an explosion
- Group B is hydrogen
- Group C is ethylene
- Group D is gasoline

Class II locations are divided into Groups E, F and G based on electrical resistivity charts listed in ANSI/ISA-S 12. 10-1988.

- Group E is combustible metal dust such as aluminum and magnesium
- Group F consists of coal, printer ink powder and coke
- Group G features agricultural dusts such as cake mix, grain dust and flour

Class III locations are not broken down into Groups.

SUMMARY OF NEC/CEC CLASSES AND GROUPS				
Class I: Flammable Vapors & Gasses (Volatile gas or vapor present in sufficient quantity to produce ignition or explosion).		**Class II:** Combustible Dusts (Combustible dusts present in sufficient quantity to present a fire or explosion hazard).		**Class III:** Fibers & Flyings (Easily ignitable fibers or flyings present but not likely to be suspended in the air).
GROUP A	Acetylene	GROUP E	Metal Dusts	
GROUP B	Hydrogen	GROUP F	Carbon Dusts - Coal	
GROUP C	Ethylene	GROUP G	Grain Dusts	
GROUP D	Gasoline			

FIGURE 1: **Summary of Classes and Groups**

Define the presence with divisions

NEC/CEC Divisions define hazardous environments by the amount of the exposure to the gases, vapors, dusts or flyings and fibers. Division 1 classifies hazardous atmospheres in which the flammable gas or vapor or combustible dust is present during normal operations or routine maintenance. The existing or potential hazardous atmosphere must also be in the right mixture concentrations to be ignitable. Thus, proper ventilation can change a Division 1 location in to a Division 2 location.

Division 2 locations are where hazards are encountered only during an abnormal situation, such as equipment failure or a spill. Locations adjacent to Class I, Division 1 areas may be deemed Division 2, as well, to accommodate for the potential seeping of gases or vapors.

Around the globe

The International Electrotechnical Commission (IEC) classifies hazardous locations into Zones, Groups and Gas Groups. Zones are similar to the NEC/CEC Divisions, except that they classify three levels of the existence of hazardous atmospheres instead of two.

- Zone 0: hazardous atmospheres are continuously present
- Zone 1: hazardous atmosphere is often present
- Zone 2: hazardous atmosphere may accidentally be present

Groups are used to denote equipment used for the mining industry. Group I consists solely of mines. Group II encompasses every industry, but mining. The Gas Groups of A, B, and C rate the pressure caused by an ignited gas, vapor or dust, much like the NEC/CEC Group. However, they are placed in the opposite order. Gas Group C therefore represents the extreme force of hydrogen and acetylene while Gas Group A denotes the less destructive forces of gasoline and natural gas.

Safely lighting facilities for the different Classes, Groups and Divisions requires engineering and manufacturing a variety of fixture designs. Each design incorporates features that meet the specific rating criteria of the hazardous location.

Enclosed & gasketed fixtures for Class I, Division 2 & Class II

Class I, Division 2 fixtures must be gasketed to prevent the hazardous atmosphere from entering the fixture's interior. As such, enclosed & gasketed fixtures are most suitable for this environment. Class II fixtures also have to function under a blanket of explosive dust as grain silos and other agricultural and mineral processing plants position lights where they can get covered by dust or grains for extended periods of time. These conditions mandate that enclosed & gasketed fixtures prevent dust egress and keep temperatures low. Internal control components need to be engineered to radiate less heat. Surfaces need to be contoured to prevent accumulation of dust on the fixture and reduce blanketing. If not engineered properly exterior light temperatures can soar.

Explosionproof fixtures for Class I, Division 1

Due to the ever-present condition of hazardous gases or vapors, fixtures placed in Class I, Division 1 locations must ensure that ignition is never allowed into the environment.

To do this, engineers calculate that the gas or vapor has successfully leaked into the interior of the fixture and has ignited. To prevent ignited gases or vapors from propagating to the surrounding atmosphere, explosionproof fixtures feature engineered flamepaths. The flamepaths vent the pressure of

an explosion by allowing the gases to escape to the outside atmosphere only after the gas has traveled within the fixture's flamepaths long enough to cool. Cooled gases are released from the flamepaths at temperatures that will not ignite the surrounding flammable atmospheres. Depending on the fixture's design and application, these flamepaths can be incorporated into ground joints, threaded joints, labyrinth-paths, close tolerance shafts, interlocking concentric rings and precision acme/conical threads.

Keeping your cool in hazardous atmospheres

A light that lasts longer is safer for the production line and the maintenance crew. It provides more light over its lifetime and reduces the potential of a maintenance-related accident by stretching out the amount of time between servicing. Simply put, cooler running lamps stay lit longer. That's why it is important to design and manufacture enclosed & gasketed and explosionproof fixtures that reduce the amount of heat they produce. Light fixture manufacturers do this through electrical, mechanical and thermal engineering. Product designs need to take into consideration such facets as the placement of internal control gear to reduce heat buildup, the use of reflectors to help in heat dispersion while producing higher photometric efficiencies and metallurgy techniques and bracket placement to draw heat away from the internal components and direct it out through the casing.

Temperatures to a "T"

Every hazardous atmosphere has a temperature that, if exceeded, will cause the flammable or combustible to ignite. Accordingly, this temperature, called the "T" rating, is a critical safety benchmark. Hazardous location lighting fixtures must run cooler than the ignition temperature of the surrounding atmosphere. Per the "T" rating chart (Figure 2), T1 rated luminaries can only be used in locations where the atmosphere needed a temperature greater that 450° C to ignite. Conversely, T6 rated luminaires run the coolest and can be used in very volatile environments where temperatures can not exceed 85° C.

HAZARDOUS LIGHTING - "T" RATING	
Degree C	ID #
351-450	T1
326-350	350
301-325	325
281-300	T2
261-280	T2A
231-260	T2B
216-230	T2C
201-215	T2D
181-200	T3
166-180	T3A
161-165	T3B
136-160	T3C
121-135	T1
101-120	T4
86-100	T5
85	T6

FIGURE 2: **Hazardous Lighting - "T" Rating Chart**

The "T" rating for a fixture is the temperature of the hottest spot on or in the luminaire depending on the luminaires' Class or Zone rating. Whether the "T" rating is recorded on or in the luminaire depends on whether it is an explosionproof, flameproof, enclosed & gasketed or restricted breathing fixture. For explosionproof and flameproof fixtures, the "T" ratings are measured on the exterior of the fixture. This is due to the explosionproof and flameproof fixture's ability to disarm any explosion caused within the interior of the fixture. Therefore, the exterior temperature of the fixture becomes the forerunning concern. Enclosed & gasketed fixtures measure their "T" ratings on the inside. If a hazard is accidentally released into

the atmosphere and reaches inside the fixture, it will not ignite assuming the fixture's "T" rating is below that of the hazard. Restricted breathing fixture construction is similar to enclosed & gasketed but requires a seal to give the product the "restricted breathing" rating. This allows restricted breathing fixtures to have their "T" ratings measured from the surface of the fixture.

Complex engineering made simple

The seemingly simple look of enclosed & gasketed and explosionproof lighting can often cause work crews to underestimate the hazardous locations that they work in and the engineering of these fixtures. This is reinforced by surveys that show maintenance practices usually do not follow standard guidelines. 80% of the time, fixtures are relamped with the electrical power on. In the 20% of the time that the power is turned off, 69% of the relamping happens as soon as the power is shut off. This does not allow the proper amount of time for many fixtures to cool. Research also shows that 32% of gaskets and seals are not inspected and maintenance crews are "pretty sure" the gaskets are properly sealed only 55% of the time. Also, 95% of the time, luminaires are maintained only after the unit fails.[1]

Unfortunately, this leads to mistakes that could be avoided. Using the appropriate lamp also contributes to fixture durability and heat build-up. Only lamps of the proper rating for the fixture should be used, not higher or lower.

[1] Haley, Mike et al. "Benefits and concerns with NEC® Section 501.1 inreference to Zone 2 lighting in Division 2 areas." IEEE Paper No. PCIC-2004-47. 7 pages.

For example, a 100-watt lamp in a 150-watt fixture can cause the internals to overheat and increase the fixture's "T" rating without any external warning or indication. Using a different wattage lamp, not found on the nameplate, voids the fixture warranty, violates the UL-rating and can put the entire facility and its workers at risk.

At Appleton, we design all of our fixtures with innovative features that speed maintenance and ensure the integrity of those fixtures remains uncompromised. Appleton's enclosed & gasketed Mercmaster III (Figure 3) fixtures offer the lowest "T" ratings in the industry for high durability and light longevity. Their captive, stainless steel latch assembly assures a proper 360° seal with just one captive nut to tighten. When a lamp does need servicing, crews can quickly unscrew the nut and swing open the fixture with one hand.

Putting our candles to the flame - At Appleton, we subject all of our hazardous environment lighting products to rigorous testing to ensure their safety and further improve on their design. Our lab in Skokie, IL features ovens that can heat the ambient air around a fixture to 65° C. Fixtures are turned on and put through a range of ambient air temperatures. Temperature measurements are taken throughout the fixture, including the exterior housing, internal components, the lamp and the globe.

FIGURE 3: **Mercmaster III**

Furthering the goal of reducing maintenance, Appleton fixtures have technology that prevents the starter from trying to ignite a lamp that has burned out or has been removed. This increases the life of the fixture by eliminating the prolonged cycling of trying to start a burned out or missing lamp.

Appleton's explosionproof fixture flamepaths are frequently viewed as simple threads. However, each thread is tuned precisely to contain, shape and control an explosion caused by the rated hazard. The threads for Class I, Division 1 fixtures for Group A and B have more robust flamepaths to handle the more violent explosions of detonated acetylene and hydrogen.

Appleton uses an exclusive combination of acme double lead threads and pre-lubrication to ensure a quick, tight seal without the possibility of galling or seizing, even in the most corrosive environments. This negates the need for added lubrication or elbow grease in tight spots. Appleton addresses safety in maintenance handling with wireless mounting hoods. All of Appleton's Class I, Division 1 fixtures, such as the Code•Master 2, incorporate safety features beyond the lamp with a proprietary and patented "wireless" mounting design. The mounting hood is easily wired by simply attaching two wires to the connection block. This allows the fixture to be installed, replaced or moved to a safer location for servicing without exposing wiring to a hazardous environment. There are no bare wires that can spark or wire nuts to handle.

Safely lighting the way

At Appleton, we are paving the way to the future by developing new lighting solutions for hazardous environments. Our induction lamping option for the Mercmaster III offers true 100,000 hours of operation. The Mercmaster III also offers the revolutionary pulse start metal halide lamp. Pulse start metal halides offer the truest white color of HID fixtures with a rated life of 15,000 hours. They fire fast with a 3-4 minute restrike time and produce higher efficacy's than standard metal halide lamps.

Lighting in hazardous locations is a necessity and a potential danger. Knowing the facility environment, combustible composition and fixture application enables the proper lighting design for a safe and productive working environment. For over 100 years, facility engineers have turned to Appleton as the leader in hazardous location lighting. They trust Appleton because our continuous engineering, rigorous testing and worldwide experience gives them the products and advice they need.

From the lobby to the largest containment, from Houston to Hong Kong, Appleton has fixtures that are right for each job and provides you with the information needed to ensure safe running for years to come.

Appleton

Appleton offers a full line of electrical products for hazardous and industrial locations that safely and efficiently distribute power, exhibit light and create connections. Each product is designed and built to maintain a safe and productive workplace in robust environments that push man and machine to the limit. Appleton's leading edge engineering facilities include explosion, environmental, photometric, electric and mechanical labs that are staffed with a team of experienced engineers dedicated to developing the best hazardous location electrical products available anywhere in the world.

Under the EGS Electrical Group family of brands, Appleton engineers help shape the industry by working closely with organizations such as UL, NECA, NFPA, CSA, NEMA, ANSI, IEC AND IEEE for new standards that promote safety and technical innovations. EGS Electrical Group's Electrical Code Review for hazardous locations, published every three years in conjunction with the NEC code updates, helps educate facility engineers and inspectors. For over 150 years, EGS brands have been providing a rich tradition of long-term, practical, high quality solutions. Distributors, contractors, engineers, electricians and site maintenance professionals around the world trust EGS brands to make electrical installations safer, more productive and more reliable.

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