FULHAM PRESENTS A COMPREHENSIVE

LIGHTING GUIDE

A resource for past and present
lighting innovations and lighting solutions

LET THERE BE LIGHT… LIGHTING… AND LIGHTING CONTROL.

No, we're not trying to rewrite history. We don't suggest that Lighting Control Systems (LCS) are bolts from the blue; that they burst fully cooked from the head of Zeus. They evolved through the dogged effort and ingenuity of generations of curious, sometimes brilliant humans. Light itself is a physical phenomenon; a universal raw material: electromagnetic radiation, photons, wavelengths, particles, optical receptors – remember Science 101?

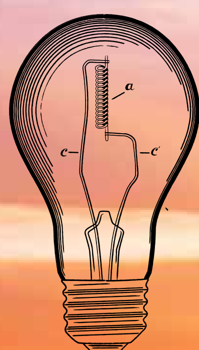
But Lighting is the conscious manipulation of Light, developed over thousands of years. The latest developments are Lighting Control Systems (LCS) -- producing and managing the most efficient lighting conditions possible. We owe this latest technology to the effort and ingenuity of generations of brilliant scientists. In these pages we will explain lighting control and its many benefits.

FIRE

Fire was good. It was humanity's first stab at producing light on demand. Fire sparked our entry into controlled lighting. Over the ages, it led to candles, oil lamps and gas lighting. Although fire produced cheery light, it did have its dark side, like accidentally burning down the house. Still, it was generally agreed that fire was… hot!

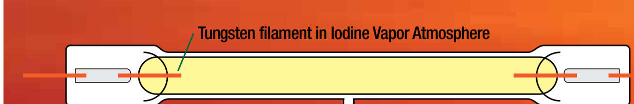
INCANDESCENT

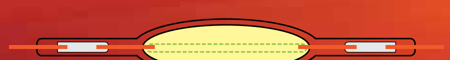
The incandescent lamp -- popularly called the "light bulb" -- came into widespread use roughly a century ago. Incandescence is produced by a heated, glowing filament sealed in a gas-filled (or vacuum) tube. Electricity surges in; a filament heats up; the bulb glows, produces light. (It also produces higher local temperatures and utility bills.)

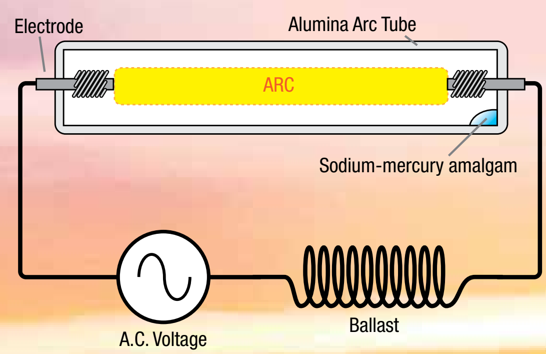


HALOGEN

Halogen lamps are souped-up incandescent bulbs with a tungsten filament. The filament is engulfed in inert gas, spiked with one of the halogen group of gases. When the tungsten heats up, its interaction with the gases triggers a chemical reaction appropriately labeled the halogen cycle. During this cycle, tungsten atoms stream from the bulb's inside surface and back onto the tungsten filament. The lamp can therefore run safely at higher temperatures, can last longer, and has the added benefit of shining proportionately brighter per unit of electricity flowing through it.





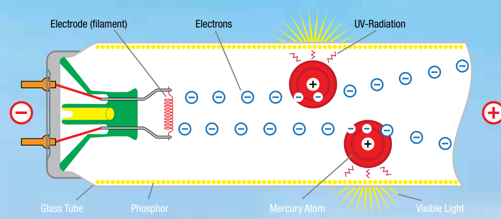


HID

High Intensity Discharge (HID) lamps fall into the gas-discharge lamp category. This means that their light output comes from electricity coursing between tungsten electrodes inside a tube filled with gas and metal salts. Sparking the arc charges the salts into a "plasma" that glows intensely -- hence the word "intensity." But despite their brilliance, HID lamps consume less energy than incandescent or fluorescent lamps, delivering more lumens per watt. HIDs' internal phosphor coating delivers a powerful and broad light spectrum, making them highly desirable for many uses in the home, in commerce and in industry.

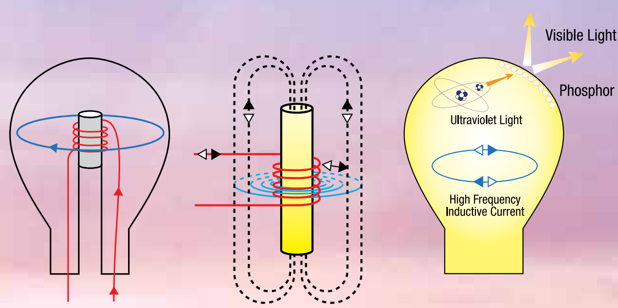
FLUORESCENT

Fluorescent lights are basically airtight tubes full of reactive gases that light up when electricity charges up their atoms, which then become... fluorescent. Compact fluorescent lamps (CFLs) are often either self-ballasted lamps or pin-based replacement lamps that operate using fluorescent technology in various residential and commercial applications, based on their relatively small sizes.



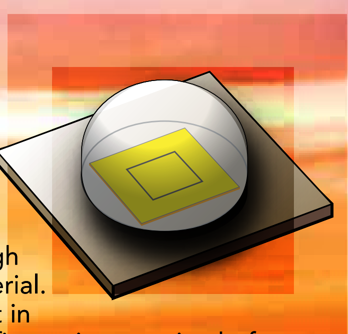
INDUCTION

Induction lighting is a hybridized form of fluorescent lighting, so it involves no electrodes. The "ignition system" isn't internal; it's not even electrical. The "spark plug" is a high frequency electromagnetic field, usually generated outside the tube. Since there are no



electrodes constantly heating up and cooling down, there are no electrodes to eventually burn out. This means longer, more efficient lamp life.

LED



Light Emitting Diodes (LEDs) operate by electroluminescence -- an optical phenomenon in which electrical current, in this case, triggers light emission as it passes through certain semiconductor material. LEDs are the source of light in light fixtures. An LED light fixture is comprised of a fixture body, a diffuser lens, and an LED Light Engine. The LED Light Engine generally consists of an array of white (or color) LEDs placed on a printed circuit board (PCB) which is powered by an LED driver, an electronic component which precisely controls the flow of electricity through the LEDs to ensure both quality of light and long life. LED Light Engines are generally tailored to specific fixtures in order to meet efficiency, aesthetics, color consistency and life requirements. LED technology has allowed creation of architectural designs that were previously impossible.

PHOTOLUMINESCENT

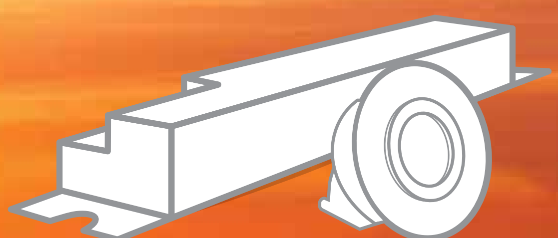
Photoluminescence (PL) is a phenomenon that lets certain substances absorb and hold photons, then re-emit them after the photon source is gone. It's like a rebound of the light the substance was exposed to. This is how glow-in-the-dark toys and signs work. PL is non-toxic, non-radioactive, and independent of electricity. It requires no batteries either, making it 100% dependable and highly cost effective. Super long-lasting PL can't experience power failure, because, as long as it is fully charged, it will "replay" that light when it's needed! This makes PL emergency lighting -- easily visible even in smoke and darkness -- ideal for safety code compliance nationwide.

PLASMA

Just think of plasma lamps as HID without the electrodes. Some science buffs even call plasma “the 4th state of matter.” Liquids, solids, gases… and this latest expression of light energy. Plasma is created by heat or streamed electromagnetism. Radiating microwaves transform certain gases and other materials into light-emitting plasma. This technology delivers remarkable illumination from such small lamps. They’re rapid start, efficient, durable (hovering around 50,000 burn-hours) and eminently recyclable. At this writing, suitable applications for plasma technology are continuing to be explored.

LIGHTING CONTROL SYSTEMS (LCS)

Lighting Control Systems are to light what advanced music systems are to sound. Acoustic scientists created precise technologies to faithfully record, fine tune, control and distribute music within sound environments. Today’s lighting engineers have made equivalent advances in visual environments. Now one simple “smart” device can control a full range of lighting. “No way!” you say? “Way!” we say. Read on and believe.



LIGHTING FIXTURE
POWER SUPPLY & DEVICES

If I have seen further than other men, it is because I have stood upon the shoulders of giants.
-- Sir Isaac Newton (1642 - 1727)

FULHAM®

ON THE SHOULDERS OF GIANTS

According to the ancient parable he was citing, even a dwarf can see further than a giant if he stands on the giant's shoulders. Sir Isaac -- indisputably an intellectual giant himself -- modestly credited the "shoulders of giants" for his success. The expression acknowledges the contribution of earlier workers for one's own achievements, since knowledge advances on the basis of previous knowledge.

But sometimes giants stand upon the shoulders of other giants. Consider the sequence of advances made by “giants” like Michael Faraday, James Maxwell, Nikola Tesla and Thomas Edison.

The solitary work of individual geniuses created a series of inspired lighting inventions. This established the foundation for a universe of practical applications, developed by later generations of scientists and technicians. The lonely eccentric's makeshift workshop has given way to extravagantly equipped lab complexes staffed with teams of trained researchers. Nowadays it is common to see close collaboration among colleagues half a world apart; speaking different languages; people from vastly divergent cultural backgrounds -- all working together in the common interest.

Technological and production advances will always be driven by inspired individual efforts. But in general, progress in our industry is the result of solid teamwork.

Nowhere is trans-national teamwork more evident than at Fulham. We are a worldwide company in manufacturing, marketing, sales and distribution. We also have world class R&D facilities in Asia and at the U.S. Headquarters, where we host an on-site UL testing facility. Our international research team includes some of the best brains in the industry, from many diverse backgrounds. All are united in Fulham's dedication to exceeding customer expectations. This commitment has grown us into a company that is truly trusted worldwide for cost-efficient lighting solutions.

U.S. INNOVATIONS BY FULHAM

Fulham has a rich history of developing innovative, award-winning lighting solutions. From Fulham’s U.S. Headquarters near Los Angeles, California, Fulham Product Managers and Engineers (working from our own UL Data Acceptance Program Testing Facility) team up to develop innovative, new product ideas that are then researched, designed and manufactured by Fulham’s own factories abroad. This all occurs under Fulham’s direct supervision as a Prime Manufacturer, thus guaranteeing the extremely high quality upon which Fulham has built its reputation for many years.

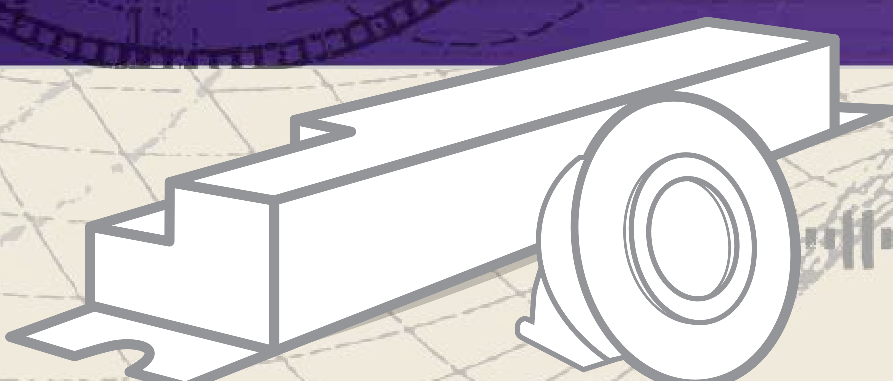
Our global programs include LED modules & drivers, electronic fluorescent ballasts & lamps, electronic halogen transformers, induction lighting systems, HID lighting systems, lighting control solutions, emergency lighting, photoluminescent egress solutions, custom solutions and more. Visit us online at www.fulham.com or contact Fulham Client Services for more information: order@fulham.com / (323) 599-5000.

CONTROL SYSTEMS

SMART MADE SIMPLE

Lighting Control Systems (LCS) may seem a bit mind-boggling at first, like all new technology. Remember your first computer? Baffling, abstract, complicated. But now you handle it without a second thought.

Guess what? LCS – for all its advanced capabilities – is as easy to use as your laptop. No bloated manuals, no tricky procedures to master. All you need to know are: (1) Which lighting scenes you want; (2) How to open a box; (3) How to use a plug. Okay, maybe you're not gizmo-friendly. Do not panic. Just hand the box to your in-house tech. Take an early lunch. Come back and enjoy your sophisticated new lighting environment! Engineers get paid to remove hassles.

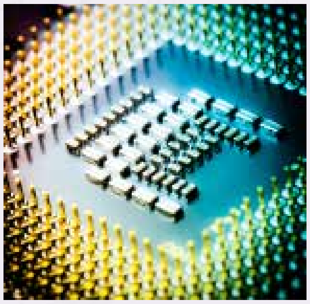


LIGHTING FIXTURE
POWER SUPPLY & DEVICES

Unlike earlier advances in the history of artificial light mentioned elsewhere in these pages, the modern state of lighting controls was not invented by any one genius, but furthered by many geniuses around the world, including Fulham's brilliant R&D team.

Through their constantly ingenious manipulation of atoms and energies, scientists and engineers are able to refashion the way the world works. Indeed, what the world IS! Once we discovered light, and kept insisting on making better and better light, human societies really got cracking. Literally -- not just metaphorically -- enlightened.

What is this thing called 'semiconductor'?



A "semiconductor" is neither a short band leader, nor a guy who drives an 18-wheeler. Electrical engineers use the term for materials (e.g., silicone, germanium) that conduct electricity better than insulators (e.g., glass, rubber), but not as well as true conductors (e.g., copper, rare gases).
Semiconductors permit nuanced control of electrical flow through circuits. Lighting engineers have employed semiconductors in many breakthroughs over the years. The transistor was one such advance. And now come Lighting Control Systems – the latest, greatest leap forward – made possible because semiconductors, wrapped in advanced technology, allow for extremely sophisticated management of two-way current flow.

LET'S GET small: Those Teeny Tiny Transistors.

Scientific progress typically moves from general theory to specific applications; from crude and cumbersome to refined and manageable. The engineer's mantra is "Lighter. Smaller. More efficient." Thus, stone clubs evolved into tasers; mainframes begat laptops; and now the telephone, camera, wristwatch, internet browser, calendar, note pad, address book and photo archive can all co-exist in palm-sized gizmos.

None of these astonishing advances would have been possible without the transistor. And the transistor would not have been inventable without the development of semiconductor technology (see above), which allowed unprecedented precision in current flow.

The "gateway" achievement in semiconductors created the physical basis for the transistor. When we hear the word "transistor," most adults remember the transistor radio. But transistors have quickly become the heart of virtually everything that runs on electrical current: lighting, telecommunications, computers, guided missiles, satellites, medical diagnostics – you name it. Now amazingly miniaturized, computers may contain billions of them; tiny calculators many millions – all functioning as internal "On-Off" switches and current modulators almost at the molecular level!

The main benefit of transistors: they replaced clunky, inefficient, fragile vacuum tubes. They generate less heat, waste less power and don't require warm up time. They operate at low voltage, so they're compatible with most small batteries. Unlike tubes, transistors are not vulnerable to shock. So they are reliable, versatile and durable – some operate for decades without replacement.

Although R&D is increasingly handled by teams of anonymous white-smocked Ph.Ds at universities, corporate labs and private research facilities, true progress still depends upon individual geniuses and their breakthrough thinking.

For the transistor, those individual geniuses were Bell Laboratory's John Bardeen and Walter Brattain, collaborating (and sometimes in competition with!) British-born physicist William Shockley. For their transistor work, that threesome was jointly awarded the 1956 Nobel Prize for physics.

Their contribution made the Information Age and the Internet possible.

In 1972, Bardeen shared a second Nobel Prize for physics – the only person ever so honored – this time for work in superconductivity. But by 1951 he had already moved to the University of Illinois (Urbana-Champaign). As Professor of both Electrical Engineering and Physics, he mentored Nick Holonyak, his first doctoral student (1954). His insight and guidance clearly contributed to Holonyak's 1962 invention of the first LED. (See page 75.) And so the torch of scientific progress is passed from genius to genius.

CONTROLLABLE
LIGHTING SYSTEMS

"Hey, it's cold in here!"

Few of us would run the sprinkler hours after our lawn is already drenched. Or keep gulping water after we're no longer thirsty. Or want the light burning inside a closed refrigerator. Yet we think nothing of wasting electrical power inside empty rooms with many times the volume of a fridge.

WASTE MATTERS

Championship athletes train for the most efficient use of their bodies' energy. Grand Prix drivers fine tune their engines for the most efficient use of automotive energy. However, no matter what kind of lighting we use, the fact is that, in most cases, we all use too much of it. We waste light energy all over the place.

And waste is bad. Bad for profits, bad for the environment – and bad for engineers' self-esteem! So lighting scientists got together to solve the waste problem. And voila! Lighting Control Systems... the latest stage in the evolution of artificial light technology.

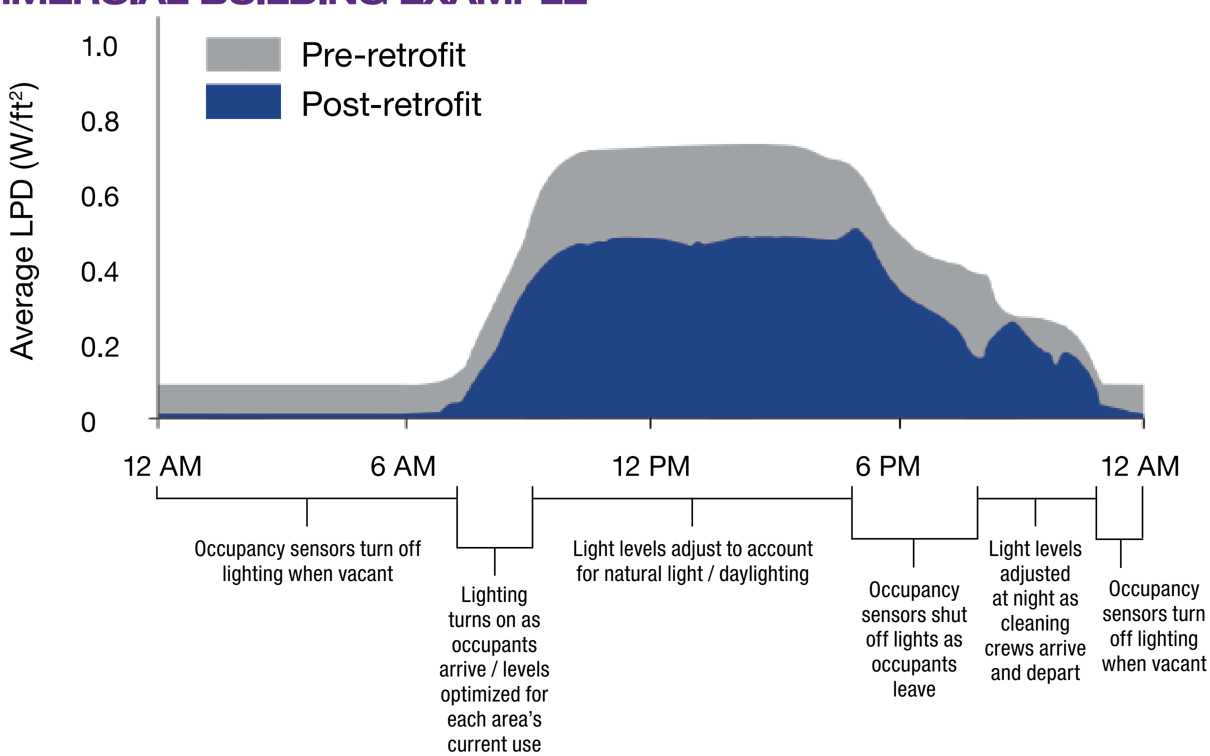
Smart people don't waste money on options they don't need. Serious mountain bikers find that a 10-speed makes sense. But they'd probably see no added value in a 175-speed bike. It's unlikely that the hundreds of ingredients listed on a 24-page menu will be as fresh as the smaller selection in a high-quality, limited-menu restaurant.

COMMERCIAL ENERGY COST TIMELINE

Fulham's "prime directive" is to produce high quality lighting technologies, but never dilute their value by trying to make them all things to all people. The Fulham Lighting Control System is designed to coordinate many lighting configurations with widely adaptable ballasts and peripheral devices. We focused on that mission and (if we do say so ourselves) accomplished it brilliantly.

CONTROLS

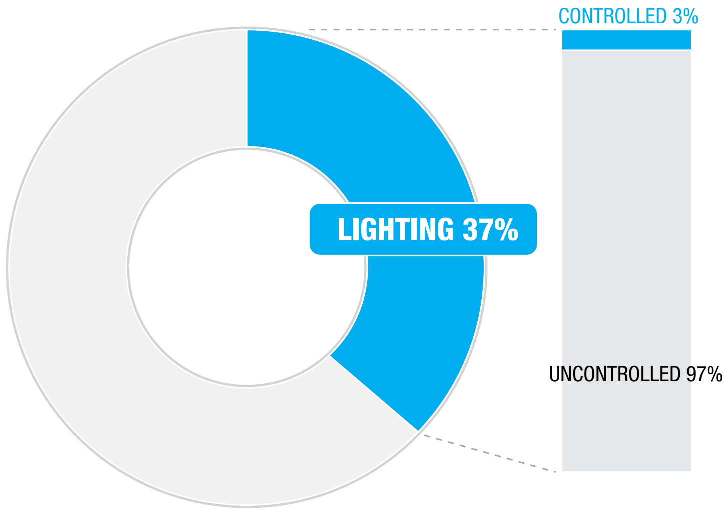
WEEKDAY LIGHTING LEVELS
COMMERCIAL BUILDING EXAMPLE



LIGHTING COST IN COMMERCIAL BUILDINGS

Commercial building lighting accounts for some 37% of all energy costs, yet only 3% of that lighting is "controlled." This offers an opportunity to save energy (and therefore to save money) with lighting control technology that senses occupancy, makes use of timers, and adjusts fixture light levels according to the light coming in through windows. Savings can reach 70% or even more – without changing the lighting type or removing existing fixtures.

Chart Reference:
Energy Information Administration, 2003 Commercial Buildings - Energy Consumption Survey, released April 2009. (www.eia.doe.gov/emeu/cbecs/cbecs2003/lightings.html) - J. Sweeny, 2009



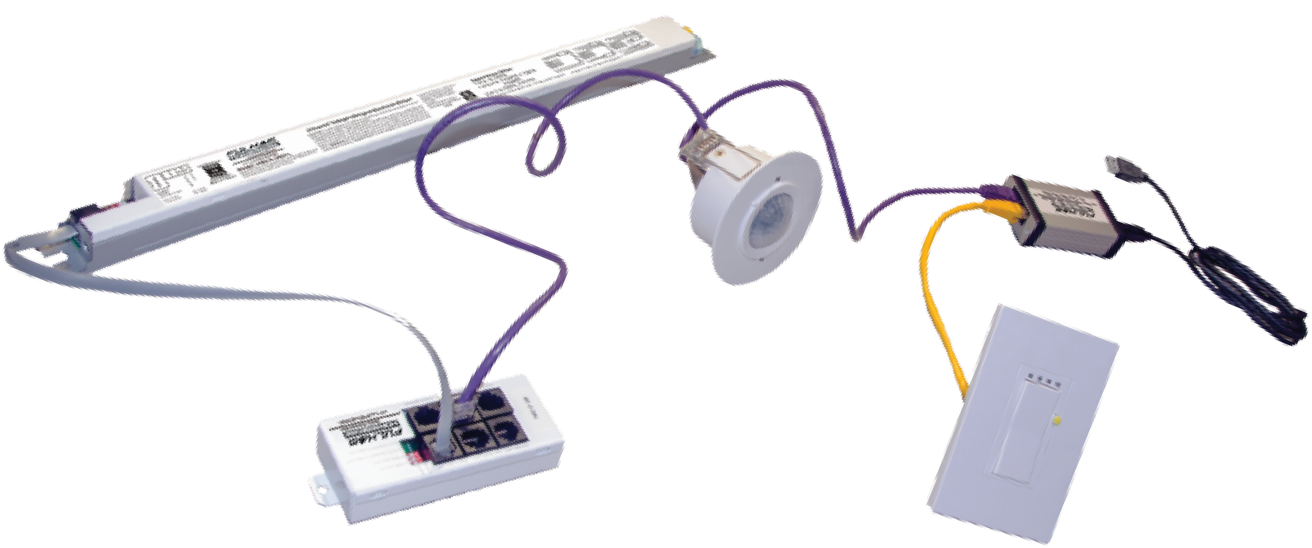
A-B-C... 1-2-3...
FLUORESCENT ROOM SOLUTIONS

Fulham Lighting Control ROOM SOLUTIONS provide efficient lighting control for virtually any warehouse, workplace, individual or multiple dwelling, corporate office, municipal area or entertainment venue.

Fulham's controllable fluorescent ballasts have individual, pre-programmed two-way communicators that the lighting control system recognizes. They're simple to install.

Fulham Lighting Controls work with fixtures and lamps of your existing lighting infrastructure.

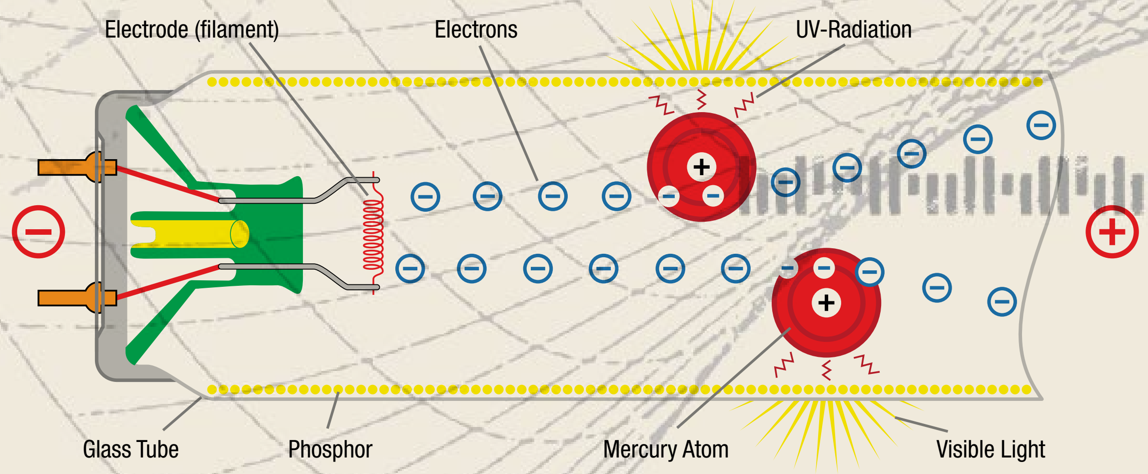
Fulham's ROOM SOLUTION is simply "plug and play." No outside help is needed. It's self-explanatory, ready to go. Your own tech just slips the pre-addressed ballast out of the box and installs it into the fixture. Easy-shmeasy hookup to switches and sensors by way of interconnect hardware that uses common CAT5 cable. The computer control knows what to do from there on. So, if your LCS is an individual office, conference room or other self-contained workplace, there's no need for "commissioning" (no, not making a non-com an officer; just bringing in an outside specialist.)



FLUORESCENT

THE RELIABLE INDUSTRY STANDARD

Fluorescent light still accounts for a great deal of industrial, commercial, municipal and residential lighting. More sophisticated than incandescence, fluorescent light comes not from electrically "cooking" a filament inside the bulb, but from gases excited to brilliance by electricity flowing between two electrodes. That charge, triggered by a ballast, generates ultraviolet light, made visible by a phosphor coating inside the tube. A major benefit: it doesn't generate as much ambient heat as incandescence, burns up less electricity per unit of light and costs much less.



Electromagnetism, Embryo

The ingenious English physicist and chemist Michael Faraday (1791-1867) was one of the most inspired experimental scientists in history. He proved the relationship between magnetism and electricity, which laid the foundation for electromagnetic theory.
His work with electromagnetic rotary devices led to the development of electric motors, the generator, and thus to the practical use of electrical power for home, industry and technology. It is Faraday who brought the terms electrode, cathode, anode, diode and others to the popular vocabulary.
In a famous exchange between Queen Victoria (1819-1901) and Faraday, the monarch noted that his lab demonstrations were fascinating -- but of what practical use were they? Faraday is reputed to have replied, "Madam, of what use is a baby?"

Her Majesty was not amused.


Michael Faraday

Scottish-born James Maxwell (1831-1879) synthesized research from several disciplines, including Farrady's initial work (magnetism, electricity, optics, classical physics), into the unified theory we now call Electromagnetism. This was his crowning achievement -- the one our industry is founded upon. Maxwell's breakthrough confirmed the suspected interrelationships among electricity, magnetism and light itself.

Maxwell's work is particularly important to daily life on Earth: his equations led to practical applications for the lighting industry. Maxwell's intuitive leap "connected the dots," producing the comprehensive theory of electromagnetism. Many believe that, without ideas advanced in Maxwell's Equations, Einstein's 1905 paper on relativity might not have been possible. (Einstein was born in 1879, the year Maxwell died.)


Peter Cooper Hewitt

Fluorescence was a lighting technique first researched in 1857 by French physicist A.-E. Becquerel (1820 - 1891). He believed that light didn't necessarily have to come from heat, but also from chemical reactions. A respected experimenter with photo-voltaic processes, he coated tubes with various chemicals that could be excited to luminescence by spraying electrons on them. This became full-fledged fluorescence when American engineer P.C. Hewitt (1861 - 1921) patented the mercury vapor lamp in 1901. Electrically charged vapors produce the glow inside the tube. It all seems so easy now: replacing nitrogen with mercury vapor creates a de facto filament, which, when electrified, produces invisible ultraviolet light, converted to visible light when it collides with the phosphorescent coating inside the lamp.

Edmund Germer (1901-1987) is credited by some historians as being the inventor of the first true fluorescent lamp. However, as we've seen, a great deal of work went into the development of fluorescent lamps prior to Germer.

FLUORESCENT
LIGHTING SYSTEMS

HUNDRED OF MODELS, COUNTLESS APPLICATIONS

A Bit About Fluorescent Ballasts and Lamps

A ballast is an ignition device and regulator, which "fires up" a gas-filled lamp and regulates the current flowing through it. Ballasts are essential to the operation of fluorescent lighting and its offshoots (CFL, HID, etc.). They vary in complexity and function, but all limit and stabilize the flow of current in an electrical circuit.

THE LIGHT THAT CAME IN FROM THE COLD

Electric power in general is affected by heat and cold, and varies with ambient temperature. The same is true for lamps. If exposed to lower or higher than normal temperatures, their power decreases.

Fluorescent lamps dislike the cold, and they show it. Like people on a sub-zero day, they take longer to get going; longer to reach maximum performance. Their problem is the cold tube wall's unfriendly effect on the vapor inside the lamp, condensing it to lazy droplets. Only when the lamp warms can they become useful "lightable" vapor. As the temperature rises, so does illumination.

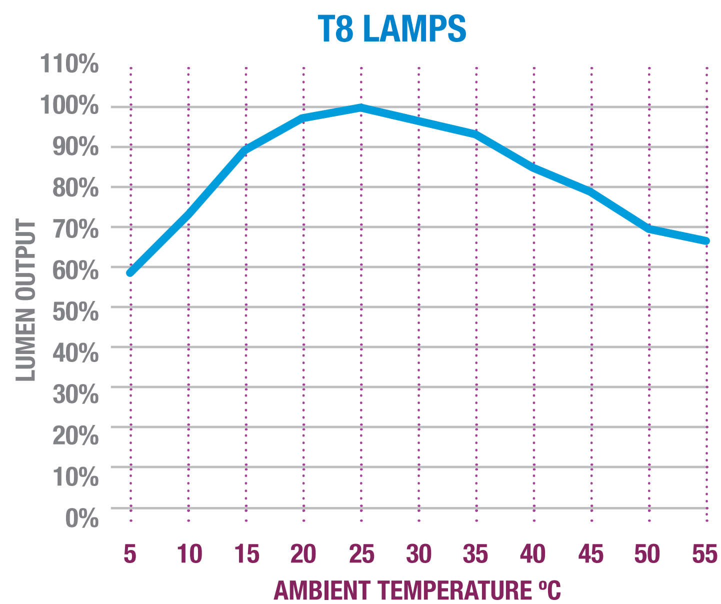
These charts track Lumen output for T8 and T5 lamps at ambient temperatures ranging from 5°C/41°F to 55°C/131°F.

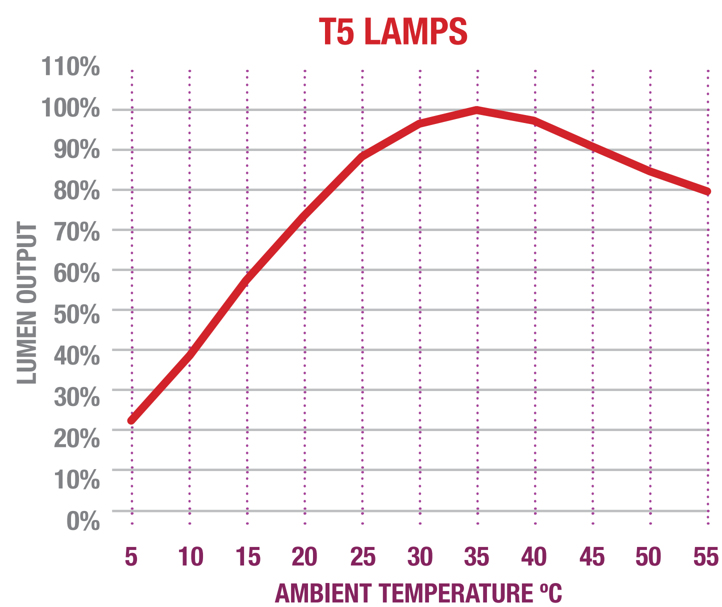
The T8 performs more or less the same at both ends of the scale, with peak luminescence between 20°C/68°F and 30°C/86°F.

T5 is somewhat crankier in the cold, producing lower lumens for somewhat longer, reaching top output later, between 30°C/86°F and 40°C/104°F. This would seem to make T5s a better choice for tropical parking lots for example.

Fulham ballasts are engineered for optimal functioning of fluorescent lamps all across the use spectrum. Just two examples: IceHorse works T8 well in consistently low ambient temperatures like refrigerators, cold display cases and outdoor Siberian warehouses. SunHorse driving T12s is an excellent choice for germicidal purposes or your tanning salon. And so it goes.

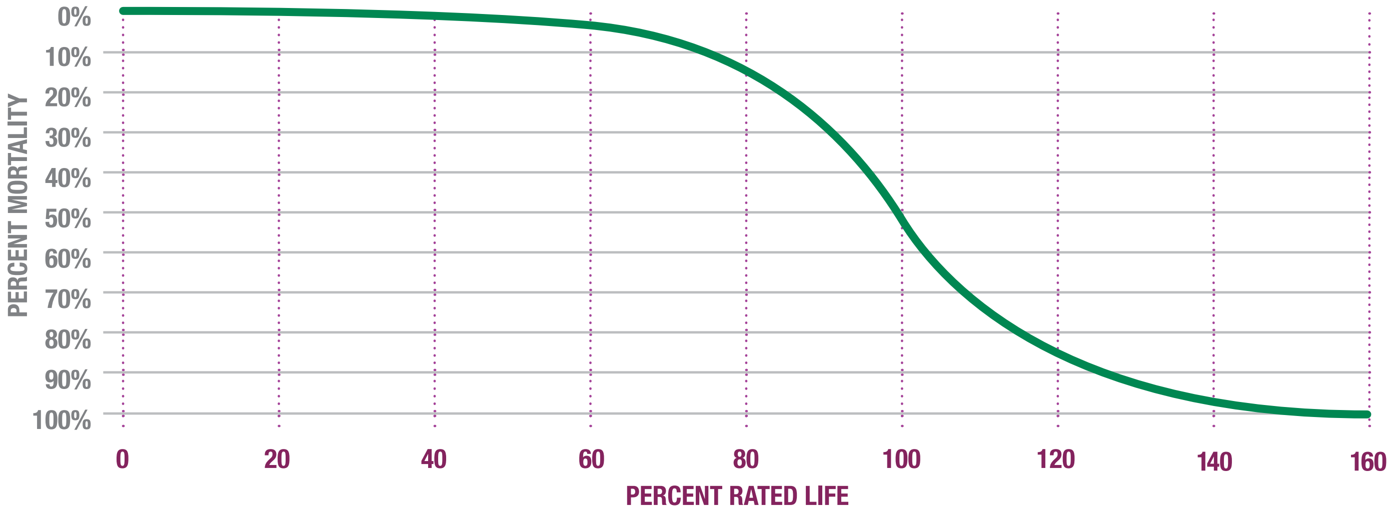
LIGHT OUTPUT VS TEMPERATURE





FLUORESCENT

TYPICAL FLUORESCENT LAMP MORTALITY



MEAN VS MEDIAN

Here's what you can expect for fluorescent lamp lifespan, expressed as a "rated lifespan." Don't confuse that with either "average lifespan" or "mean lifespan," which is calculated by adding up the working hours of all lamps tested, then dividing by the total number of lamps.

Instead, rated life indicates the median lifespan, the point when 50% of all tested lamps expired and the other 50% were still going strong. Following the 50% mortality line across, we see that half of the lamps in the test sample were still alive and kicking at 100% rated life span.

DID YOU KNOW?

WHERE GLASS TUBES COME FROM

There are three basic techniques for shaping glass. The most ancient one -- seen in TV documentaries or old classroom films -- is blowing. The craftsman collects a blob of molten glass on the end of a long metal pipe, then gently blows through the pipe into the blob. He does not inhale. Bad idea. He shapes the glass by blowing while turning the pipe, occasionally re-heating his creation. When it reaches the desired form and thickness, it is cooled down and snapped from the pipe. Blowing can be done, more uniformly, by machine.

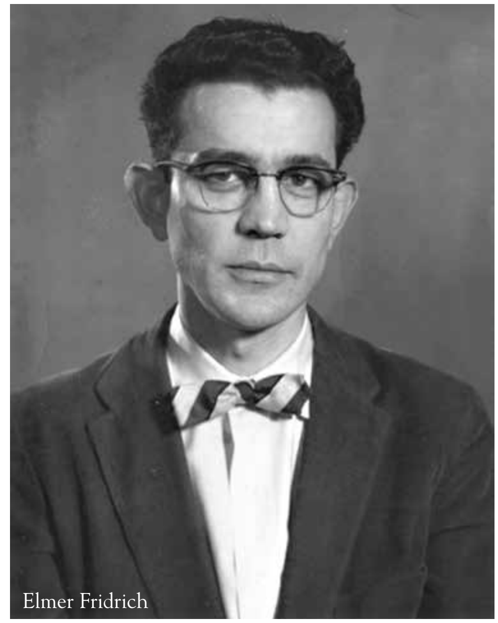
Glass can also be "pressed," dropping the molten discharge from the oven into a mold and pressing on it, like a waffle iron. This is the preferred way to make glass containers, ovenware and items like ash trays or platters.

The third method is "drawing." The glass is either flattened (windows, mirrors) or teased into tubes (fluorescent lamps, test tubes). For fluorescent tubes, molten glass is drawn in to coat the inside surface of a rotating cylinder. Air blows through it, forming a continuous tube as it exits the cylinder and cools. The tube is then cut into desired lengths.

All three methods require controlled reheating and cooling for molecular bonding to prevent shattering.

HALOGEN
LIGHTING SYSTEMS

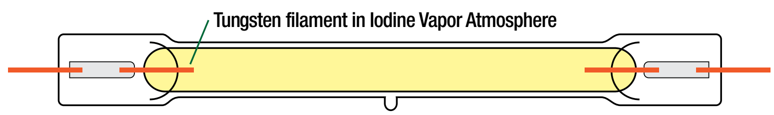
Think of halogen lighting as incandescence on steroids. It's bright, shows color well and is very affordable. Halogen is an excellent choice for track lighting, architectural design and displays.

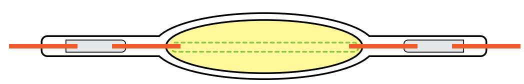

Elmer Fridrich

In 1959 Elmer Fridrich and Emmett Wiley created the first workable (and patentable) tungsten halogen lamp. Only a year later, GE scientist Frederick Moby improved on Fridrich and Wiley's invention with the "A-Lamp" that anyone could screw into their ceiling sockets or bedside table lamps. In 1962 came "Multi-Vapor Metal Halide" technology. Since then, lighting companies have been refining the design and operation of halogen lamps.

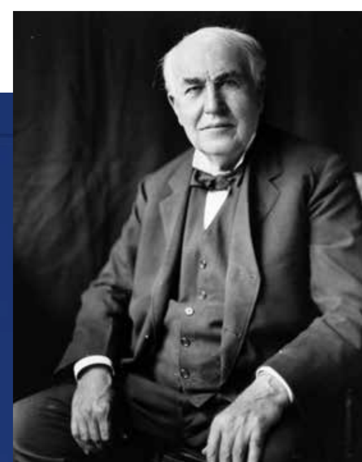
The halogen cycle kicks in only at high temperatures (nearly 500 degrees F.), otherwise the gas won't vaporize enough to work its magic on the tungsten. So bulbs must be smaller and stronger than incandescent bulbs, and made of heat resistant materials. Thick walls enable it to be packed with gases at very high pressure. The gas density slows tungsten degeneration from the filament, so the bulb doesn't become as blackened as soon. And the lamp's useful lifespan is increased.

That's not all. Halogen produces brighter, whiter-quality light while using less energy than ordinary incandescent bulbs of the same wattage. They are available in a variety of configurations, ranging from as low as 20 up to 2,000 watts.





DID YOU KNOW?
A MOST PRODUCTIVE MIND: THOMAS ALVA EDISON



Earlier we spoke of "the shoulders of giants" upon which scientific advances depend. Surely no Comprehensive Lighting Guide could be complete without mention of the giant called Thomas Edison (1847-1931) whose work in incandescence paved the way for halogen lighting. Edison's work is largely responsible for the "electrified" modern world: the phonograph, movies, municipal power grids and practical home lighting.

Few realize that Edison also possessed a first rate business mind. Establishing the nation's first major industrial rersearch laboratory, he pioneered the concepts of team research and mass production. Among history's most productive inventors, Edison held over 1,000 patents in the U.S. alone, and hundreds abroad.

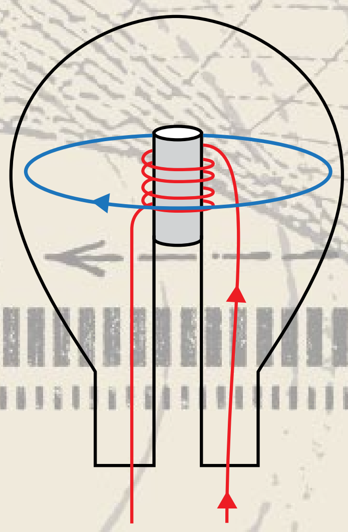
He was mainly self-taught. A slow talker (he didn't speak until almost age 4), "Little Al" was considered dull-witted by his first teachers. So he rarely attended school, being tutored instead at home by his mother. At age 11 he began devouring the contents of the local library, increasing his knowledge by endlessly questioning adults on topics that interested him.

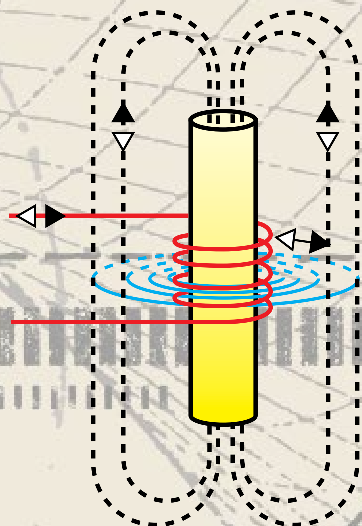
Unlike his rival, the lifelong celibate Nikola Tesla (see Induction), Edison was a family man. He married twice and fathered six children. Considering his exhaustive work schedule, where he found the time remains a mystery.

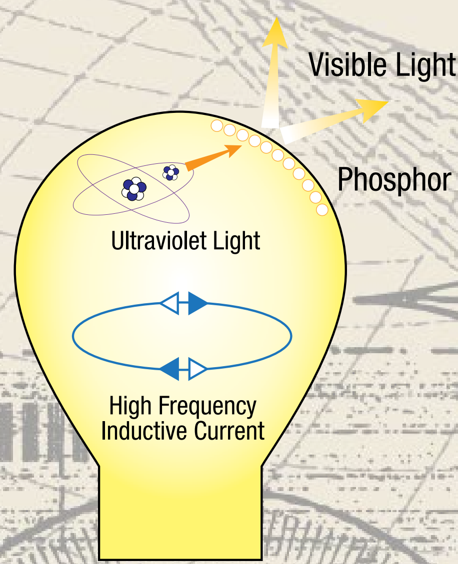
INDUCTION

BRINGING NEW CLARITY TO BRILLIANCE

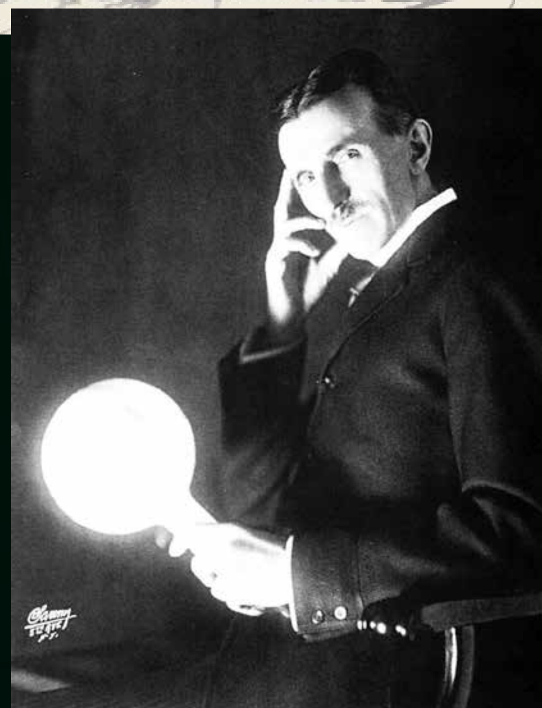
Picture a fluorescent lamp with an electromagnet wrapped around it. The electromagnet fires up. This excites gas molecules inside the lamp, producing a powerful electrochemical reaction that results in a stream of photons generating ultraviolet light, then visible light – based on the phosphor coating on the inside of the glass tube.



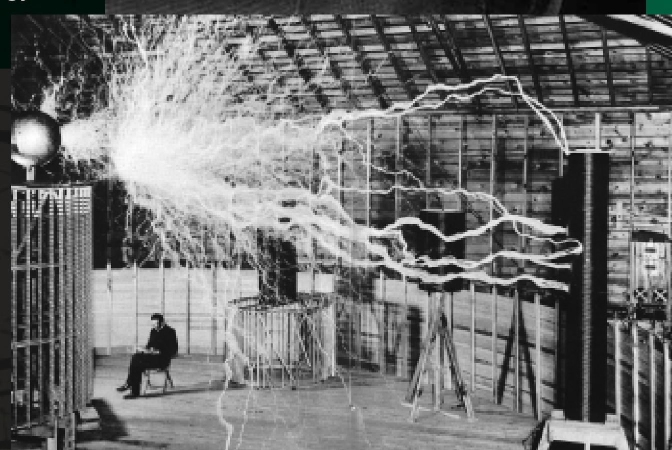




Here, Igor - Hold These Two Wires!



Enigmatic scientist and inventor Nikola Tesla (1856-1943) has been defined in many ways. Visionary. Pioneer. Seminal genius. Renaissance man. Polyglot. Prophet. Crackpot. An ethnic Serb born in what is now Croatia, he studied at several European universities in various languages before emigrating to America. An eccentric by most standards (vegetarian; lifelong celibate; clean-freak; claimed not to need sleep; photographic memory; devoted to pigeons, et al.), many aspects of his life remains opaque. To this day, many of his works are still studied, puzzled over, classified -- even suppressed (was he developing a Death Ray?). But our interest centers on his revolutionary work in electromagnetism and its applications, which match -- and often surpass -- those of his rival Edison. In the late 1800s (!), Tesla had already devised ways to transfer electrical energy into both fluorescent and incandescent lamps. In 1891, he patented a recognizable ancestor of the induction lamp. His diagrams for the U.S. Patent Office look very like designs for the electrode-less lamps we know today!



"An inventor's endeavor is essentially life saving. Whether he harnesses forces, improves devices, or provides new comforts and conveniences, he is adding to the safety of our existence."

-Nikola Tesla

INDUCTION
SUPERIOR LIGHTING

VISION IS IN THE EYE OF THE BEHOLDER

Popular wisdom holds that "the better the light, the better you can see." But not necessarily "the brighter the light." It's the quality of the light, not the wattage, that matters for visual acuity. Induction lighting produces breakthrough light quality because it was engineered according to the latest understanding of how our eyes process visual stimuli.

The human eye is built to perceive shapes, motion, colors, spatial orientation and other information from the environment (about 80% of human perception comes via eyesight). Induction lighting produces vision-friendly light. More clarity per watt.

Visual stimuli must transit the eye for processing in the brain. Efficient transit depends on the efficient functioning of cells in your retina called rods and cones. Rods are excellent for seeing at night ("scotopic vision") but don't "do" color. That's a job for the cones, which thrive at brighter levels ("photopic vision"). When the two work smoothly together they create optimal "seeing." The better the quality of the S/P balance ("mesopic"), the better the quality of that seeing.

Induction lighting assures the best possible interaction between rods and cones, thereby achieving superb mesopic balance.

Color Temperature

Degrees Kelvin is a temperature measurement as commonly understood. But in the context of "color temperature" it can be misleading, since that expression refers to the spectral quality of the color emitted by the lamp -- not the bulb's hotness, chill or color saturation.

That quality of light, described in Kelvin (K), ranges from yellowish "soft white" at the low end (standard household bulbs); through "bright white" (big retail store lighting); to "daylight" at the upper (bluish-white) end. The lower the "K" (2700 - 3000) the "warmer" the light quality; the higher the "K" the "cooler" as it rises to the blue end of the spectrum (5000+K). Fulham induction lamps are offered in a wide variety of color temperatures by adjusting the phosphor coating applied to the inside of the lamp's glass tube. This delivers the quality of light you need for YOUR purposes.

CRI

"Color Rendering Index" is the expression electrical engineers use to describe how white your white looks; how red your red; how blue your blue -- in other words, how closely your lamp reproduces colors to the way they look in ordinary daylight. The more color matters to you or to your business, the happier you'll be with a high CRI.

Lighting Efficiency

For cars, efficiency = MPG. For batters, it's RBIs. Lamp efficiency is expressed by Lm/Wt -- Lumens per Watt. That's light output per unit of energy input. Different lamps deliver different Lm/Wt ranges. Your choice.

SCOTOPIC/PHOTOPIC (S/P) RATIO

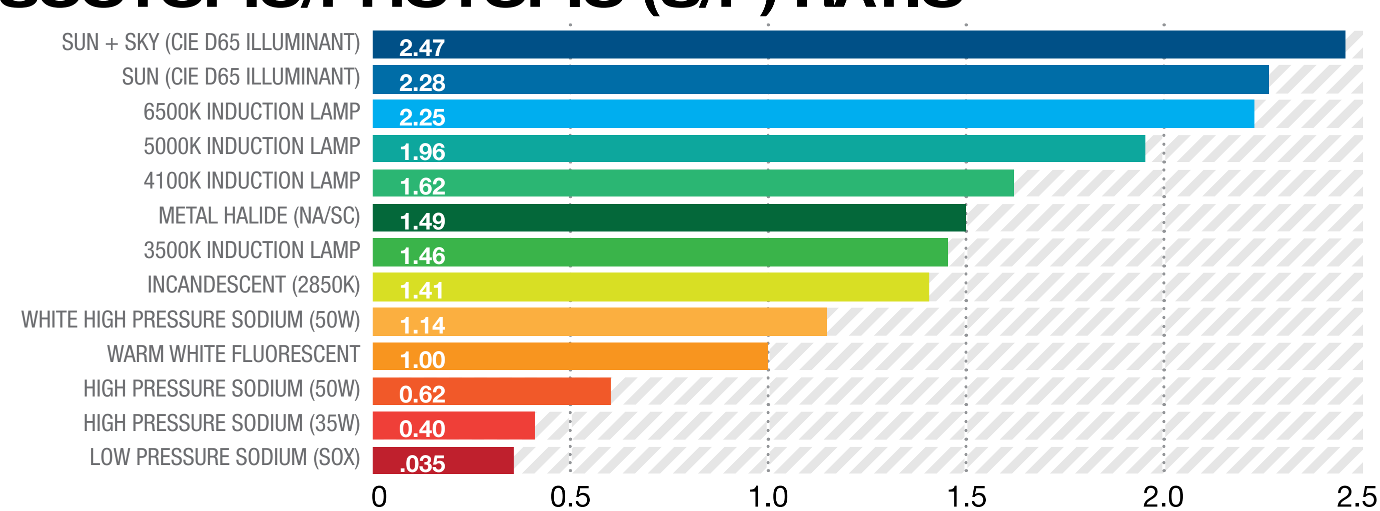


Chart calculations by Berkley Labs - actual selection of induction lamp wattage and type will vary with installation and user requirement.

> *"The scientific man does not aim at an immediate result. He does not expect that his advanced ideas will be readily taken up. His work is like that of the planter – for the future. His duty is to lay the foundation for those who are to come, and point the way."* -Nikola Tesla

COMPARE THE SPECS

When compared to other common light sources, Induction's specifications clearly dominate the competition

	INDUCTION	LED	METAL HALIDE	HIGH PRESSURE SODIUM
LAMP LIFE HRS	100k	30k - 50k	10k - 15k	15k - 24k
LIGHTING EFFICIENCY Lm/Wt	65 - 90	90 - 150	60 - 110	60 - 120
CRI	> 80	> 80	> 70	> 20
S/P RATIO	1.46 - 2.25	1.96	1.49	0.62
COLOR TEMPERATURE	Full Range	Full Range	Limited Range	Limited Range
HOT RESTART	INSTANT	INSTANT	DELAY	DELAY
MERCURY	Low	N/A	Low - High	Low - Medium

Hot Restart

Your lamp goes dark. You need to light it up again. But how quickly can you do it? Some lamps are designed for instant re-start. Others need a cooling-off period, which could be as long as half an hour, sucking up valuable production time, etc., etc., etc.This table shows which lamps jump right back on line (Induction, LED), and which need time to think things over (MH, HPS).

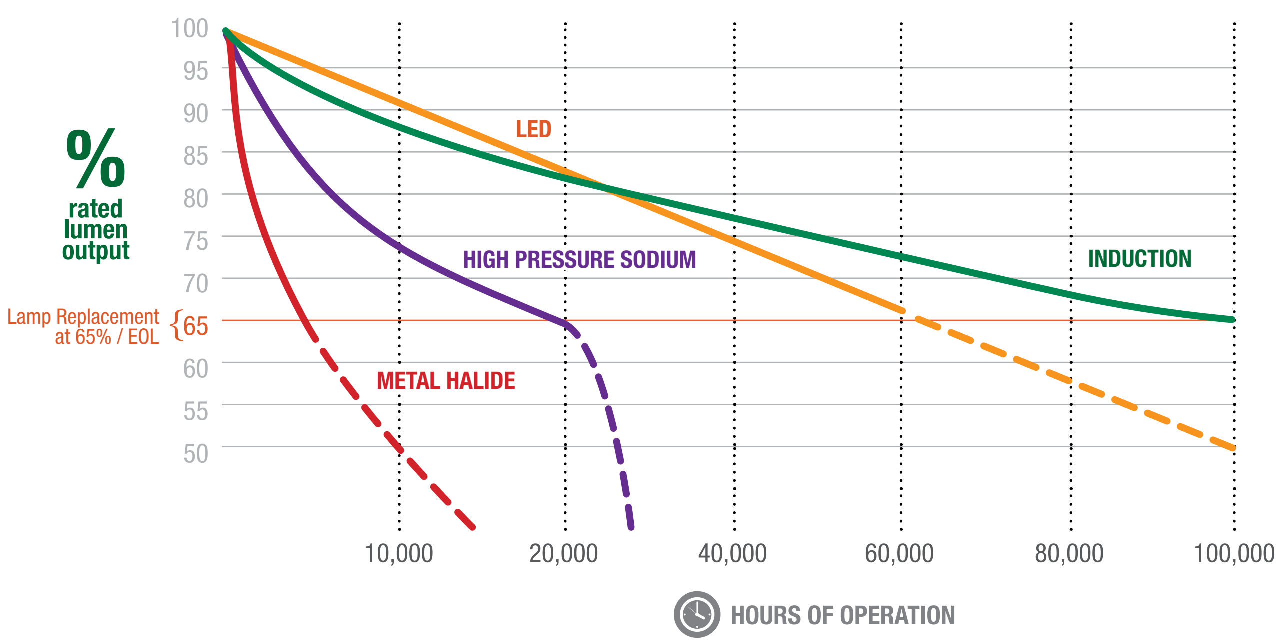
Lumen Maintenance

This "actuarial chart" below compares the active life expectancies of several of the most common lamps. Even though a lamp may still provide marginal light levels, industry norms consider its real potency gone at 65%, the failure level used in this diagram. All four lamps start at 100% efficiency, then gradually, as is to be expected in the real world, lose potency over their lifetime. Some maintain high levels fairly long; others reach dropoff (see the dotted line) relatively early.

HID lamps (MH and HPS) live fast, love hard and die fairly young. LEDs maintain robust levels until 50,000 hours or so, before dipping below useful levels. But induction lighting is engineered for the long haul. It unquestionably outlasts them all -- while still maintaining impressive strength.

LUMEN MAINTENANCE

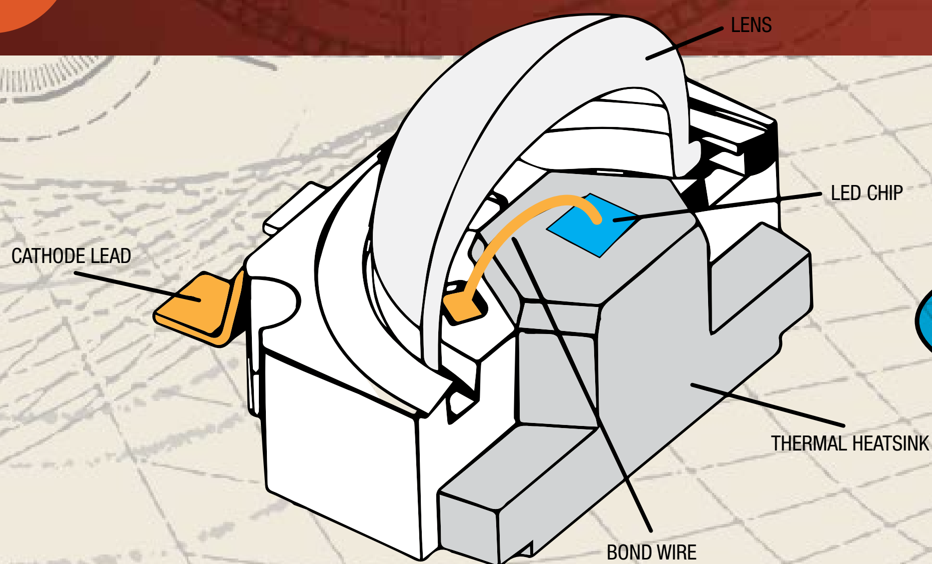
Induction's ultra long lamp life provides low maintenance costs through out the life of the lamp. This means big savings over the competition.

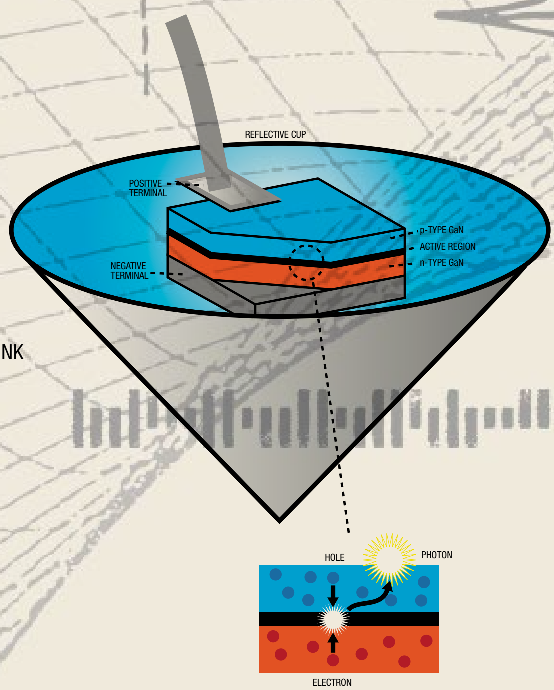


LED LIGHT EMITTING DIODE

BREAKING NEW GROUND

A Light Emitting Diode (LED) is a semiconductor designed to let electric current pass through in one direction and convert part of that energy to light while preventing backflow, not unlike a water valve.





Here's to the red, blue and white!

Shuji Nakamura

Nick Holonyak

H. Paul Maruska

The light-emitting diode, or LED, was invented in 1924 by the Soviet Russian scientist Oleg Losev (1903 - 1942). A skilled radio technician, Losev noticed that diodes in crystal set radios glowed when electrical current flowed through them. Based on that insight, he developed devices to generate light by electro-luminesence -- light produced by substances charged with electrical current. Although Losev published papers on his findings in various technical journals, credit for his breakthrough came only decades after his premature death.

Nick Holonyak, Ph.D. (b.1928) gets credit for inventing the first practically useful LED in 1962 while consulting at GE labs. Some have dubbed him "the father of the LED," but that paternity has been at the very least a shared, if not a group, enterprise. Dr. Holonyak has fathered many other inventions, including the first light dimmer; the red-light semiconductor laser (used in CD, DVD and cell phones); and a transistor laser.

LED technology developed relatively slowly, partly due to high R&D costs. The earliest LEDs were red only, followed by green and amber. By the mid-1990's blue and white LEDs joined the spectrum.

Pankove, Maruska, Nakamura: these guys gave us the blues

In 1968, Dr. James Tietjen of RCA labs - already envisioning what is now flat screen TV - tasked Herbert Paul Maruska (b. 1944) with finding a way to produce blue-yield LEDs. Maruska had already been "growing" red LEDs. He pored over research studies from the '30s and '40s, and beavered away for the next two years. In 1970, at 26, no longer eligible for the Vietnam draft, he moved to Stanford for his Ph.D. RCA financed the degree, stipulating only that his thesis consist of work on the blue LED. He was to rejoin RCA's research team as Dr. Maruska, and destined to join forces with the legendary Russian-born, French-raised Jacques Pankove (b. 1922), a pioneer in LED luminescence. (Indeed, Pankove's groundbreaking research virtually spawned the LED industry.) With a Master's from Berkeley, Pankove had joined RCA's research team in 1948. Teamed with Maruska at RCA, he created the Gallium Nitride LED (GaN LED) and the first blue LED (1971), cornerstones of the category.

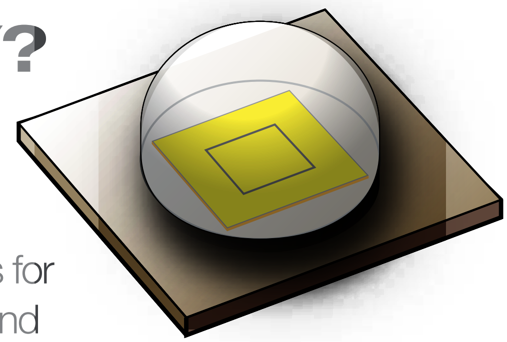
Later, halfway around the world, the founder of Nichia Corporation, Mr. Nobuo Ogawa, sponsored research headed by Shuji Nakamura (b. 1954) who was inventing the process that led to the first truly marketable GaN LED capable of emitting bright blue light. By 1993, Nichia had succeeded in developing a marketable product, which then went into production.

A year later Nakamura was awarded a Ph.D. in Engineering degree from his alma mater, the University of Tokushima. In 1999 Dr. Nakamura parted company with Nichia and accepted an engineering professorship at UC Santa Barbara.

In recent years, he has worked on green and white LEDs, and also blue lasers (as in Blu-ray™). And in 2014, Nakamura, together with Japanese scientists Isamu Akasaki and Hiroshi Amano, won a Nobel Prize in Physics for the invention of the blue LED.

LED
LIGHTING SYSTEMS

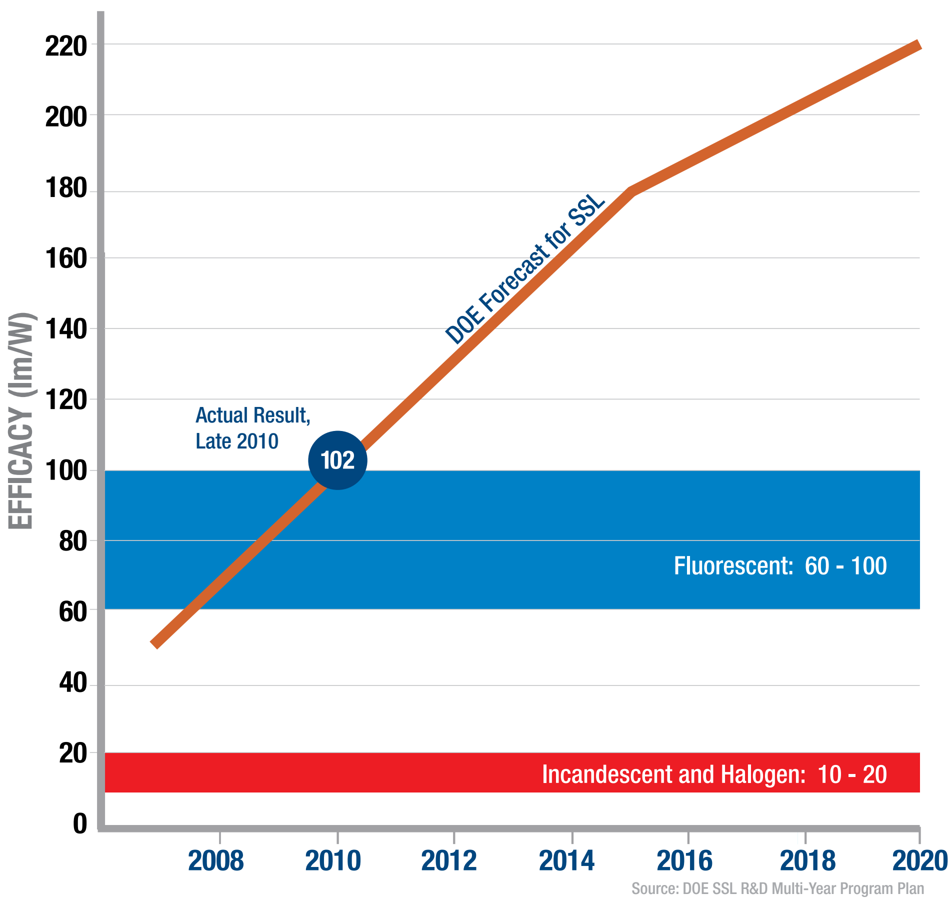
SURE, THEY'RE COOL, BUT WHAT USE ARE THEY?



LEDs are an excellent choice for aviation and automotive lighting (indicator lights, turn signals, brake lamps, etc.); traffic signals; advertising billboards; VCRs, video and computer displays; communications applications and remote control units for a variety of consumer electronic products. Colored, Ultraviolet and Infrared LED lamps are ideal for signalling, tracking, inspection, forensics (tracing blood), fluorescent dyes or other marked substances. Infrared LEDs are an important component in night vision equipment.

Here's what users like about them

LED lamps use about 30% less power than high-intensity discharge (HID) lighting, and generate less heat. They're fast switching, and pack lots of lumens in a smaller size. LEDs are bright enough to be plainly visible in broad daylight. They're also tougher than typical incandescent lamps (Solid State means no filaments to break). LEDs are trustworthy "work horses," often burning far longer than comparably powered incandescent lamps. They also require no special disposal, because they are entirely mercury-free.



SSL forecast

This chart at left dramatizes the skyrocketing SSL forecast. These are heady times for LED development. Not only are new applications being discovered regularly, but outyear projections for LED efficacy are nothing short of stunning. 2010 DOE data shows LED efficacy indexing at 102. In 2014, 150 is a better estimate; at its current rate of improvement, LED Lumen/Watt efficacy is predicted to hit an amazing 220+ in less than a decade! Meanwhile, other lamp categories are predicted to remain static.

LED Lumen/Watt efficacy is predicted to hit an amazing 220+ in less than a decade!

CONSTANT CURRENT VS. CONSTANT VOLTAGE

There are two different approaches to the electrical interconnection between an LED driver and LED modules. Those are called Constant Current and Constant Voltage. Factors considered when deciding whether to use Constant Current or Constant Voltage include how the system will be installed; how it will be configured; and overall system efficiency requirements.

With Constant Current, the LED driver feeds a steady current through all LEDs on the module. Since each individual LED requires a certain voltage for the current to flow (known as Vf), the driver must provide enough voltage to equal the sum total of all the voltages of that module's LEDs. Note that, while the LED module is frequently designed with all LEDs connected in one continuous serial electrical chain, it is also possible to create branches that split the current flowing through the module. So it's essential to understand the design of the module's circuitry, and the electrical rating of the LEDs themselves when connecting a Constant Current driver to Constant Current LED modules. Constant Current architectures offer higher operating efficiency than Constant Voltage, but less flexibility in connecting different modules and LEDs to the driver.

With Constant Voltage, the LED driver provides a steady voltage supply that enables power to flow through all LEDs connected. Since any given current flow requires a specific amount of voltage for each individual LED, it is necessary to buffer or regulate the voltage with a resistor (or equivalent component) in line with the connected LEDs. With proper resistance selection, the series-connected LEDs receive proper -- never excessive -- voltage to regulate the current inflow. The Constant Voltage approach is most commonly used when the number of LED modules varies widely from different installations or product designs.

DID YOU KNOW?

SIGNIFICANCE OF GALLIUM NITRIDE

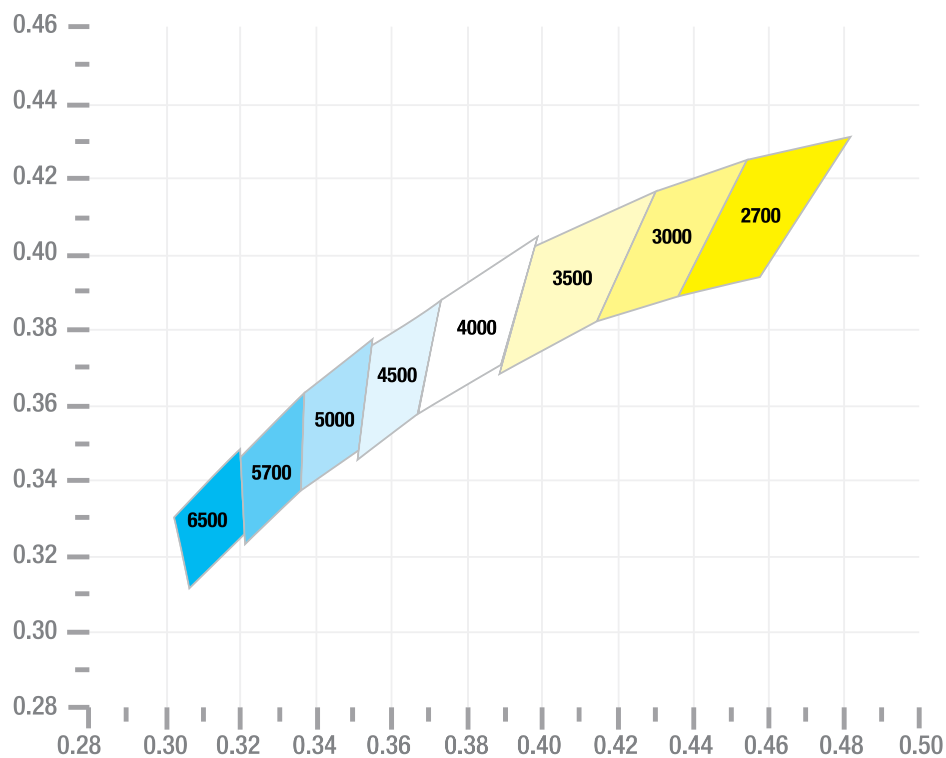
Gallium Nitride (GaN) is a non-toxic compound composed of elements Gallium and Nitrogen that form the basis for most blue and white LEDs. For use in LEDs, it is formed by a process that takes place at >1000°C known as metal organic chemical vapor deposition (MOCVD). In addition to Gallium, small amounts of Indium and Aluminum can be added to GaN in order to change the wavelengths of the LEDs to be fabricated. Gallium Nitride is unique among semiconductor materials; it has a hexagonal crystal structure of its individual atoms that results in unique properties. Gallium Nitride is also used to make lasers for HD DVD and Blu-Ray players and can be used to fabricate microelectronic devices for applications such as high-speed wireless communication and electrical power conversion. Most recently, advanced scientific research is being conducted to explore uses of GaN in biomedical implants.

ANSI BINNING

Not everyone realizes that, despite advanced manufacturing techniques and our best intentions, LEDs are not all created equal. There is always some variation from one to another in color temperature, lumens and even voltage among newly-minted LED "wafers," ranging from very slight to fairly significant.

This means that precise matching of color depends on further processing.

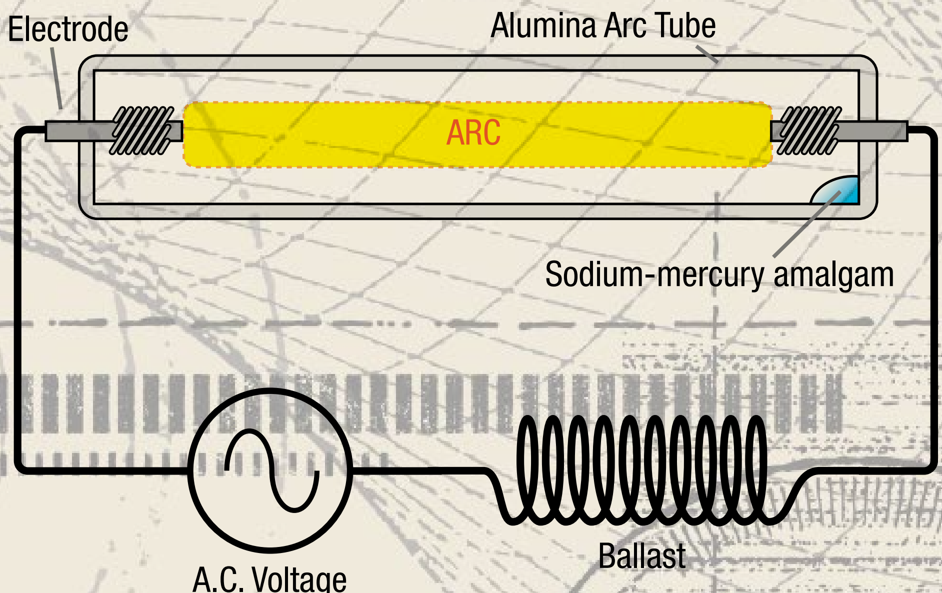
LEDs are taken one by one, activated, measured, then sorted into bins, each bin tagged for a Kelvin color range. This graph depicts that range, from bright white daylight (6500 K bin) all across the visual spectrum to soft mellow yellow (2700 K). There is an accepted industry standard for managing this color-matching process. Fulham follows that convention. This ensures that all our LEDs can be reliably interchanged with equivalent lamps of other manufacturers, either as original equipment (OE) or replacements.



HID HIGH INTENSITY DISCHARGE

AN ARC OF GENIUS

The light from HID lamps is produced by electricity passing between tungsten electrodes inside a tube that's filled with an ignition gas and metal salts. Firing up the arc converts the salts into an intensely glowing plasma. Despite the brilliance, HID power consumption is less than ordinary incandescent or fluorescent lamps, delivering far more lumens per watt.



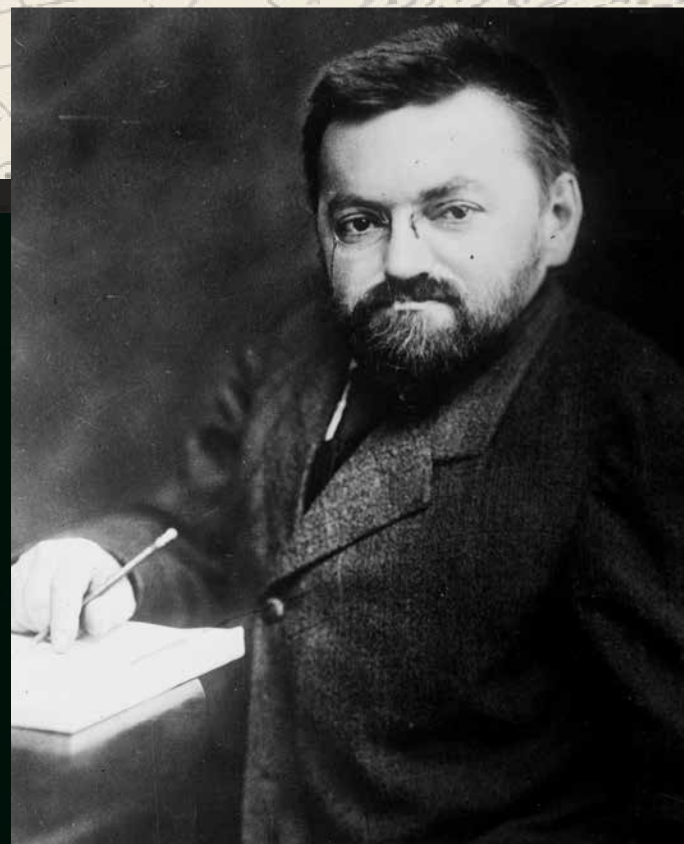
More Light, Less Heat

High Intensity Discharge lamps are, in fact, pretty intense. They belong to a group of gas-discharge lamps that literally developed over centuries.

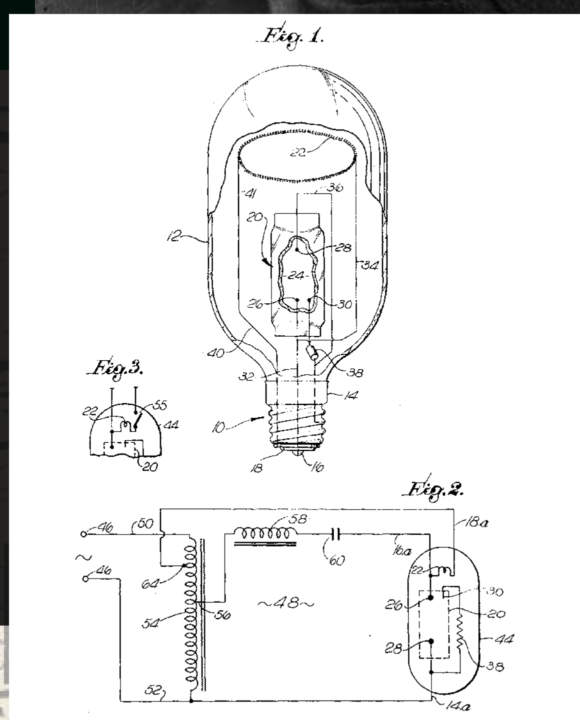
The earliest work on what evolved into mercury vapor lamps was done by the English scientist Francis Hauksbee (1666-1713), a Fellow of the Royal Society. Around 1705, he found that electrical charges on metals in an airless globe produced a glow not unlike St. Elmo's Fire (that scary electricity that zigzags on airplane wings and in mad scientists' labs). This work eventually led to developments such as neon lighting and vapor lamps.

In 1912, the gnomish German-born mathemetician/engineer Charles Steinmetz (1865-1923) promoted the development of alternating current, helping to grow the U.S. electric power industry. Steinmetz experimented with metal halide compounds in mercury lamps, which laid an important foundation for productive research in the 1950s, when many physicists were testing the feasability of halogen lamps.

Xenon gas short-arc lamps - the model for HID - were developed by German scientists in the 1940s. The lamps were quickly adopted by cinema projectionists, as a replacement for the less efficient carbon arc lamps because of their daylight-quality luminance. This benefit was subsequently improved upon by Gilbert Reiling (b. 1928), who in 1959 began work on the thermodynamics of mercury discharge lamps at GE labs. A year later he produced a lamp with about twice the light output of the standard 400 Watt mercury-vapor lamp with an even brighter white light. This became the metal halide lamp, which GE began to develop vigorously in 1962.



Charles Steinmetz



HID
LIGHTING SYSTEMS

INTENSE LIGHT, WITH LOW ENERGY CONSUMPTION

HID lamps have been in use, as an alternative to "regular" light bulbs, since the introduction of the mercury lamp in 1901. All versions of HID are more efficient than electric filament lamps, delivering more light per unit of electrical energy.

Some of today's HIDs have phosphor coating inside the lamp, providing a powerful and broad color and light spectrum. This makes them highly desirable for architectural, industrial, municipal and commercial lighting.

HID lamp attractive advantages

HID lamps take a moment to fire up, because they run off ballasts. But they last longer and burn brighter than their incandescent cousins. They consume less wattage – electricity is only to start – so they cost less to operate. HID delivers high light output from a concentrated source.

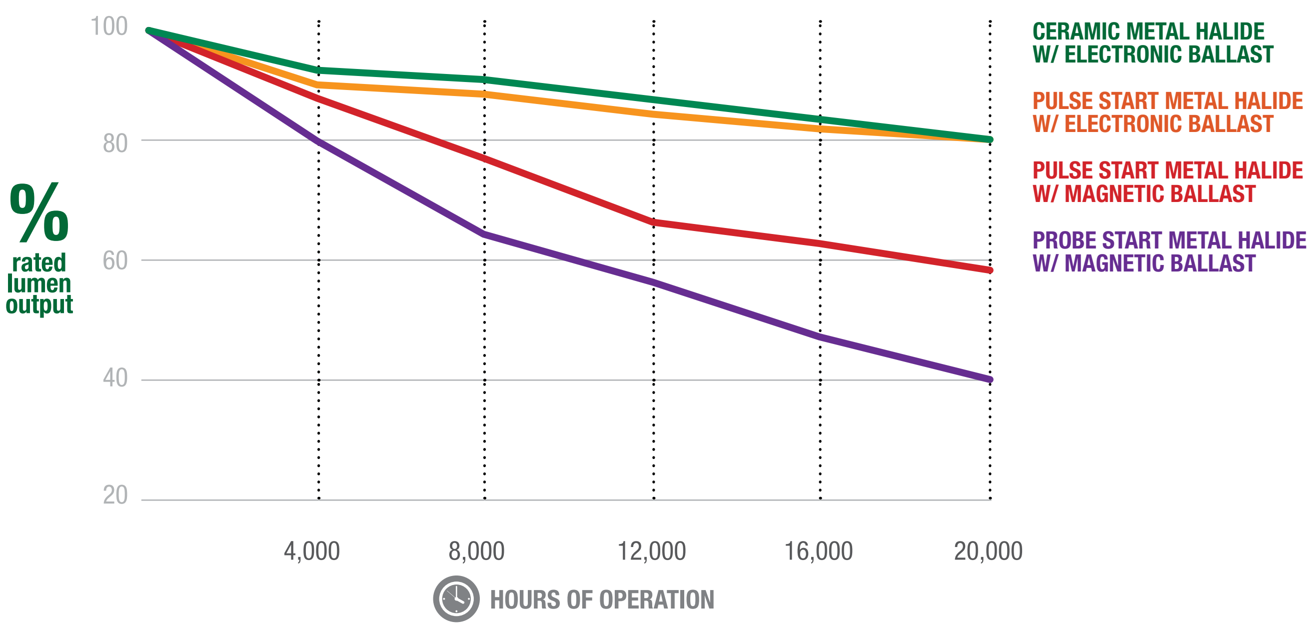
They come in four iterations. Mercury Vapor was the earliest version but can no longer be sold in fixtures. High Pressure Sodium lamps often line highways, with their yellowish-orange glow. Low Pressure Sodium delivers the best Lumens per Watt ratio (about 200!), but probably has the least light quality. Metal Halide, on the market since 1960, seems to deliver the best blend of benefits, so it has become the lamp of choice for big stores, warehouses, industrial plants, outdoor arenas and municipal locales. These lamps are cost efficient; the light quality is good enough for home use; and they are color-friendly.

Magnetic ballasts

With your basic "core and coil" magnetic HID ballast, a coil of (usually copper and/or aluminum) wire is wound around some

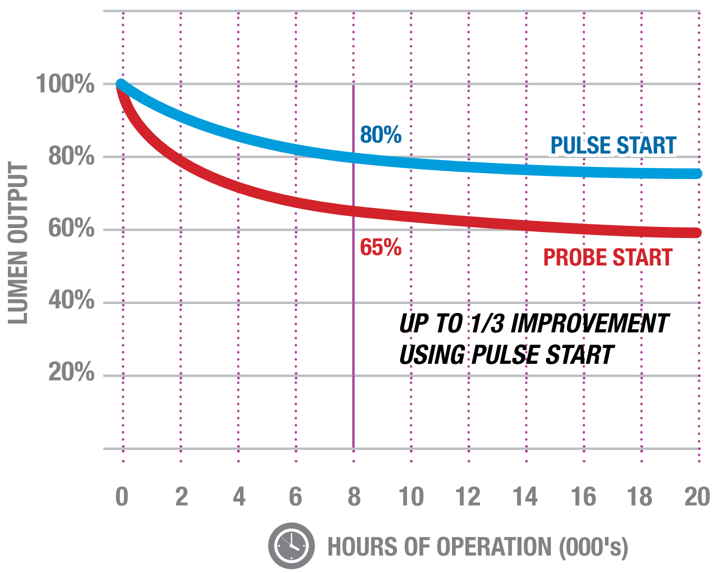
LUMEN MAINTENANCE

This graph illustrates Lumen dropoff for the four basic categories of Metal Halide (MH) lamps, comparing efficacy of magnetic vs. electronic ballasts. Probe Start Metal Halide lamps with magnetic ballasts show the earliest and steepest lumen decline. Pulse Start Metal Halide lamps with magnetic ballasts fare somewhat better, maintaining a relatively higher lumen level for longer. Pulse Start electronic ballast MHs have a much higher lumen level, staying fairly consistent through 20,000 hours; while Ceramic MH lamps managed by electronic ballasts do best of all, achieving 80% lumen maintenance at 20,000 hours and beyond.

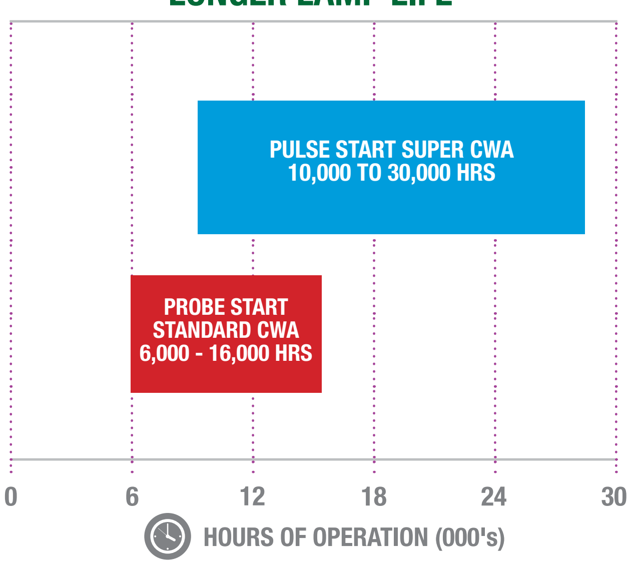


PULSE START VS PROBE START MAGNETIC HID BALLASTS

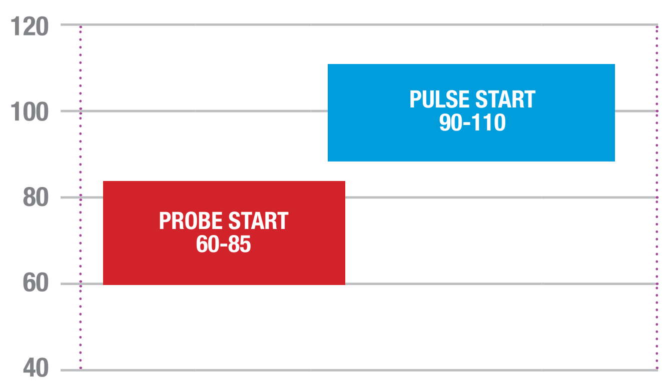
BETTER LUMEN MAINTENANCE



LONGER LAMP LIFE



MORE LUMENS PER WATT



kind of metallic core. Electricity charging through the wire loops produces an electromagnetic field – hence "magnetic" ballast. It modulates current inflow at a fairly low cycle rate. Because "core and coil" technology involves metals, magnetic HID ballasts are heavier, therefore somewhat more expensive to operate than Electronic HID ballasts.

Magnetic ballasts operate a variety of metal halide and high pressure sodium HID lamps, using either Probe or Pulse technology.

Probe technology consists of a starter electrode and two operating electrodes inside the lamp. The electrical charge arcs from the starter to one of the operating electrodes, which in turn bounces electrons over to the other one. Once the lamp is "live," the starter electrode switches off. Side effect: continued operation of the lamp results in tungsten atom deposits on the tube's wall, eventually dimming the light output and affecting true color perception.

The Pulse system, instead of a starter probe, employs an ignitor that sends high voltage "pulses" which heat the electrodes faster. Pulse starting has a reputation for extending MH lamp life up to 50%, providing faster starts even in extreme cold, and delivering faster re-strike times with less warm-up time. The eyes have it: Pulse CRI and general luminescence is about a third better than Probe, since the ignitor system cuts down on tungsten escape.

Electronic ballasts

Sophisticated Electronic HID ballasts are computerized to sense the appropriate power level for their designated lamp(s), and restrict current flow to that level. So they can quite precisely regulate the current flowing through the circuit. Their higher cycle rate reduces or eliminates most noise and flicker.

Electronic ballasts offer the advantages of increased overall efficiency and lower operating costs. They run cooler than magnetic ballasts and aren't energy gluttons. They operate at higher frequencies. This cuts end losses, and delivers 10% to 15% higher lamp-ballast efficacy. They extend lamp life by at least 50%. EHID ballasts are lighter than magnetic ballasts, because they have no copper coils.

MAGNETIC VS ELECTRONIC

Running on magnetic ballasts, you can expect lumen depreciation of about 60%... as opposed to only 20% over the same time period from electronic ballasts.

When HID is boosted with electronic ballasts, lighting becomes more efficient and less expensive. Switching to EHID significantly cuts the need for service visits, resulting in fewer service charges. You can use the same lamps, but they will work better and last longer. And you can get the same illumination from lower-wattage lamps or fewer fixtures!

EMERGENCY EXIT

LIGHTING THE WAY

Civilized societies take seriously the health and security of their citizens. Therefore they use technology not just for material practicality, but also for people's well-being. Along with the rise of social awareness, safety lighting evolved for normal daily convenience, and especially for emergencies.

Emergency lighting can be provided by just about any lighting technology. When trouble strikes, we don't much care about specifics -- we just want to see well enough to get to safety. Fulham engineering has developed a variety of reliable systems to handle any emergency lighting situation.

“Hey, Pop, What's An Egress?”

Let's admit it. Deep down, we're all afraid of the dark. This is especially true in emergencies, when bad things can happen in the dark, even in familiar places. Can't find the exit. Trip over the cat. Bump into something lethal, harmful or just plain messy. Even if it's not a fire or an earthquake, when lights fail, we're back in prehistoric times.

That's why, in modern times, we created emergency backup lighting, designed to kick in automatically when the main system goes down. This is usually a secondary generator or battery system that provides temporary illumination until a location is vacated, or the lights go back on. Until recently, backup lighting was noticeably inferior to the main system. It was, after all, designed to be just a stopgap measure, like those dinky 25-mile emergency spare tires we slap on when our high quality, 100,000-mile radials unexpectedly plotz.

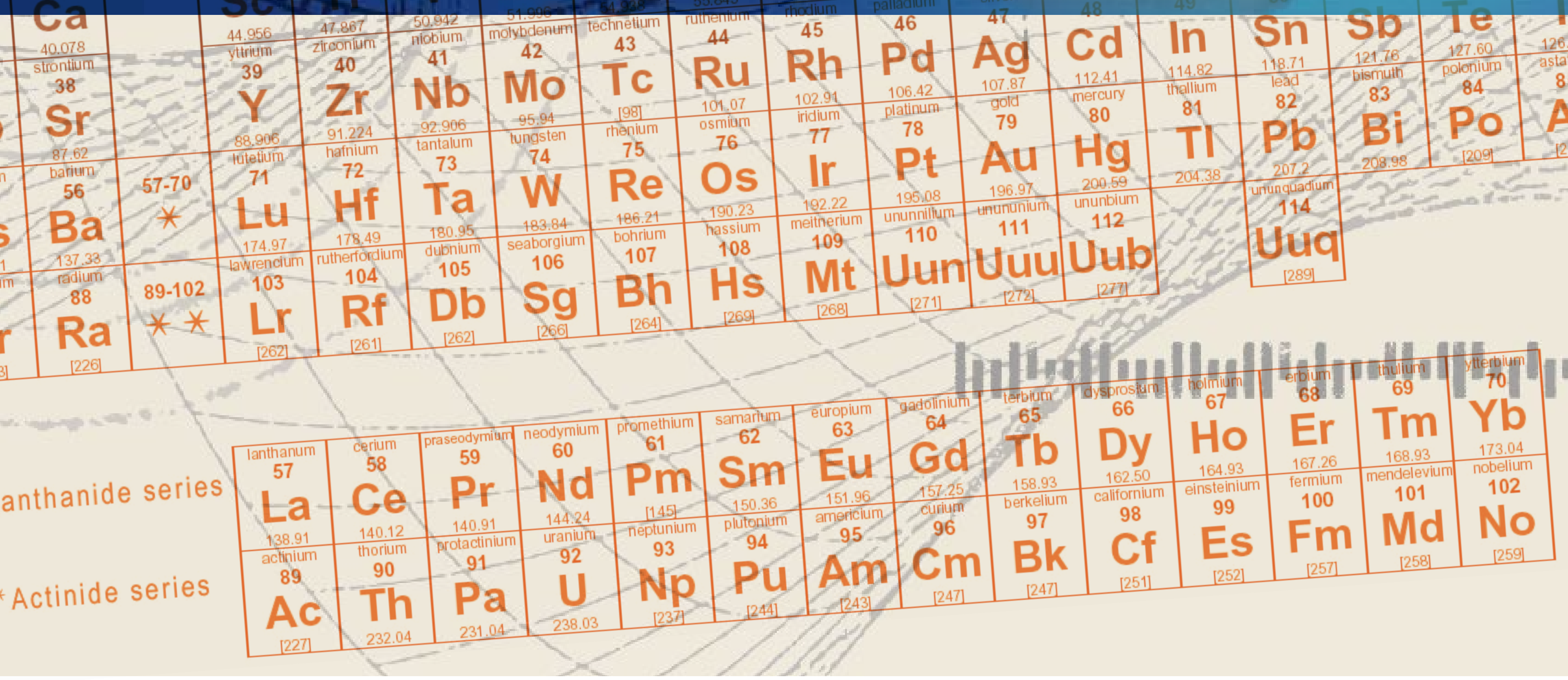
But now, in response to increasingly stringent safety code requirements, the lighting industry has developed a variety of reliable, long-lasting and brighter-burning emergency systems. These range from incandescent bulbs to LED clusters to banks of batteries to newer self-luminescent technologies. The objective is to get us out of some dark, maybe smoky, danger zone. So besides lamps to light the "egress path," an approved emergency system usually includes illuminated signage to speed the evacuation process safely along.

In most cities, emergency lighting is mandatory for all commercial, industrial and multiple residence buildings. Code specs list requirements for lamp locations; wiring; mimimum illumination levels; periodic system testing and maintenance; timely equipment replacement; and clear indications of emergency service call box locations, stairnosing, handrails, stairwell landings, clear delineations for paths of egress and related code requirements. Inexpensive home emergency lighting packages have also become increasingly popular.

FREELITE

ZERO ELECTRICITY REQUIRED

Like many modern technological marvels, photoluminescence (PL) appeared first in nature, in this case as fireflies and glow worms. Actually, they're not flies, but flying beetles; and they're not worms, but insect larvae. And what they exhibit is technically bioluminescence, but let's not get picky. Nature's glow inspired a concept of lighting which humans learned to emulate.



The glow in the dark that saves lives.

In simplest terms, PL is a kind of "light echo." Certain rare earth elements, when exposed to ambient light energy, gobble up the photons, then re-emit them into the environment even when the light source is no longer present.

Many American children have photoluminescent glow-in-the-dark toys, bedroom ceiling "stars" and spooky Halloween toys. The same principle applies to emergency safety lighting. PL systems are just like those glowing toys -- only more so.

10-YEAR COST COMPARISON (EST.)	COMPACT FLUORESCENT	LED	FREELITE PL (Without frame)
Lamp Life	14,000 Hrs	50,000 Hrs	None
Energy Consumption	21 Watts	5 Watts	-0-
Sign Cost	$60	$75	$64
Installation Materials	$48	$48	$0
Installation Labor	$196	$196	$6
Total Initial Costs	$304	$319	$70
10 Year Costs			
Electrical Power	$184	$53	$0
Lamp Replacement Costs	$100	$50	$0
Lamp Replacement Labor	$120	$24	$0
Battery Replacement Costs	$20	$20	$0
Battery Replacement Labor	$24	$24	$0
Total Operating Costs	$448	$171	$0
Total 10 Yr Life Cycle Cost for 100 signs	$75,200	$49,000	$7,000

"GLOWING" IS GROWING, NATIONWIDE

"Safety first" is more than just a slogan -- it's the law. Safety codes in most cities require sufficient and prominently positioned exit and emergency signs. Specifics vary, but the basic requirement nationwide is for commerical buildings, factories and multiple tenant residences to clearly indicate safe egress -- day or night -- for all hazardous conditions (fires, earthquakes, power outages, hostile incidents, severe weather or floods, etc.). PL is ideally suited to comply with these laws.

PL PROVIDES MULTIPLE BENEFITS

Photoluminescent lighting is highly visible in dark and smoke emergencies. It's virtually failure proof, since it doesn't depend on electrical power. (Just 5 foot candles of light during the day is enough to keep it charged.) It can't just go out.

PL is non-toxic, non-radioactive (Tritium-free), recyclable and shock proof. There are no batteries to buy, replace or dispose of, which also eliminates the significant cost and hassles of testing and record keeping for Code compliance.

Energy savings are especially significant in larger structures. And the savings last for years -- a typical PL system's life span is about 25 years!

This chart outlines typical expenses for 10-year operation of three major lamp categories, dramatizing the astonishing cost effectiveness of Freelite PL. Compare the numbers for CFL and LED against Freelite. Then tell us which column you'd rather have represent your operation. We didn't even include T10 incandescents, which score "off the chart" in terms of cost and energy use.

FULHAM
Lighting...Global. Intelligent. Sustainable.

Fulham Headquarters (USA)
12705 S. Van Ness Avenue
Hawthorne, CA 90250
Tel: (323) 599-5000
Fax: (323) 754-9060
order@fulham.com
www.fulham.com

Fulham Company Ltd. (International)
Unit 6, 6/F, Kowloon Plaza
485 Castle Peak Road
Cheung Sha Wan, Kowloon
Hong Kong
Tel: +852-2314-4801
Fax: +852-2314-4186
hongkongsales@fulham.com

Fulham Co., Inc. (Canada)
24 Kicking Horse Way
Port Moody, BC, Canada, V3H 0G5
Tel: (604)-288-2609
Fax: (604)-648-9065
canadasales@fulham.com

Fulham Electronic Co. Ltd. (North China)
No. 9 Xingchang Road, Nanshaozhen
Changping Science Park
Beijing 102200
P.R. China
Tel : +86-10-6073-5858
Fax : +86-10-6073-3765
northchinasales@fulham.com

Fulham Electronic Co. Ltd. (South China)
Room 1402, Block D, The First Place Wealth Centre
No. 200 Hongfu Road
The South Dongguan City, Guangdong Province
P.R. China
Tel: +0769-2202-7555
Fax: +0769-2202-7553
southchinasales@fulham.com

Fulham Electronic Co. Ltd. (Central China)
Room 312-315, Xing Yuan Technology Plaza
No 418, Gui Ping Road
Caohe-Jing Hi-Tech Park
Shanghai, P.R. China
Post Code: 200233
Tel: +86-021-6495-2777
Fax: +86-021-5426-5271
centralchinasales@fulham.com

Fulham (Latin America)
Rosendo Vela Acosta St., Bldg #9
Carolina, PR 00987
Mobile: (787) 565-5197
Tel: (787) 757-6000
Fax: (787) 769-1851
latinamericasales@fulham.com

Fulham Company GmbH (Europe)
Karolinenstrasse 18
D-58507 Lüdenscheid
Germany
Handelsregister Iserlohn: HR B 6286
USt.-IdNr.: DE253959344
Tel: +49 2351 4327416
Fax: +49 2351 6567349
Mobile: +49 152-0-9838495
europesales@fulham.com

Fulham Company Ltd. (Middle East)
LOB-2, No 127 P.O. Box 261051
Jebel Ali Free Zone, Dubai, United Arab Emirates
Tel: +9714-8873577 Fax: +9714-8873599
fulhamdubai@fulham.com

Fulham (India) Pvt. Ltd.
1 Sukhada Building
Sir Pochkhanwala Road
Worli, Mumbai 400030
Tel: +91 22 66388775-9
gmalkani@fulham.com
sghose@fulham.com

Fulham (India) Pvt. Ltd.
Survey No. 26-3
Village Narhe
Taluka Haveli, District: Pune 411041
Tel: +91 20 24690703/4
Fax: +91 20 24690712
gmalkani@fulham.com
sghose@fulham.com

CATALOG-V15-04B