Stingray Energy Effective Lighting

Metal Halide vs. Fluorescent in the Industrial Environment

High intensity discharge (HID) light sources such as metal halide and high pressure sodium have long been the standard in industrial lighting applications for a number of reasons. They are durable, reliable, efficient, easily maintained, and cost effective. As the name implies, HID lamp technologies have been specifically developed to provide a great deal of light, and to do so from a relatively compact package. When combined with an efficient and effective optical system, this allows a single luminaire (light fixture) to illuminate a relatively large area. The benefits in terms of installation cost and maintenance are obvious. Another key characteristic of HID light sources has been their relative insensitivity to environmental temperature.

Fluorescent lighting has been used both successfully and extensively in industrial applications, but its primary market has traditionally been commercial interiors. Like HID, fluorescent lamps are durable, reliable, easily maintained, and cost effective. However, this technology offers additional benefits thought to be particularly well suited to commercial spaces. These include relatively low lamp brightness, instant on, high color rendering, a broad range of color options, indistinguishable lamp to lamp color consistency, and highly efficient dimming capability among other things. As one might anticipate, lighting needs in commercial spaces differ from those of industrial ones. Ceiling heights tend to be vastly different, and the nature and schedule of the activities being undertaken is equally dissimilar. Safety and ease of maintenance are often chief concerns in the industrial environment while occupant comfort and aesthetics tend to be relatively higher priorities in commercial interiors.

Each of these lamp technologies has traditionally exhibited a unique blend of attributes that has allowed it to be the best solution for a particular type of application. Over time, however, the difference between the two has become increasingly less distinct. As the respective technologies have continued to advance, each is effectively seen to be converging on the same objective: a highly efficient, easily controlled (both optically and electrically), thermally stable, color constant, long term source of white light. While all types of lamps continue to make significant strides in the area of energy efficiency, recent advancements in HID and fluorescent have effectively resulted in each becoming more like the other. High pressure sodium has all but disappeared from industrial application and state of the art metal halide lamps now rival the best light sources in terms of color quality.
Meanwhile, fluorescent lamps are getting smaller and delivering progressively higher light output. The significance of compactness will be expanded upon.

The end result is that today's technological environment is one that makes the choice of light source more complicated than ever. The situation is further exacerbated by lack of available performance data, and the data that does exist is frequently misapplied. For instance, two recent reports[1,2] suggest that metal halide lamps have been observed to provide between 2 and 3 times rated life when operated round the clock. This makes perfect sense, since cathode erosion is a primary determinant of lamp life (as well as light output over time) that occurs primarily during lamp ignition. However, the only readily available performance data regarding lamp life and light output over time corresponds to lamps operated on a duty cycle of 10 hours per start. The bottom line is that an accurate comparison of options is often more elusive than it first appears. The simple truth is that no light source delivers a clear and consistent advantage over others for all applications. Lamp manufacturers provide literally thousands of unique lamp types exhibiting every imaginable combination of attributes and each has its place. Selecting the best product for a given application involves a host of considerations. Among these are:

- Life
- Efficacy (lumens/watt)
- Lumen Depreciation
- Color Temperature
- Color Rendering Index
- Color Consistency
- Lumen Output
- Source Size
- Cost
- Availability
- Ease of Replacement
- Dimming and Controls Compatibility
- Ballast and Driver Compatibility
- Warm-up Time
- Re-strike Time
- Luminance (~brightness)
- Operating Frequency
- Enclosure Rating
- Operating Position
- Emergency Options
- Stocking and Storage
- Thermal Operating Environment
- Beam Quality (R, Par, MR, etc…)

This list is admittedly overwhelming and some bullets apply only to certain light sources, but it helps to put the needs, priorities, and conditions that various applications represent into perspective.

Industrial environments are highly diverse. Unlike most commercial spaces, they vary wildly in terms of size, proportion, cleanliness, ambient temperature, occupancy, hours of operation, chemical exposure, nature of visual tasks, and so on. Comparatively speaking, these environments tend to be somewhat harder on lighting equipment. Thus reliability, durability and ease of maintenance often weigh as heavily in product selection as economics and the quality and quantity of illumination.

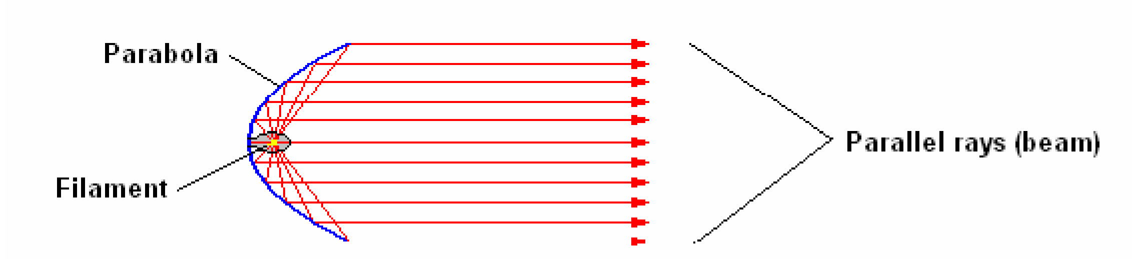
Relatively recent developments in fluorescent lamp technology have caused manufacturers and lighting professionals to re-evaluate the viability of this light source for industrial environments. State of the art fluorescent systems utilize highly efficient electronic ballasts that significantly improve lamp performance, both initially and over life. New T5 and T8 lamps are also substantially smaller in diameter than T12 while the T5HO provides nearly twice the light of standard linear fluorescent products (under optimal thermal conditions). When combined with a high performance optical system, these advancements have significantly altered the industrial lighting landscape in recent years.

However, even more recent developments in metal halide lamp technology promise to swing the pendulum back the other way for many applications. Electronic ballasts are now available for metal halide lamps and ceramic metal halide technology has been expanded to include medium wattage products that are particularly well suited to high-bay application. The impact of the electronic ballast is comparable to that of fluorescent. Ballast losses are dramatically reduced compared to magnetic devices while increasing both the performance and life of the lamp. Ceramic metal halide lamp technology is significant in that it represents a quantum leap for metal halide in the area of color quality. It efficiently provides crisp white light with color rendering properties that are suitable for even the most demanding applications such as retail.

The advent of multi-lamp T5 and T8 fluorescent high-bay luminaires has resulted in a plethora of comparative tables that presume to break out and clarify the respective attributes of fluorescent and metal halide systems. Unfortunately, too many of these are found to compare state of the art fluorescent technology to decades old metal halide. Furthermore, they frequently neglect the impact of thermal conditions and optical control within the environment. In other words, it's not simply the lamp lumens produced under controlled laboratory conditions that matters. Those lumens must be effectively delivered to the work plane and under less than ideal circumstances. The issue of optical control will be addressed first.

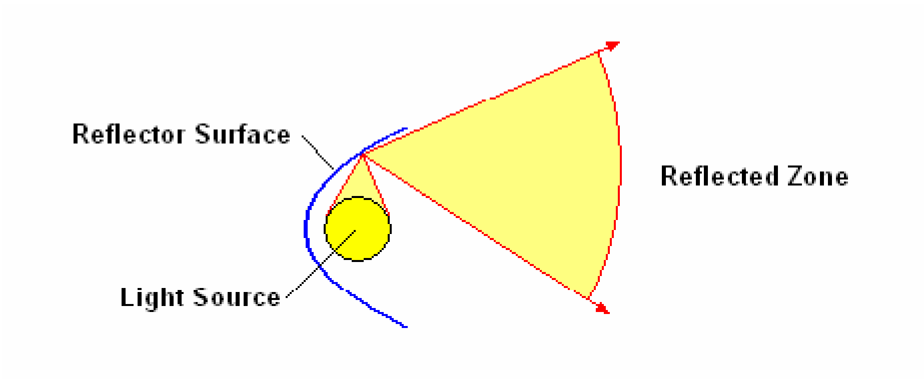
In the lighting industry, references to "point source" and "point source optical control" are common. The point source is actually conceptual in nature, referring to a light source that is infinitely small so as to cast its rays outward from a single point in space. This is highly convenient from an optical standpoint in that reflective and refractive devices can be easily developed to redirect the lamp's light energy in a more useful direction. Consider the case of a flashlight (figure 1). The tiny filament radiates light energy in all directions outwardly. A reflector having a special shape known as a parabola is then placed around the lamp to redirect those rays into a parallel beam through the aperture of the device. It is the fact that the filament is small, approaching a true point source, that allows the flashlight to produce such a precise and tightly directed beam. The precision with which light energy may be directed is referred to as optical control.

Figure 1



Now, consider the behavior of a large light source (figure 2). In this case it is more convenient to think in terms of angular zones rather than individual rays. Light is incident at a point on the reflector through a zone defined by the size and proximity of the light source and exits through a zone of the same dimension. Clearly, such an arrangement is incapable of producing a parallel beam, or at least not efficiently.

Figure 2



This physical limitation leads to a loss of optical control. It applies to refractive optics as well as reflective. Small light sources afford a greater degree of optical control, or ability to efficiently direct and control light energy. There are two reasons that this is important. Generally speaking, greater optical control means that a higher percentage of lumens can be placed where they are most needed (at the work plane), or that the light can be more effectively utilized. Secondly, light that is not carefully controlled typically emerges in the form of high angle brightness or glare, which is counterproductive in that it has been proven to actually reduce occupant comfort and inhibit overall visibility. According to the Illuminating Engineering Society of North America (IESNA), "Even minimal glare… can result in measurable loss of seeing efficiency and undue fatigue" in industrial environments[3].

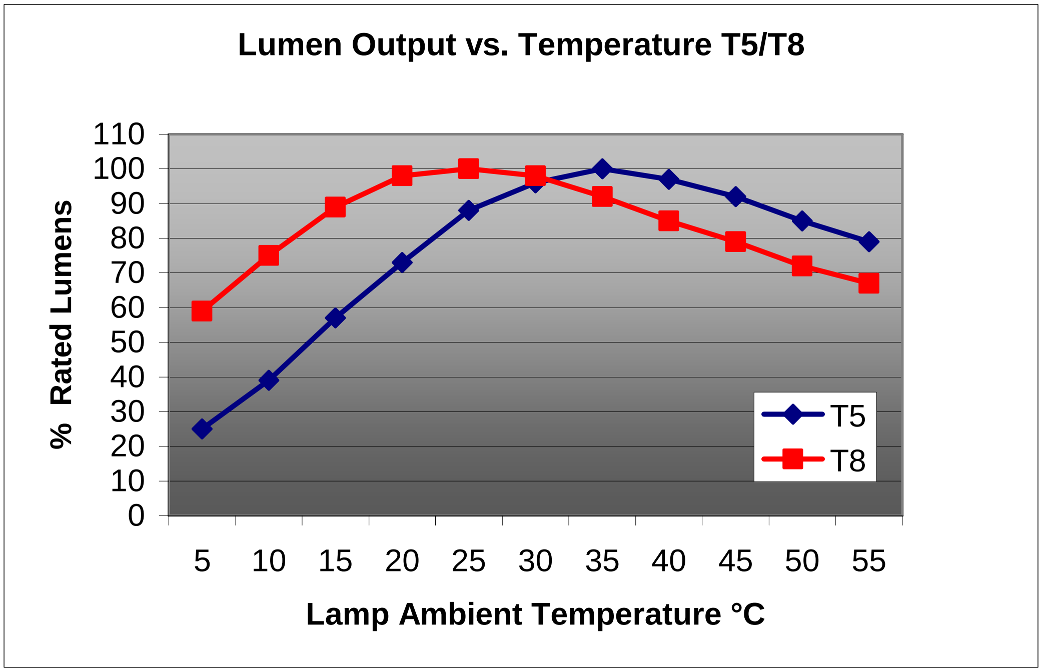
The significance of optical control as it relates to a comparison of metal halide and fluorescent lamp technologies is rather obvious. In cross section, the fluorescent lamp is a reasonably compact circle and therefore a significant degree of optical control can be achieved in that plane. However, the perpendicular dimension is quite another story. In this dimension the fluorescent lamp is 4 feet in length, which completely compromises optical control in that dimension. There are well established techniques that can be applied to mitigate this issue such as concentrating prismatic diffusers and parabolic louvers, but each of these involves non-trivial losses to luminaire efficiency and therefore the total amount of light delivered to the space.

In contrast, metal halide lamps are relatively compact and axially symmetric when mounted in a "base up" or "base down" configuration. This allows a typical dome-shaped reflector to provide consistent and significant optical control in all directions about the luminaire. Comparatively speaking, more light is effectively delivered from the typically high ceiling of an industrial facility, down to the work plane where visual tasks are being performed. Additionally, the compactness of the light source permits glare control to be easily achieved in all directions around the luminaire.

The second frequently overlooked difference between metal halide and fluorescent is thermal sensitivity. Metal halide lamps are effectively insensitive to the thermal environment in which they operate. This is partially responsible for their abundance in outdoor applications. The ballasts that drive them commonly have limitations (as do fluorescent ballasts), particularly in high temperature environments, but the lamp is generally unaffected. This is a very important point because so-called “high-ambient” luminaire ratings are based primarily on the ballast rating (insulation), which is indicative of its ability to ignite the lamp and sustain continuous operation. However, no guarantees are implied relative to the actual lumen output of the system under those conditions. Metal halide lamps can be expected to produce rated output but this is generally untrue of fluorescent.

Figure 3 depicts the typical temperature profiles of T5 and T8 fluorescent lamps. Note that the horizontal axis corresponds to lamp ambient temperature and the vertical axis to percent rated lumens. It can be seen that T5 and T8 lamps only produce rated output at 35 °C and 25 °C respectively. It’s also important to appreciate that lamp ambient temperature and room ambient temperature are not equivalent in most applications. Both lamps and ballasts produce heat. Enclosures tend to elevate lamp temperature relative to room ambient as does re-entrant light and lamp clustering, all of which are characteristics of fluorescent hi-bay luminaires. Thus, the actual lamp ambient temperature depends on the individual luminaire design as well as the room ambient temperature and therefore predicting the true performance of these products in application requires that both effects be accounted for. Since industrial spaces are typified by relatively high ceilings and air is known to stratify, the temperature differential between the floor and ceiling areas can be quite pronounced, even in a relatively temperate work environment.

Figure 3



The bottom line on these important factors is that an accurate comparison of fluorescent and metal halide lamp technologies cannot be performed independently from the products that utilize them or the applications for which they are being considered. Nor should conclusions be drawn based purely on measurements taken in a sample installation. Lumen maintenance must be considered, surrounding luminaires can significantly confound the legitimacy of the readings, existing environmental conditions may not be most representative of the application in general, and achieving meaningful results requires a fair amount of engineering discipline and specificity relative to the point sampling strategy. Point-by-point computer analysis based upon IESNA approved photometric test data provides a far superior means of performing such comparisons. These predictive methods are very well established within the lighting industry and multiple factors can be confidently applied to account for a wide variety of conditions based upon sound research and test data. This includes the factors mentioned above.

Stingray Energy Systems has conducted a vast number of computer analyses, utilizing independent laboratory test data for our own products as well as that of numerous manufacturers of fluorescent high-bay systems. When all of the necessary factors are taken into account, our experience consistently shows that Stingray's metal halide solutions are highly competitive with state of the art fluorescent systems for the majority of industrial spaces. Our clients are strongly encouraged to subject our products and those of our competition to an accurate, application specific performance comparison. Only then can a meaningful comparison be made.

In addition to raw performance comparisons, there are a number of practical issues differentiating metal halide from fluorescent. Metal halide high-bay luminaires are arguably more rugged, cost effective, and easier and less costly to install and maintain. They also provide vastly superior glare control and may experience reduced light loss as a consequence of dust accumulation.

There is only one reason that fluorescent high-bays employ multiple lamps. Industrial luminaires must generate a significant amount of light and even high output fluorescent lamps fall short in this regard. The obvious solution is to use more of them, but this involves an element of compromise whose ramifications may not be fully apparent. Relative to a metal halide solution, six times as many lamps must be purchased, shipped, stored, replaced and disposed of. A similar argument applies to ballasts as well. Six-lamp fluorescent high-bay luminaires typically employee 2-3 ballasts per unit. There is one apparent advantage to this configuration. A bad lamp or ballast does not necessarily result in a complete luminaire outage. When subjected to greater scrutiny however, even this becomes a concern. After all, it is the very nature of an outage that typically prompts maintenance personnel to respond in a timely manner and it is the speed of their response that ensures that minimum light levels are maintained and that damaged or faulty components are not damaging others in turn, or potentially creating a hazard.

Today’s generic metal halide high-bay luminaire represents decades of progressive development with respect to installation. This is naturally affected by the shape and weight of the product, as well as certain features designed to simplify wiring and reduce the number of tools required to do the job. In contrast, fluorescent high-bay products are relatively new and their design has been largely constrained by the multi-lamp requirement. Whereas metal halide products are routinely installed by a single individual, fluorescent may require two. Metal halide high-bays are commonly suspended from a single point while fluorescent typically requires two. Additionally, Stingray luminaires provide beam adjustability that is highly conducive to system reconfiguration as space utilization changes over time. In contrast, most fluorescent high-bay luminaires provide only a single fixed photometric distribution.

Fluorescent lighting systems do provide advantages over metal halide for certain applications. The most obvious attribute is “instant on”. Fluorescent lamps ignite immediately and reach full brightness virtually instantaneously. They can be configured with unit inverters to provide both general and emergency lighting from the same system. They also offer a broader range of control capabilities including continuous dimming down to 1% for some systems, and are available in a broad assortment of color temperatures.

In summary, both fluorescent and metal halide lamp technologies have seen tremendous improvement in recent years. Each delivers a level of lighting quality and energy efficiency that can result in a highly successful energy saving retrofit. Choosing the very best product for a given application requires an intimate understanding of the attributes, limitations, and respective value to the application that each technology has to offer.

References:

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