Lighting: HID Versus Fluorescent for High-Bay Lighting

High-intensity discharge (HID) light sources, such as metal halide and high-pressure sodium lamps, have long dominated the market for lighting indoor spaces with high ceilings. These "high-bay" spaces are typically found in warehouses, factories, large retail stores, and athletic facilities. In recent years, both HID and high-intensity fluorescent (HIF) technologies have improved, but HIF technology has retained a performance edge in most applications, and it continues to gain market share. The improvements in fluorescent lamps and the emergence of new HIF fixtures have made fluorescent lighting the most cost-effective choice for lighting high indoor spaces. These HIF systems are more energy-efficient than HID solutions and feature lower lumen depreciation rates, better dimming options, virtually instant start-up and restrike, better color rendition, and reduced glare.

What Are the Options?

HID lamps. HID lamps produce intense light in such a small area that they are considered "point sources." As a result, they are often installed in fixtures that direct their light using parabolic reflectors. Compared with other installations (of the older T12 fluorescents, for example), an HID installation requires fewer individual fixtures, which sometimes allows for lower capital and installation costs. HID lamps are popular in applications that feature large expanses lit by distant fixtures, such as indoor and outdoor sports facilities, factories and warehouses with high ceilings, and streetlighting.

Although there are several different kinds of HID lamps, the most popular types for indoor applications are metal halide and high-pressure sodium lamps. A key difference between these two is the type of vaporized metal that constitutes the gas within the inner glass vessel of the lamp, through which the electric arc is struck. Of these two types, metal halides—with their high-quality light, high efficacy, and wide range of sizes—are more versatile. Also, ballasts for metal halide lamps can typically start at temperatures as low as minus 20 degrees to minus 40 degrees Fahrenheit (F).

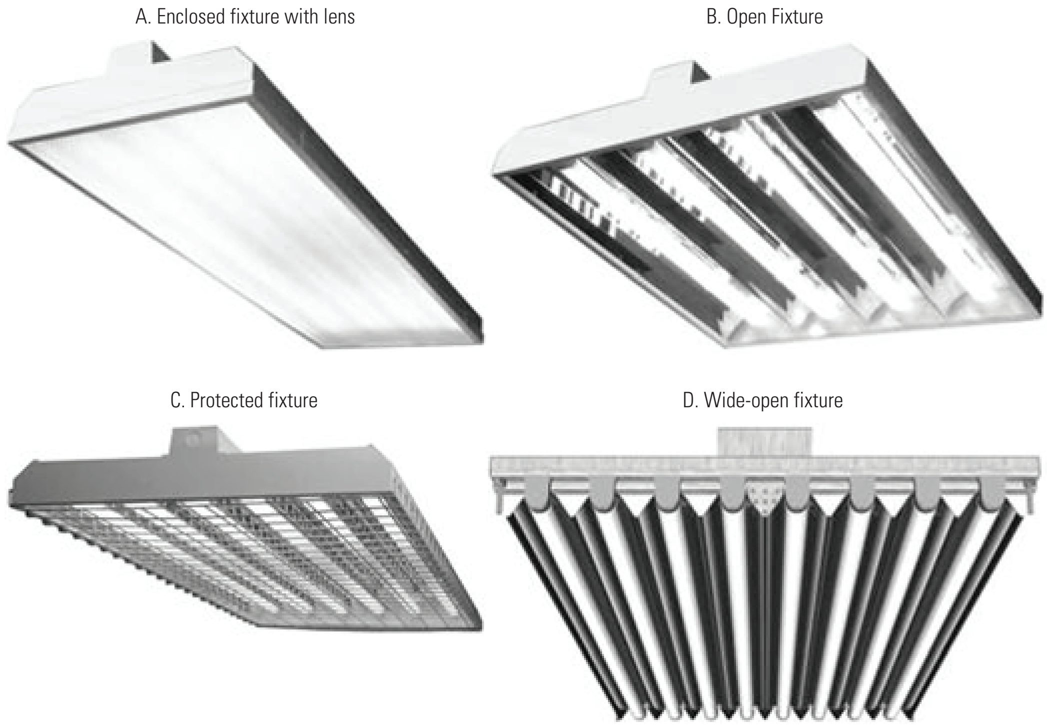
Two recent developments in metal halide technology—ceramic arc tubes and electronic ballasts—have improved their performance. Pulse-start metal halide lamps, which utilize ceramic tubes with electronic ballasts, can be the most effective high-bay lighting solution for applications where color quality, fixture aesthetics, and uniform uplight are important, and where facilities are subject to high and/or low temperature extremes.

Electrodeless induction lamps. Inductive fluorescent lamps also have a role in illuminating high-bay areas. These relatively new lamps use radio frequency energy rather than an electric arc to excite phosphors and produce light. Inductive fluorescents have an extremely long life (up to 100,000 hours) and excellent cold-start properties (–40°F). They also have the ability to instantly restrike. However, they offer lower efficacy than metal halide and conventional fluorescent lamps, and suffer from high lumen depreciation (about 40 percent). There are also concerns in some applications about how their radio-frequency energy might affect adjacent electrical equipment.

Fluorescent lamps. Fluorescent lamps emit diffuse light from long glass tubes. This characteristic of diffusivity has enabled fluorescent fixtures to dominate the market for lighting commercial, institutional, and industrial spaces with ceilings less than 15 feet high. In recent years, however, the emergence of more intense and efficient fluorescent lamps coupled with specially designed reflecting fixtures has enabled fluorescent systems to break through the ceiling-height barrier and compete directly with HID lamps in indoor applications. Earlier rapid-start versions of T8 and T5 lamps were unable to turn on below 50°F, but now most fluorescents can start at temperatures as low as 0°F.

Figure 1: Common HIF fixture shapes

High-intensity fluorescent (HIF) fixtures are now available in different shapes and sizes, which makes them more versatile than earlier fluorescent lamps. Most, however, are square or rectangular.



Courtesy: Used with permission; Acuity Brands Lighting–Austin (A, B, C) and Orion Energy Systems (D)

High-intensity fluorescent fixture designs. Most of today's HIF fixtures use linear fluorescent lamps, either T8s or high-output T5s, because they provide longer life, higher efficacy, and less lumen depreciation than compact fluorescent lamps (CFLs) and twin-tube lamps. Better reflector designs allow HIF lamps to be applicable at any height where an HID lamp is used. Although HIF fixtures are available in a number of shapes, most modern high-bay HIF fixtures are square or rectangular (**Figure 1**). Another HIF design that is effective for wide-open spaces is the "star" fixture, which uses CFLs or twin-tube T5s arrayed on 2-foot "arms" that radiate out from a center core (which usually houses the ballasts). This design provides circular light distribution and has been used successfully for such applications as skating rinks.

Historically, HID technology has had a big advantage over HIF with respect to its better performance in locations with wide temperature ranges. However, the introduction of amalgam technology—the process of mixing certain metals with the mercury inside the lamp—helps HIFs maintain maximum output levels over a wide range of temperatures. One disadvantage of the amalgam technology that limits its applications is that amalgam lamps can't be dimmed.

How to Make the Best Choice

The new fluorescent fixtures designed for high-bay applications have seven advantages over similar HID fixtures: lower energy consumption, lower lumen depreciation rates, better dimming options, faster start-up and restrike, better color rendition (see **Table 1**, next page), more pupil lumens (see **Table 2**, next page), and reduced glare. Not only do these advantages make fluorescent fixtures more cost-effective in many applications, they also enable them to provide superior lighting to the spaces they illuminate.

Table 1: The color rendering index of fluorescent and HID lamps

Measured on a scale of 0 to 100, the color rendering index (CRI) describes the capability of a light source to accurately render a sample of eight standard colors relative to a standard source. Light sources that exhibit higher CRIs render color better than sources with low CRIs.

Lamp type	CRI
T8 fluorescent	75–98
T5 fluorescent	75–98
High-color-rendering metal halide	80–93
White high-pressure sodium	60–85
Standard metal halide	60–70
Pulse-start metal halide	65–70
High-pressure sodium	27
Low-pressure sodium	5

Source: E SOURCE; data from GE, Osram, and Philips

Table 2: Conversion factors for lumens to pupil lumens

Correction factors applied to conventional values of lumens per watt yield a value for pupil lumens per watt, which is a measure of how effectively the eye sees the light that is emitted. The pupil is more receptive to light at the blue end of the spectrum.

Light source	Conventional lumens per watt	Correction factor	Pupil lumens per watt
Low-pressure sodium	165	0.38	63
5,000-K T5 fluorescent	104	1.83	190
4,100-K T5 fluorescent	90	1.62	145
Clear metal halide	85	1.49	126
5,000-K pure triphosphor fluorescent	70	1.58	111
3,500-K pure triphosphor fluorescent	69	1.24	85
50-watt high-pressure sodium	65	0.76	49
2,900-K warm white fluorescent	65	0.98	64
Daylight fluorescent	55	1.72	95
35-watt high-pressure sodium	55	0.57	31
5,000-I 90-CRI fluorescent	46	1.70	78
Vitalite fluorescent	46	1.71	79
Deluxe mercury vapor	40	0.86	34
Standard incandescent	15	1.26	19
Tungsten halogen	22	1.32	29

Note: K= Kelvin; CRI = color rendering index.

Source: E SOURCE

Perform a cost-effectiveness calculation. The cost-effectiveness of fluorescent lighting compared with HID depends on several factors including lamp life, lumen depreciation, hours of operation, and cost per kilowatt-hour. Use this online calculator as a screening tool to compare the costs of HID lighting with fluorescent alternatives. Make sure to compare alternatives that provide approximately equal amounts of light. The calculations include a correction factor for pupil lumens—a factor not universally accepted. To perform the calculations without considering pupil lumens, simply input values of 1.0 for the conversion factor.

Online Lighting Calculator

What's on the Horizon?

In coming years, both HID and HIF high-bay lighting will continue to improve. Manufacturers of both technologies are working to achieve higher efficiencies, lower lumen depreciation rates, and better dimming options, and HID makers are working on faster start-up and restrike times.

On the HIF side, it is likely that higher lumen packages will emerge and that developments will occur that make lamps even less sensitive to temperature variations. For HIDs, ongoing developments in electronic ballasts and improvements in color quality will keep HIDs competitive in the market. In addition, improved controls and wireless technology will make both HIF and HID systems more effective in the future.

Although improvements in HID lamps and ballasts may eventually make HID lighting systems as energy-efficient as the new fluorescent systems, it is unlikely that lighting manufacturers will ever be able to eliminate the warm-up and restrike delay associated with HID lights. This inability to instant-start severely limits the use of occupancy sensors and other switching methods that can save energy.

Lastly, it appears that HID lighting has a ways to go before it can match the very low lumen depreciation of T5 lamps. Even 20 percent lumen loss is a problem when compared with the 5 to 10 percent loss of T5 fluorescent systems. Until these drawbacks can be eliminated, HIF will continue to be the best choice for most high-bay applications.