High Bay Lighting

ENERGY SAVING FACT SHEET

Introduction

The choices today for lighting are numerous. High bay lighting, that is lighting generally fixed above 20 feet, also has recently seen transition to energy efficient applications of high output fluorescents. Sport and recreational facilities, retail merchandizing, and warehouse facilities are often designed with point source High Intensity Discharge (HID) Metal Halide (MH) lighting. In making an evaluation, look at those factors that are most important to your application, and then be sure to make comparisons based on advances that have been made in both MH and fluorescent technology. The common features of comparison include: glare, contrast ratios, shadows, color appearance, end-of-life vertical foot candles and horizontal foot candles. Other retrofit considerations, include: light distribution, spacing criteria, lumen maintenance, ambient temperature range, ballast case temperature ratings, warm-up and restrike times, lamp life, labor cost (for maintenance), and lift rental costs for lamp replacement. These characteristic features and design considerations are further discussed in some detail in the Illuminating Engineering Society of North America (IESNA) Lighting Handbook.
(See References)

Fluorescent Technology

Basically, a fluorescent lamp is made up of five components:

- A ***glass tube***, coated on the inside with fluorescent powders called *phosphors,*
- Two ***electrodes*** (or cathodes) coated with *emitter*, supported by a glass mount structure, and sealed at the ends of the tube,
- ***Filling gas,*** usually a low pressure of Argon or Krypton/Argon mixture,
- A small amount of ***mercury*** (less than 20 mg), which vaporises during the lamp operation, and
- ***Lamp caps*** cemented to each end of the tube to connect the lamp to the lighting circuit.

The "T" refers to tube, followed by the diameter in eighths of an inch. For example, T8 specifies 8/8," which is 1" diameter. A T5 tube is 5/8" diameter, but has a miniature bi-pin base that is not interchangeable with T8 lamps. T5 lamps are designed to peak in their lumen output at 95°F, (35°C), compared to 77°F, (25°C), for T12 and T8 lamps. The HO designation refers to "high output".

T5 and T8 Comparisons	T5	T5HO	T8	T8HO
Initial Rated Output[1]	2900 lumens	5000 lumens	2950 lumens	7200 lumens
Nominal Lamp Watts	28 watts	54 watts	32 watts	88 watts
Initial Lamp Efficacy[1]	104 lpw	93 lpw	92 lpw	82 lpw
Initial System Efficacy[2]	89 lpw	85 lpw	90 lpw	77 lpw
Lumen Maintenance[1]	97%	95%	93%	91%
Maintained System Efficiency[2]	86 lpw	81 lpw	84 lpw	73 lpw
Rated Life[3]	20,000 hrs	20,000 hrs	20,000 hrs	20,000 hrs
Optimum Operating Temperature	95°F	95°F	77°F	77°F

[1] – Based on 4ft nominal lamp length, 85CRI lamps (lumens per watt or lpw)
[2] – Based on 4ft nominal lamp length, 85CRI, 2-lamp rapid-start electronic ballast
[3] – This value varies, depending on manufacturer and phosphor coating technology used in the manufacturing process

The different kinds of **ballasts** for fluorescent lamps include — Rapid Start (RS), Program Start (PS), and Instant Start (IS) ballasts. While RS ballasts are more energy efficient and result in longer lamp life, they cost 5 to 10 percent more than IS ballasts. Electronic ballasts are used at different intensity levels of discharge voltage according to need — energy conservation to high output. These factors vary from about 0.75 to 1.15. The older magnetic ballasts are being replaced with electronic ballasts on lighting T8 and T5 upgrades resulting in several beneficial features — no hum or flicker, one electronic ballast per 4 lamp fixture vs. two for magnetic and significant energy savings that result in total lumen output per watt input for the newer fluorescent technologies.

Fluorescent vs. Metal Halide

Hot temperatures can dramatically reduce the life of some MH electronic and many fluorescent electronic ballasts, but are usually not a concern for MH magnetic ballasts. A typical maximum ballast case temperature rating is 158°F (70°C), and the rated ballast life is often listed at 60,000 hours at the maximum ballast temperature.

That rating can shrink 50 percent with just an 18°F (10°C) temperature rise. Ballast temperature tends to be more problematic for T5HO than T8 high-bays, because the narrower T5HO high-bays create a greater concentration of heat. Smaller ballast compartments, or those using steel instead of aluminum, can fail prematurely from temperatures that exceed 158°F (70°C). For extra ballast life, designs that limit the ballast case temperature below 140°F (60°C) are preferable.

The light output of MH lamps is relatively constant with relationship to temperature. However, the light output of most fluorescent lamps is very dependent on ambient temperature. Above the optimum lamp operating temperature limit, the efficacy falls by approximately one percent for every degree the temperature rises. Below this limit, the efficacy decreases by approximately five percent for every degree the temperature falls. If the ambient temperature is cold or ranges from cold to normal, T8 lamps are preferred over T5s. Tube guards, lenses, and/or enclosed fixtures can be used to raise the lamp "ambient temperature," but will also block some of the light. For fairly hot applications, T5 lamps are preferred.

Lamp Lumen Maintenance - with typical magnetic CWA ballasts, the end-of-life lumen maintenance of quartz (65 to 70 percent) and ceramic (80 percent) MH still pales in comparison to high performance fluorescents (over 90 percent). However, there are higher performance MH electronic ballasts with enhanced starting and high frequency current wave forms that can approach the lumen maintenance of fluorescents.

Lamp Life

Because instant start (IS) ballasts are often used for hi-bay applications, the end user should note that the lamp life can be reduced by short cycles, such as those that would be driven by occupancy sensors. Lamp life is typically tested in 10-hour cycles for HID lamps and in 3-hour cycles for fluorescent lamps. Fluorescent lamps that are run at the more typical 10-hour cycles for hi-bay applications may see longer life. As noted above, end-of-life (EOL) lumen maintenance should be considered. For example, a 400W standard probe-start MH lamp can often last 30,000 hours, but may only be rated for 20,000 hours, due to the lower lumen maintenance past this point. For T5HOs with program-start ballasts, lamp life rating is 20,000 hours at 3-hour cycles and 25,000 hours at 12-hour cycles.

Luminaire Dirt Depreciation (LDD)

Horizontal fluorescent lamps need to be cleaned regularly, because dirt can land and stay on the top of them more easily than on vertical metal halide lamps.

The following table compares light fixtures with different types of lamps and ballasts.
Note the variation in lumen output among the choices listed in the table. Four T5HOs or six T8s provide one-third less lumens than the initial lamp rating of MH. Only when end of life illumination is considered, do the numbers fall into the same ballpark. Lumen maintenance becomes a very important factor for these comparisons. The initial illumination differences are more striking if recent advances in MH technology are considered, such as the 400 watt, 44,000 lumen (110 lumens/watt), multi-vapor lamp offered by GE and others. If six 54 watt T5HOs are chosen to increase the lumen output, then the energy usage increases to over 360 watts for this lamp/ballast system.

Ceramic MH with Magnetic or Dimming Electronic Ballast Option

Ceramic MH is becoming more popular for retail and other applications where very high color quality is important. Ceramic MH does not sacrifice light output for CRI, (as is the case with fluorescents that have CRIs in the 90s). Lumens per watt for ceramic MH matches that for pulse-start quartz MH. Ceramic MH lamps use the same magnetic and electronic ballasts that pulse-start MH lamps use. If price is an issue, a less expensive alternative to ceramic MH lamps may be the 90 CRI 5,000°K pulse-start MH lamps. There are also pulse start MH lamps with electronic ballasts capable of dimming down to 35 percent for additional energy savings.

Successful T5HO Upgrades

The typical T5HO replacement of a 400W standard MH that has a spun aluminum dome usually involves four F54T5HOs, and can reduce energy use from about 450 watts to 234 watts. There are also situations where four F54T5HOs can replace 350W PS MH. Be sure to look at lumen output in this comparison, both initially and at end of life conditions.

Hi-Bay Comparisons - HID Metal Halides and Fluorescents

Fixture Type	CRI	EOL Lumen Maintenance	EOL Lamp Lumens	Luminaire Lumens	Systems Watts	EOL Lum/ Watt	Avg. Life, Hrs.
400 Watt MH, Probe Start, Spun Al. Reflector	65	45%	17,100	12,825	**458**	28	12,000
320 Watt MH , Pulse Start, Magnetic Ballast	65	65%	20,800	19,136	**345**	55	20,000
320 Watt MH, Pulse Start, Electronic Ballast	65	70%	22,400	20,608	**333**	62	20,000
320 Watt Ceramic MH Lamp, Electronic Ballast	92	80%	24,000	22,080	**333**	66	15,000
4F54T5HO Lamps, Program Start, Electronic Ballast, AL. Reflector	85	93%	18,600	17,112	**234**	73	20,000
6F32T8 Lamps, Instant Start, Electronic Ballast, Al. Reflector	85	92%	19,680	17,909	**220**	81	15,000

Reference Source: ***Hi-Bays - It's All about the Details*** **by Stan Walerczyk, Director of Lighting, Sun Energy Solutions**

References: www.iesna.com

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