Does Size Really Matter?

***Peter Ngai** evaluates the merits of T8, T5 and T5HO systems*

WEDNESDAY, MAY 7, 2003 — 4:00pm-5:30pm

T8 lamps were introduced to the market for about 20 years when most of the linear fluorescence lamps were T12 variety. T8 lamps had steadily and gradually gained popularity throughout the years and now represents the lion's share of the specification segment of the market. The main reasons for T8's popularity is that it is more energy efficient than T12 and has a smaller cross-sectional size, (1 in. diameter for T8 vs. 1.5 in. for T12) which means better optical performance.

Since 1996, an even smaller size T5 lamp with 5/8 in. diameter was introduced to the american market. There are actually two different types—the Standard Output (T5) and the High Output (T5HO) version. Due to their small sizes, high light output and good color rendition, these T5 lamps have created a lot of excitement in terms of innovative luminaire designs and lighting applications.

How do these newer and smaller lamps perform when compare with the more established T8 lamps?

Understand Performance Characteristics of T8, T5 and T5HO

Each lamp type comes in various lengths such as 2, 3, 4 and 5 ft. They also come in circular versions. For illustration purposes, we will focus on the most popular linear 4 ft versions.

From **Table 1**, it certainly seems that T5 and T5HO are more efficacious than T8. However, this really is not the case. In order to understand this, we need to revisit how the rated lamp lumens are reported. For T8, the rated lamp lumen is measured with reference reactive ballast operating at 60 Herz frequency. This 32 W consumption also includes the 1.5 to 2-W power spent for lamp filaments. The T5 and T5HO however, are rated with reference electronic ballasts operating at high frequency with filament current cut out after the lamps are started. The apparent difference in efficacy between these two lamp types has more to do with the way the lamps are operated rather than their actual efficacy. This is because efficacy of a fluorescent lamp increases as the frequency of the input power increases. Electronic ballasts operate at a frequency of 20KHZ to 50KKZ. This will increase the efficacy by 10 to 12 percent as compared to 60 Herz. Also, by employing filament cut out circuitry, such as in program start or instant start, wattage consumption can be reduced by 1.5 to 2 W. Hence, when a T8 lamp is operated with reference high frequency electronic ballast and filament cut out, only 28 W is needed to produce 2900 lumens. Therefore, the efficacy of T8 and T5 are the same and is about 10 percent higher than T5HO.

Table 1

	T8	T5 (Standard)	T5HO
Diameter	1	5/8"	5/8"
Length	48"	46"	46"
Rated Lamp Lumens	2900	2900	5000
Lamp surface luminance (cd/m^2)	9000	15,000	27,000
Lamp Wattage(watt)	32	28	54
Efficacy (lumens/watt)	91	103	93
Optimal Ambient OperatingTemp	25°C	35°C	35°C
Warm-up time (to 90% output)	<30 sec	≈2 minutes	≈2 minutes

Please note:
All values are approximate and representative only
Actual values may be different depending on specific types and manufacturer.

Table 2

	T5	T5HO
25°C (lumens)	2580	4450
35°C (lumens)	2900	5000

Please note:
All values are approximate and representative only.
Actual values may be different depending on specific manufacturer

Optimal Operating Temperature

Light output of a fluorescent lamp is temperature sensitive. Unlike T8 or T12 fluorescent lamps, T5 and T5HO lamps produce maximum light output at an ambient temperature of 35°C, which is 10°C higher than the T8 (25°C). Lamp manufactures reported T5 and T5HO light output are approximately 10-12 percent higher at 35°C than at 25°C. **Table 2** shows the light output (as published by the lamp manufacturers) vs. temperature.

Recent testing of these lamps showed that the light output difference between 25°C and 35°C for T5 and T5HO is not around 10 percent but only about five percent.

Regardless of the actual light output difference between 25°C and 35°C, this difference had created a controversy on just how T5 and T5HO luminaire photometric performance are to be reported.

Controversy of Photometric Report for T5 and T5HO Luminaires

Current IESNA testing procedures call for conducting luminaire photometric testing at 25°C laboratory ambient temperature and measuring bare-lamp light output at this same 25°C temperature. Critics of this method believe this is not a realistic representation of the performance of a luminaire because the bare lamp(s) light output is referenced at 25°C while the lamp(s) inside the luminaire housing can be operating at a completely different temperature. As a consequence, the luminaire photometric performance reported this way could be misleading. For example, reported efficiency of a luminaire could be over 100 percent and total light output could be overstated or understated. An added complication with this methodology is that light output vs. temperature characteristics vary from lamp to lamp. Hence, different testing laboratories with different test lamps can result in different photometric reports for the same luminaire.

A suggested testing procedure is to have the bare-lamp light output referenced to the temperature that the lamp(s) actually operates inside the luminaire. Furthermore, in order to eliminate differences between lamps, the reported lamp lumen rating at a particular temperature is referenced to the standard light output vs. temperature performance curves furnished by lamp manufactures.

The argument against the proposed method is that this procedure deviates from the standard testing methods for T8 and T12. After all, criticism of T5 and T5HO photometry applies to T8 and T12 photometry. Should all those be changed as well? Furthermore, it is argued that efficiency over 100 percent is acceptable. Or perhaps, if insisted, be changed to another term such as Light Output Ratio. As for overstating or understating total light output of a luminaire, this can be avoided by using test lamps that have exactly the same photometric and thermal characteristics as the manufacturers published data.

Luminaire Performance

As stated earlier, the efficacies of T8 and T5 are virtually the same. However, for equal performance, the size of a T5 luminaire is proportionally smaller than a T8 system. This can be translated into significant advantages both in terms of innovative product design opportunities for architectural appropriateness and reduced resource in material requirement for a lighting project. It is also fair to say for luminaires with the same physical sizes, T5 performs better optically than T8.

Although T5HO efficacy is less than T5 or T8, a well-designed T5HO luminaire can be just as efficient and better in performance than a corresponding T5 or T8 system. This is because while two T8 or T5 lamps are somewhat higher in

total lamp lumens than a single T5HO lamp, the mutual lamp absorption between the two-lamp systems will reduce the final output of the luminaire by a few percentage points. Furthermore, in order to match a one-lamp T5HO optical performance, a two-lamp system may have to intensely control the optics. This will most likely reduce the efficiency of the luminaire further.

There are also situations that are impossible or not practical to match the one-lamp T5HO photometric distribution with a two-lamp T5 or T8 luminaire. For some applications, this can make T5HO a more attractive system. For example, in a specific application where ceiling luminance uniformity is critical, a one-lamp T5HO system may be able to space further apart than a two-lamp T5 or T8 system for a given level of illuminance. This can result in energy savings and/or material and cost savings for the lighting system. We termed this "application efficiency." One area that needs special attention in T5 and T5HO applications is the control of brightness. This is especially true for luminaires where the bare lamps are visible. If the luminaires on the ceiling direct most of the light downward, they can create intense glare and result in a very uncomfortable visual condition for the occupants.

Due to its high lumen package and small size, T5HO has found its applications into areas where it is not an option before, such as high bay and industrial lighting applications.

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Generally speaking, for indirect lighting applications, T5HO is the most desirable light source due to its small size and high lumen package, which enable luminaire designer to create superior optical distributions with minimal loss in efficiency. This usually can compensate for its somewhat lower efficacy. Similarly, T5 indirect luminaire can do what a T8 luminaire can but with a better photometric distribution and/or smaller size.

The reasoning also holds for direct and direct/indirect luminaires, except for one very important point: brightness control for the T5 and especially for the T5HO luminaires. How well can the brightness be controlled without adversely affecting the efficiency is a matter optical design?

When everything is said and done, it is the photometric, architectural, esthetic and overall budgetary requirements of a specific lighting design application that determines which is the most appropriate lighting source for the project.

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