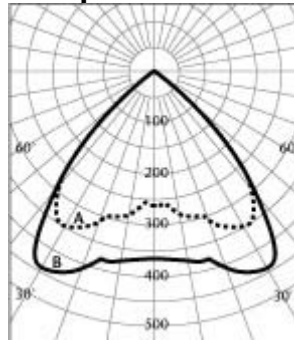


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T5 Lamps Boost Fluorescent Lighting Efficiency

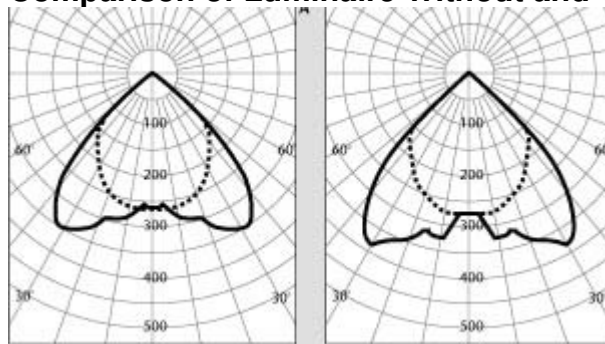
New T5 fluorescent lamps in combination with super-reflective aluminum could increase the efficacy of luminaires for fluorescent lamps by more than 30%. But there are many pitfalls to watch out for.

Comparison Between T8 and T5 Lamps (T5 with Miro)



A = 1 x 36W T8 HF, **B** = 1 x 28W T5 HF Miro
Light distribution cd/1000 lm (Cross section)
Source: Tommy Govén, AB Fagerhult

Comparison of Luminaire Without and With Miro Aluminium



Combulime Gamma 1x36W T8 HF **A**: Conventional aluminium **B**: **Miro aluminium**
Light distribution cd/1000 lm - Across ...Along the luminaire)
Source: Tommy Govén, AB Fagerhult

At the Hannover Fair in April 1995, the T5 lamp was introduced with great fanfare. Until then, announcements concerning new products in the fluorescent lighting market had been released at a fairly



steady rate, with each new lamp or ballast tying into the existing product standard on the market. There were the old "fat" T12 lamps that began being replaced by efficient T8 lamps in the early 80s. The T8 lamps served as direct replacements for T12 lamps in existing luminaires, resulting in a reduction in energy use of about 20 percent ("T8" and "T12" refer to their diameter in eighths of an inch, i.e. 8/8 and 12/8 of an inch or 26 mm and 38 mm respectively).

In the mid-80s the electronic high-frequency ballast arrived on the market, which offered a further 15-20% reduction in energy use. It is now a mature product that offers dimming and can be integrated into building control systems. Yet another development was the introduction of full-spectrum (five-band) fluorescent lamps that are slightly more efficient and provide improved color rendering.

These various developments-electronic ballasts, T8 lamps, and improved phosphors-came step by step, as a result of compromises that made all parts fit into the existing whole.

The T5 lamp, however, broke with this tradition. It is slimmer (16 mm diameter), and the T5 technology has been touted as representing a radical step in a new direction, with each part of the system first being assessed on its own merits before being integrated into an improved whole. The result of this integration/optimization work is claimed to be a more economic, energy-efficient and environmentally friendly fluorescent lamp. But what really lurks new behind the smoke screen?

New dimensions & higher efficiency

Completely new things are rare in this world, and the T5 technology is no exception. The slim lamps had, in fact, been in the pipeline for years, but there was little motivation to bring them to market.

Then, a few years ago, the major lamp manufacturers, who had seen their profits from lamp sales falling owing to competition from low-price imports, decided it was time to launch a technology that would help them jump out in front of their competitors again.

Looking at the technology as such, it does offer some new features: The first, and probably most important, departure from today's dominating standard is the new dimensions of the T5 lamps. This applies not only to its slim diameter, but also to its length: Each lamp is about 50 mm shorter than its T8 counterpart and cannot be used in existing luminaires. The shorter lamp length allows the use of new luminaires which can be better integrated into the metric 600-, 1 200-, or 1 500-mm building modules that are the standard for many European countries.

With the new miniature ballasts introduced together with the lamp, it should now be possible to manufacture very light, flat luminaires,

thereby helping to reduce resource use in the production, as well as the need for transport and packaging. In the case of recessed luminaires, a flatter design is very attractive since it frees up space for wiring and ventilation above the inner ceiling.

T5 lamps can only be operated on electronic ballasts, which must be exclusively designed for the T5 technology. The lamp and ballast are, on average, about 7 percent more efficient in terms of lumen output per watt, compared with T8 lamps (see [Table 1](#)).

Although exact comparisons are hard to make, owing to differences in wattage and lumen packages for the two systems, an electronically ballasted T8 36-W lamp, for instance, reaches 89 lumen/watt, whereas the 35-W T5 lamp reaches 96 lm/W. (The 36-W T8 lamp operates at a total power of 36W including the ballast.) The difference is slightly higher at lower wattages. An important feature that contributes to the increase in efficiency is the fact that the new lamps are optimized to run at a higher ambient temperature than T8 lamps, i.e. +35 °C instead of 25 °C. This higher temperature is said to better reflect the real ambient temperature within a luminaire. With today's T8 lamps, the nominal light output is based on testing at an ideal temperature of +25 °C. When the lamp is placed within a typical luminaire, light output drops, and this drop has to be compensated for when planning a lighting installation.

INCREASED LUMINAIRE EFFICIENCY

Due to their slim diameter, the T5 lamps can help increase luminaire efficiency by about 5%, according to measurements by Tommy Govén, head of the lighting technology department at Fagerhult, Scandinavia's largest luminaire manufacturer. This is because a thinner light source will allow the light to be directed more exactly to where it is needed, and the thinner the lamp, the less it blocks its own light within the luminaire. It should be noted, however, that the optical efficiency has to be established for each luminaire. If the temperature optimization of the lamps (i.e. real light output stays the same as nominal light output) also is taken into account, the calculated efficiency will increase by a total of about 15% compared with T8 luminaires. ([Table 2](#))

Finally, another important advantage with the T5 lamps is their low mercury content. The lamps have a coating on the inside of the glass wall that stops mercury from being absorbed into the glass and the phosphors. This drastically reduces the need for mercury from ~15 to 3 milligrams per lamp. Less mercury is, of course, good news in itself, but it has another very important advantage: Since mercury absorption causes the lamp's light output to depreciate over its life, the coating helps to keep light levels much closer to initial ones (only 5% depreciation after 12 000 hours compared with 15% with the older lamp types).

Typically, fluorescent lighting systems are designed for higher initial light levels in order to compensate for the depreciation in light output. With the new technology, lighting systems can be designed for lower initial light levels and still ensure that sufficient amounts of light are provided-even toward the end of the lamp's life. This saves energy. However, it should be noted that-despite marketing claims-this is not an exclusive feature of the T5 technology, having already been introduced in 1994 by Philips (See IAEEL Newsletter 4/94).

In the area of aluminum technology, developments independent of the light source will contribute greatly to enhancing luminaire efficiency. Namely, the German-based firm Alanod has started to market a super-reflective aluminum reflector material with a reflectance of ~95%, compared with the 85-87% characteristic for conventional reflector aluminum. This improvement alone could increase the light output by ~10%.

INITIAL PROBLEMS

So much for all the theoretical advantages-How have the lamps performed in real-life tests?

First, it seems as though manufacturers were a little too eager to get the lamps out on the market. Luminaire manufacturers soon found that it was hard to verify the lamp's nominal data when run on the new miniature ballasts. Thus, one and a half years after the lamp had been introduced, Philips issued a temporary specification stating that its lamp and ballast had an optimal ambient temperature of 28-29°C (by early 1997, delivered ballasts are to be corrected and will run at an ambient temperature close to 35°C.) Osram, who started out later with the lamps but was quick in delivering ballasts, reportedly has had few or no problems with their T5 ballast. However, there have been reports that in early 1997 Osram allowed higher-than-normal variations in light output from their lamps.

The dimmable T5 ballast was another disappointment to the luminaire industry.

Original plans were to have it on the market by the autumn of 1996, but it has been delayed. Philips has announced that dimmable ballasts will be ready for production by the time of the Hannover Fair in mid-April 1997.

GLARE CAN INCREASE

Another problem is that with these slim lamps, more light is emitted from a smaller surface, making the lamps brighter. The luminance-surface brightness-lies between that of T8 lamps and CFLs ([Table 3](#)). Discomforting glare may become a serious problem if luminaire manufacturers are not careful or do not have the necessary optical competence. This is especially true with direct lighting concepts. As an indication of the potential problems, when CFLs first emerged on

the market, even quality manufacturers often failed to solve the glare problem in downlights and other CFL luminaires. It should be noted that the five manufacturers submitting T5 luminaires to the large-scale Swedish efficient office lighting demonstration and testing scheme all had chosen a combination of direct and indirect lighting.

Furthermore, in some countries the new lamps come in different wattages and lumen packages, which makes a lot of the older rules of thumb hard to follow. In the Netherlands, for instance, the 3 650 lumen package of the new 35-W lamp does not produce enough light when used in four 1-lamp luminaires in a standard office unit. More lamps will have to be added, which would drive up the costs. Another problem is related to the temperature optimization: In countries such as Germany and the Netherlands, air is often extracted through recessed luminaires. This is done to extract excess heat from the room and to bring down the luminaire temperature to match the old T8 optimum of 25°C. With the T5 lamp this cannot be done, and at least one manufacturer is now designing recessed luminaires where the air is drawn through channels along the outside of the luminaire instead of being drawn through it.

OBVIOUS EFFICIENCY

Despite these problems, most luminaire manufacturers seem to have welcomed the obvious efficiency improvements made possible by T5 technology. But in order to realize the savings, a simple retrofit cannot take the place of careful design considerations. And much can be achieved. In the Swedish office lighting project mentioned above, some T5 luminaires met the strict lighting quality requirements while achieving illumination with only 7W m².

One thing is clear, however. The more advanced technology now being introduced will increase the gap between manufacturers that manage to design for it without causing visual performance problems for the users and those that fail to do so.

Nils Borg

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