This is even though the Directive 2000/55/EU1 says it quite clearly: a T8 lamp rated 58 W together with an improved magnetic ballast of Energy Efficiency Index EEI = B2 has a maximum electrical power intake of 67 W. An even more improved magnetic ballast of EEI class B1 may reduce this value down to 64 W, but that’s really the end of it. Better magnetic ballasts than that are not really readily available on any market in the world. A shift to class A3 electronic ballasts will cut this maximum value down to 59 W, and still you may feel free to upgrade to class A2 and hence go down to a limit value as low as 55 W. This is, as any electrical expert will tell you, because an electronic ballast has much lower losses than a magnetic one.

But is this really so? Having a look at Table 1 you realise that a 58 W lamp – who would not have expected this – uses a power intake of 58 W. In a class B1 magnetic ballast this allows for an internal power loss of 64 W - 58 W = 6 W. But when operated on an electronic ballast – as already stated. So this means that two different kinds of measures are being used here – but not for much longer. This tweaked Directive will soon be “straightened” by a more even and impartial one.

But even before it comes to this the sceptics wanted to find out what the facts really were. So measurements were commissioned by Deutsches Kupferinstitut DKI and the company PalmStep with an independent, accredited lighting lab to identify the potentials of two rather different energy saving techniques to be applied to fluorescent lamps.

- T8 type fluorescent lamps with improved magnetic ballasts (EEI = B1) and voltage reduction (so-called energy saver installations – to DKI’s knowledge no less than 10 producers of such devices, with a great variety of properties and sophistication, are active in Germany so far, but none in South Africa) and
- T5 type fluorescent lamps with dimmable ballasts (EEI = A1).

In order to obtain objective, comparable results, commonplace readily available lamps (colour rendering index 840) and the best available techniques were used in the respective cases, i. e.:

- The most commonly used T8 lamp rated 58 W and a magnetic ballast of energy efficiency index EEI = B1 (Vossloh-Schwabe LN58.512, Ref-No. 164611),
- A twin electronic ballast (Vossloh-Schwabe ELXd 249.614, Ref-No. 188343) with two T5 lamps, since in further measurements not discussed here it had turned out that a twin electronic ballast usually has lower losses than two single-lamp ones. Apart from this, T5 lamps from the HE series (High Efficiency) were selected, since the HO T5 lamps (high output) display poorer efficiencies (see Table 1). Again, the greatest available wattage rating of these, rated 35 W, was selected because the greatest efficiency could be expected from these.

The T8 lamps were tested at an ambient temperature of 25°C according to the standard (IEC 60081) where they usually deliver their best efficacy. Beyond this, the T5 lamps were additionally measured at an ambient temperature of 35°C, deviating from the standard, since for good reasons they are optimised to this ambient temperature.

The results were summarized in Fig. 1, where the systems’ light outputs were plotted against the respective electrical power intake. Further, a line was included in the plot, representing...
Comparison of T5 and T8 fluorescent lamps

<table>
<thead>
<tr>
<th>Lamp</th>
<th>T5&quot;HE&quot;</th>
<th>T8 (measured values)</th>
<th>T5&quot;HO&quot; (catalogue data)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>1449 mm</td>
<td>1500 mm</td>
<td>1449 mm</td>
</tr>
<tr>
<td>Power rating</td>
<td>35 W</td>
<td>58 W</td>
<td>49 W</td>
</tr>
<tr>
<td>operated with</td>
<td>Magnetic ballast (50 Hz)</td>
<td>Electronic ballast (HF)</td>
<td></td>
</tr>
<tr>
<td>Rated system power</td>
<td>42 W (A3)</td>
<td>67 W (B2) * 64 W (B1) * 58 W (A3) * 92 W (A3)</td>
<td>39 W (A2) * 55 W (A2) * 88 W (A2)</td>
</tr>
<tr>
<td>Measured lamp power</td>
<td>---</td>
<td>53 W</td>
<td>58W</td>
</tr>
<tr>
<td>Measured system power</td>
<td>37 W (A1)</td>
<td>55 W</td>
<td>61 W</td>
</tr>
<tr>
<td>System voltage</td>
<td>207 V..253 V</td>
<td>217 V</td>
<td>230 V</td>
</tr>
<tr>
<td>Light flux</td>
<td>3300 lm</td>
<td>4596 lm</td>
<td>4915 lm</td>
</tr>
<tr>
<td>System light efficacy</td>
<td>79 lm/W (A3)</td>
<td>84 lm/W (B1, measured)</td>
<td>81 lm/W (B1, measured)</td>
</tr>
</tbody>
</table>

Table 1: Efficiency comparison T5 HE lamps, T5 HO lamps and T8 lamps

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A constant efficacy of \( \eta = 80 \text{ lm/W} \), which should represent a guideline for the efficiency in today’s lighting installations. This way the following becomes evident:

- The efficacy of any T8 system increases during input power reduction. Generally speaking, the values in the lower segment lie above the 80 \( \text{lm/W} \) “guideline”, while in the upper half they lie below, and especially in the overload range they strongly tend to flatten out.

- The T5 lamps exhibit the inverse behaviour: Efficiency decreases during dimming. Values in the upper range tend to lie above the “guideline”, while values in the lower range tend to lie below.

- The improved efficiencies of the T5 lamps at 35°C against the values measured at 25°C become quite obvious.

- As an aside, any fluorescent lighting system turns out to be far superior to halogen lamps, which are incandescent lamp systems and as such are only marginally better than generic incandescent lamps.

Unfortunately this type of plot is not very adequate for a direct comparison of either system against the other one because there are not any two lamps T5 and T8 with equal electrical power ratings available. It was therefore successfully tried to find a different method to compare either of the systems to each other by plotting the light efficacy against the relative system power (Fig. 2). In this type of graph a direct comparison of different systems should be possible when keeping the following remarks in mind:

- For the T8 systems, what is meant by relative systems power is the ratio of the measured systems power at the respective voltage divided by the measured systems power at rated voltage of the same system (for instance, with the old magnetic ballast class EEI = C the reference point representing 100% is 69 W, that of an improved magnetic...
ballast class EEI = B1 is 61.4 W, which represent the respective system’s values at 230 V).

- For the T5 system, what is meant by relative system’s power is the ratio of the measured system’s power at the respective dimming level divided by the measured system’s power when set to full light output (same system undimmed).

- According to the Directive 2000/55/EU, to match efficiency class EEI = A1 an electronic ballast has to be dimmable down to 10% of rated lamp light output at least (i.e. by ±90%). While not dimmed, it has to match the requirements of EEI class A3, and at 25% of rated light output it shall not use more than 50% of the rated power intake (i.e. that of class A3). In the chart this requirement is plotted in stroked-dotted lines once for measurement at 25°C and once at 35°C for ease of orientation.

Hence, the above description facilitates the following observations:

- The T5 system under test by far exceeds the minimum requirements.

- It becomes even clearer now that the efficacy of the T8 system increases due to power reduction (and accordingly drops inadequately in the overload range), while the efficacy of the T5 system is best at full power and drops during dimming.

- At full load and 25°C ambient temperature the T5 system is about equally efficient as the best T8 system (class EEI = B1).

- At full load and 35°C ambient temperature the T5 system is ±10% more efficient than the best T8 system at 25°C.

- When reducing or dimming, respectively, down to ±75% (here referring to the respective electrical power input measured at 230 V or, respectively, to the undimmed lamp, not to the light flux) the efficacy of the best T8 system is about equal to that of the T5 system at 35°C.

- When reducing or dimming the systems power to ±60%, respectively, the efficacy of the T5 system even drops below that of a T8 system with an ancient EEI = D magnetic ballast which was rescued from a scrap metal container back around 1986.

- When reducing to ±50% input power the possible range of application for the voltage reduction technique ends. Otherwise the lamps will go out completely. A greater dimming range can be implemented with dimmable electronic ballasts only.

This facilitates the following conclusions:

- Dimmable ballasts provide only a rather limited energy savings potential. Who wants to save energy should reasonably employ a combination of voltage reduction and subsequent grouped automatic switching (e.g. from the aisle side to the window side in an office) after exploiting the (limited) “dimming” potential of voltage reduction – optionally, wherever possible, applying a technique which comes without any need for stand-by consumption and using electronic starters, which spare the lamp life as well as the employees’ nerves when switching occurs more frequently than once a day.

- The voltage reduction technique is no replacement for dimming. Who wants to dim has to use dimmable electronic ballasts. On the background of today’s knowledge all techniques for dimming magnetic ballasts that have ever been around are makeshift solutions and do not satisfy modern needs. They should therefore not be considered any longer.

Still, these considerations do not yet include the following circumstance:

Dimmed operation of fluorescent lamps represents permanent cathode heating operation. The position “Lights off” is usually identical with the position “Dimmed down to 0”. Unless care is taken that the supply voltage to the lighting installation is shut off after work and on weekends, the lamps continue to be operated in a “Dimmed down to 0” state. This sabotages the underlying endeavours to save energy, e.g. with the following assumptions:

- On a T8 lamp rated 58 W (whose systems power is 59 W in class A3 or A1, respectively) a power saving of 55.8 W is possible (“Dimmed down to 0” with a residual consumption of 3.2 W),

- an average office is in operation for 3000 h/a,

- the light is in operation for about 2/3 of this time, yielding 2000 h/a,

- during half of this time, say, 1000 h/a,

- half of this power level is sufficient, i.e. 500 h/a savings potential, converted to full-load hours,

- the stand-by consumption, however, remaining active during all of the 8760 h/a yields the following calculation for the energy saved:

\[ W = 500 \frac{h}{a} \times 55.8 \frac{W}{a} = 28 \frac{kWh}{a} \]

The basically useless additional consumption calculates as:

\[ W_s = 8760 \frac{h}{a} \times 3.2 \frac{W}{a} = 28 \frac{kWh}{a} \]

Thereby a savings potential does no longer exist. In some favourable exceptions this is taken into regard and installed accordingly, so that the user does not deplete the daily savings at night, but it remains to be doubted that this way of taking care is the rule among specifiers and designers.

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