

Efficiency Increase at Low Temperatures through Heat Accumulation Tube Sections in Synthetic Material Damp-Proof Luminaires with T5 Fluorescent Lamps

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Introduction

Commercially available luminaires with energy-saving three-band fluorescent lamps are in practice deployed in many ways both in indoor and also in outdoor areas. Depending on the ambient conditions and in particular at low temperatures, a noticeable loss in luminous intensity occurs in the instance of such luminaires. This loss makes it self felt already in fields of applications like railway stations and in enclosed parking garages with seasonally dependent temperature variations in the range of +30 °C to -10 °C in moving air. The loss in luminous intensity and thus the energy loss are due to a high heat exchange between the fluorescent lamps and the ambient air. The degree of the noticeable loss in luminous intensity may here depend on the selection of the fluorescent lamps being used.

For the purpose of increasing energy efficiency at low temperatures special luminaires with so-called heat accumulation tubes [1–6] were developed for accommodating three-band fluorescent lamps. Here the fluorescent lamps are equipped with at least one concentric, translucent full-length protection tube which is fitted in parallel to the fluorescent lamp in the lamp cover and which accumulates the heat radiated by the fluorescent lamp.

This well-known luminaire design does offer advantages for special applications like cold storage rooms, but the complexity of such luminaires is correspondingly high, incurring significant manufacturing costs.

The three-band fluorescent lamp T5/16 mm represents the latest development level of the lamp manufacturers. The special characteristics of the T5/16 mm fluorescent lamps which can be operated only with electronic ballasts EVG are their high luminous efficiency at optimum operating conditions and owing to the trend towards smaller sizes in the outside tube diameter which has been reduced to 16 mm. Their particularly high nominal luminous flux of 6150 lm [5] is defined at 25 °C. This means that the advantage of the T5/16 mm fluorescent lamps can be seen as an increased luminaire operating efficiency for enclosed lu-

minaires (under standard conditions). For this reason the T5/16 mm lamps are being increasingly deployed in new indoor systems. Owing to the significantly decreasing luminous flux below 0 °C and the problematic ignition characteristic at low temperatures (an electronic ballast unit can only be operated reliably above -25 °C), the T5/16 mm fluorescent lamp without additional design aids is today still not recommended for low ambient temperatures.

What shall be Achieved?

Aim is the development of synthetic material higher protection class luminaires [1] which can be deployed in an energy efficient manner also at low temperatures in the range of +30 °C to -10 °C in moving air in connection with three-band fluorescent lamps of the type T5/16 mm.

The design measures for an optimisation shall not have any detrimental effects on the way in which the luminaire is operated or the efficiency at normal or higher temperatures. At the same time design and material related additional complexity shall be minimal. The synthetic material luminaires shall contain closed lamp covers, interior high-performance reflectors and built-in open heat accumulation tubes.

Design Solution

The design solution relates to a luminaire with a closed housing which is at least translucent on the radiating side, for accommodating at least one fluorescent lamp socketed on the face side, being supported and contacted in the face sections of the lamp cover end components.

Owing to the smaller diameter of the T5/16 mm fluorescent lamp, the higher luminous flux [2] compared to the T8/26 mm fluorescent lamp and the so-called »cool spot« [5] at one lamp end, it is conceivable to dispense with a closed full-length heat accumulation tube made of shatter-proof PC running in parallel to the lamp and instead provide heat accumulation tube sections in the electrode area only. The use of an 8% to 10% light absorbing PC heat

accumulation tube encompassing the lamp can thus be dispensed with.

This solution is flexible for many cover variants. The increasing air temperature can circulate in the cover and is not accumulated by the relatively small diameter heat accumulation tube due to the significantly higher temperatures in the instance of the T5/16 mm fluorescent lamp.

The optimum length of the symmetrically arranged heat accumulation tube sections needs to be defined based on own laboratory measurements. The results are communicated in detail in the following.

Design Features . This task is solved chiefly by providing a thermal jacket encompassing the fluorescent lamp at a specified distance and adjacent with respect to the housing end components. The axial length of the thermal jacket is so rated that at least the inside electrodes of the fluorescent lamp are covered along their entire length.

Through the thermal jackets provided at both housing end components and through their design respectively rating it is achieved with minimal complexity restricted chiefly to the utilisation of two short tube sections, that in particular with T5/16 mm fluorescent lamps having a diameter of 16 mm the previously unavoidable loss in luminous flux at low temperatures and possibly also occurring functional impairments are mostly prevented. For vertical installation the stamp of the lamp (long lamp electrode) must be at the bottom.

Through the thermal jackets provided at both ends, installation of the fluorescent lamp becomes entirely independent because it is at always ensured that the electrodes of the fluorescent lamp are located in the area of a thermal jacket. For this reason, lamp replacements can be performed without problems and without having to consider special installation regulations.

The length of the respective thermal jacket is usually selected depending on the wattage, i.e. the rated lamp power so that the longer inner electrode (at the lamp end with the stamp) is covered by the thermal jacket. From this there result in connection with T5 fluorescent lamps different lengths for the thermal jacket in the range of approximately 60 to 100 mm.

The radial distance between the respective fluorescent lamp and the corresponding thermal jacket needs to be determined based on the inner volume of the closed lamp cover whereby a change in the radial distance is catered for. The optimum effect of the thermal jacket thus depends also on the possibly to be determined volume between fluorescent lamp and thermal jacket on the one hand and the volume of the closed housing on the other hand.

For simplification of installation and to facilitate the lamp replacement, the free end of the thermal jacket is shaped as an insertion aid whereby the funnel shaped insertion aid can be implemented by way of a separate component which preferably is joined to the thermal jacket by way of a clamp coupling.

The thermal jacket could be made of one piece together with the housing end component, but frequently it is releasable and held in place by a clamp guide.

The material for the thermal jacket can be substantially selected freely and may consist, for example, of temperature resistant, preferably glass-type polymers or metal.

The polymer material is usually coated with a heat reflecting material.

According to a further design, the thermal jackets may be provided in the area of one of their ends with cross-section reducing elements for defining a permissible amount of air exchange with the inner volume of the housing. These cross-section reducing elements are generally matched by way of a single part to the thermal jacket or are provided by way of their shape.

The thermal jackets preferably used together with T5/16 mm fluorescent lamps can be combined with all types of lamp cover irrespectively of the lamp covers being non-reflective or mirrored.

In the course of designing luminaires it is always necessary to ensure that the parameters are defined correctly. "Ever smaller and nicer" is surely not in all cases the right answer with respect to the requirements for a reliable and durable product. For the kind of application discussed here, low ambient temperatures were the basis as well as a design with a large single-chamber luminaire housing and an additional metal installation support to which the electronic ballast is fitted.

Execution Example and Figures. The design solution detailed in the following is based on an execution example and with reference to Fig.1. The figure depicts the end section of a luminaire with a thermal jacket, the other end of which is formed correspondingly.

In accordance with Fig. 1, the depicted luminaire comprises a support housing (1) suited for ceiling or wall mounting for accommodating ballast units, connecting cables and alike and at which through the end components (2) a translucent housing (3) is held in place.

The free ends of the housing (3) are chiefly inserted for sealing off a shape-wise matching groove in the respective end components (2) so that both end components (2) and the housing (3) form a sealed volume.

In the example depicted, the lamp cover (3) has been designed to accept a fluorescent lamp, but of course by way of suitable dimensioning of the housing also a volume can be created for accommodating several fluorescent lamps arranged in parallel with respect to each other.

The end components (2) are provided with through-passage apertures for the fluorescent lamps socketed at both respective ends and which are contacted in the area of the end components. Adjacent with respect to each end component (2) and the through-passage aperture a thermal jacket (4) is provided which exhibits a certain radial distance with respect to the fluorescent lamp and which extends over a certain length along the fluorescent lamp not depicted in the figure.

The thermal jacket (4) could in principle be designed by way of a single part together with the end components (2) but in most instances it will be a separate component which regarding the end component (2) is mounted by means of several retaining elements (6) around the circumference which clamp the thermal jacket (4) in place.

Generally for the fluorescent lamp an insertion aid (5) is provided at the free end of the thermal jacket (4) which is designed to be funnel shaped, exhibits on the inside guide ribs and which may be connected by means of a clamp holder to the thermal jacket (4).

Through the utilisation of thermal jackets which consist of a comparably short tube section thereby requiring not much material, above all in the instance of T5 fluorescent lamps [7] having preferably a diameter of 16 mm, it is possible to create for the electrodes at low temperatures an area in which the temperature is stable or does not fluctuate too much, allowing to maintain operational stability of the fluorescent lamp across a wider temperature range and avoid unwanted losses in luminous flux at low temperatures.

Whereas the radial distance between the fluorescent lamp and the thermal jacket (4) is selected depending on the volume trapped between the housing (3) and the end components (2), the axial length of the thermal jacket depends on the power rating respectively wattage of the respective fluorescent lamp and is for this reason in the range of 60 to 100 mm.

It is important that through the thermal jacket the in each instance longer in the electrode of the luminaire is covered.

Depicted in the figure is a translucent [4] housing (3) which is translucent throughout whereby the lamp cover (3) may certainly also be mirrored.

The thermal jackets consist mostly also of translucent synthetic materials since then they will be practically optically not apparent. However, in certain applications it may be beneficial to implement thermal jackets which are made of specially coated synthetic materials or even metal.

Owing to the releasability of the thermal jackets, the basic luminaire design may be deployed with or without thermal jacket (depending on the design of the lamp cover) so that equipping of luminaires with thermal jackets is possible quickly and without problems should the specific application require this.

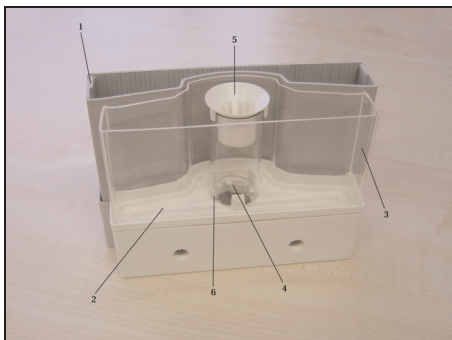


Fig. 1. Luminaire housing with built-in heat accumulation tube section (Pracht system MEDIO) and insertion aid (image courtesy of pracht group): 1 – support housing; 2 – end component; 3 – translucent housing; 4 – thermal jacket/heat accumulation tube section; 5 – insertion aid; 6 – retaining element

Summary of Important Design Aspect:

1. Luminaires with enclosed housings and translucent at least on the radiating side for accommodating at least one fluorescent lamp socketed on the face side and held and contacted in housing end components so that adjacent to the housing end components (2) a thermal jacket (4) is provided encompassing the fluorescent lamp at a specific distance, the axial length of which is so designed that the inner electrodes are fully covered.

2. The length of the thermal jacket (4) needs to be selected depending on the wattage so that the longer electrode of the fluorescent lamp regarding its position with respect to the stamp width is covered.
3. The thermal jacket (4) needs to be between 60 and 100 mm long, depending on the wattage.
4. As fluorescent lamps, T5/16 mm fluorescent lamps shall be used which on one side shall exhibit two differently long inner electrodes.
5. The radial distance between fluorescent lamp and thermal jacket must be dependent on the inner volume of the closed housing (3) whereby through different volumes a change in the radial distance is provided for.
6. The free end of the thermal jacket (4) must be formed as an insertion aid (5) for the fluorescent lamp.
7. The preferably funnel-shaped insertion aid (5) of the thermal jacket (4) needs to be designed by way of a separate component linkable to the thermal jacket.
8. The thermal jacket (4):
 - a) must be releasable at the respective housing end component (2) and needs to be held in place in particular through a clamp guide (6),
 - b) can consist of a temperature resistant, clear polymer material,
 - c) can be manufactured of a polymer material coated with a heat reflecting material,
 - d) can consist of metal and
 - e) exhibits at least in the area of its free end cross-section reducing elements for specifying a permissible air exchange with the inside housing volume.
9. The thermal jackets (4) used in connection with T5/16 mm fluorescent lamps shall be usable in combination with all variants of closed, non-mirrored and mirrored covers (3).

Lighting Engineering

From Fig. 2 the increase in efficiency with built-in heat accumulation tube sections (HLR WSTAB) is apparent in comparison with an unprotected T5/16 mm fluorescent lamp and in comparison with a closed high-performance reflector (HLR) without technical modifications. The luminaire without heat accumulation tube is unsuited for low temperatures and offers at a normal ambient temperatures up to +40 °C the best light yield.

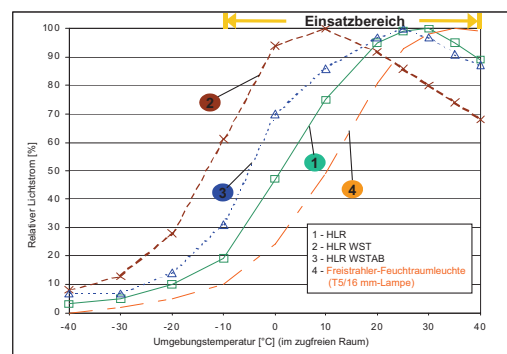


Fig. 2. Relative luminous intensity as a function of ambient temperature (HLR: high-performance reflector, WST: heat accumulation tube, WSTAB: heat accumulation tube section)

The variant with the heat accumulation tube sections provides an improvement with respect to the standard version without heat accumulation tube. The measurement results fall between standard version and version with full-length accumulation tube. At -10 °C only approximately 30% of the luminous flux is attained, however, it exhibits at higher temperatures a good light yield.

A further improvement is, however, only possible with an increased material and cost share. Through the installation of a full length heat accumulation tube (HLR WST) the optimisation and increasing efficiency at low temperatures is apparent.

Conclusions

Owing to the smaller diameter of the T5/16 mm fluorescent lamp, the higher luminous flux compared to the T8/26 mm fluorescent lamps and the so-called cool spot (under the stamp) at one lamp end, here a full-length closed heat accumulation tube [3] made of light absorbing PC is dispensed with and heat accumulation sections are employed only in the area of the electrodes. In the increasing air temperature may circulate in the cover and is not accumulated in a complex heat accumulation tube. This tube as it is required for the T5/16 mm fluorescent lamp owing to the considerably higher temperature range, and as the result of this review results in an increase in efficiency in the luminous flux of the T5/16 mm fluorescent lamps. This solution is flexible for many cover variants.

The material PC is preferably employed for the heat accumulation tube sections for reasons of temperature re-

sistance and production engineering handling.

Through a relatively simple but engineering-wise ingenious design the engineering advances are clearly apparent. For this reason it is not feasible to maintain costly and material intensive solutions when it is possible by drawing on scientific knowledge to attain a higher efficiency with simple variants.

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The new energy-saving fluorescent lamp generation T5/16 mm exhibits an extremely high operational efficiency at room temperature. However, low ambient temperatures cause a significantly reduced luminous flux and thus a low operational efficiency. It is therefore for economic reasons not practical to deploy this new generation of lamps at low temperatures. In the present paper and engineering solution is discussed which is capable of improving the luminous flux in consideration of the special conditions in higher protection class luminaires. Ill. 2, bibl. 8 (in English; abstracts in English and Lithuanian).

F. Pracht. Liuminescencinių lempų T5 efektyvumo didinimas esant žemai temperatūrai // Elektronika ir elektrotechnika. – Kaunas: Technologija, 2011. – Nr. 4(110). – P. 135–138.

Naujos kartos liuminescencinė lempa T5/16 mm pasižymi itin dideliu efektyvumu. Tačiau šviesos esant žemai aplinkos temperatūrai srautas gali sumažėti. Darbe pateikiama pasiūlymų, kaip padidinti jų šviesos srautą aukštos saugos klasės šviestuvuose. Il. 2, bibl. 8 (anglų kalba; santraukos anglų ir lietuvių k.).