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# Tubular Luminaire System in the Sense of Product Responsibility

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**Introduction**

Architecturally appealing strip light systems with tubular luninaires are preferably employed to illuminate building objects. Especially in the case of specialised areas of application involving high levels of humidity and dust, tubular luminaires must fulfil the highest engineering requirements.

Tubular luminaires consist of tube shaped housing and are sealed off at the face side of the housing with releasable, detachable covers.

Energy conserving fluorescent lamps of the type T5/16 mm or T8/26 mm serve as the illuminants. Besides LED (light emitting diode) and RGB (red-green-blue) versions, wattages up to three lamps are possible.

**What shall be Achieved?**

The design is aimed at developing a new strip light system without a dark section in the light strip. The sealing system shall be extremely short and the cover shall on the one hand be easy to fit and disassemble and engage at a clearly defined ultimate torque level, and on the other hand exhibit in the axial direction of a housing dimensions which are as small as possible.

**Project Management**

Important for a successful development process is in the introduction of a project management system [4], [11]. Even though this involves considerable organizational changes.

The luminaire system and all components are designed based on a computer aided design (CAD) process [10].

The preproduction series units are produced by relying on rapid prototyping [1] in connection with an integrated product development process [2] and with respect to the specifications of product responsibility in accordance with § 22 of KrW-/AbfG (Waste Avoidance and Management Act) [3].

**CAD Design Software used**

The tubular luminaire was designed using SolidWorks® Office Premium [3–5] CAD automation software – a feature protected, parametric design tool for volume modelling (a volume model is the most comprehensive geometrical model type being utilised in CAD systems) using the easy to learn graphical user interface of Windows™ (How does a model perform when it is changed?) [3].

**Discussion of the List of Questions**

Before any new development process is initiated, the creation of a detailed specification document is mandatory. Thus there results a list of questions which covers the relevant aspects and compliance with international standards: for efficient operation, light engineering aspects need to be specially considered like: luminaire efficiency, luminous intensity distribution, luminous flux distribution, glare restriction unified glare rating (UGR) method.

**Environment Aspects – Product Responsibility - Recycling Management**

Through a consistent inclusion of the new EU directives WEEE and RoHS as well as the fulfilment of product responsibility at the end of the life cycle, the new system of luminaires was developed in full awareness of environmental aspects [12]. Fig. 1 depicts a cover arrangement designed by relying on CAD methods.

**Example of an Embodiment**

The present invention is explained with reference to an example of an embodiment given below and with reference to Fig. 2–5. The item numbers refer to these figures. Fig. 2 depicts a schematic cross-section of the end area on the face side of a luminaire with protection tube with an uncompressed sealing element, Fig. 3 depicts an embodiment in accordance with Fig. 2 with a compressed sealing element, Fig. 4 depicts a three-dimensional exploded view of a possible embodiment for a cover arrangement, and Fig. 5 depicts a sectional view of a cover arrangement in accordance with Fig. 4 in the assembled state with compressed sealing element.

**Cover arrangement:** Fig. 2 depicts the end area of a tube shaped, cylindrical housing (10) into which a cover arrangement is inserted from the open face side. This cover arrangement consists chiefly of an end cap (12), a counter-

pressure disk (14), a sealing element (16) and a tension lock not depicted in this figure, which is arranged at (18) in the central area of end cap (12) and counter-pressure disk (14).

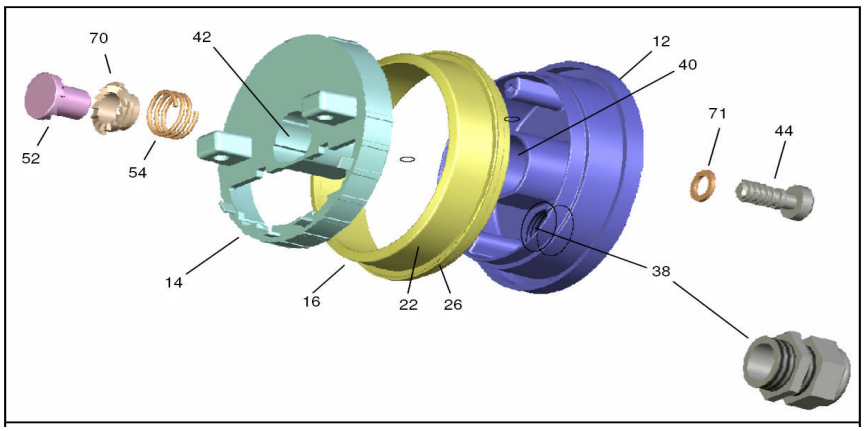


**Fig. 1**. CAD exploded view of an embodiment of the tension lock system on the face side with a well-defined torque cut off point

**End cap and counter-pressure disk:** the end cap (12) and the counter-pressure disk (14) are rotationally symmetric with respect to the longitudinal axis of the housing (10), whereby the end cap (12) exhibits in its cross-section a T or mushroom shape, i.e. the two adjacent sections A an B exhibit differing diameters. The end cap area A with the smaller diameter exhibits a contact surface (20) for the sealing element (16). Here the contact surface (20) extends concentrically to the inside wall of the housing (10). The diameter of section A of the end cap (12) is so designed that between the inside wall of the housing (10) and the contact surface (20) sufficient space is left for the ring shaped sealing element (16).

The section B with the greater diameter of the end cap (12) is so designed that it cannot be inserted into the inside of the housing (10); in fact the diameter of section B corresponds to the outside diameter of the housing (10), so that the shell surface of section B aligns with the shell surface of the housing (10). The outside diameter of the pressure disk (14) corresponds to the inside diameter of the housing (10). Whereby the counter-pressure disk (14) is movable in the direction of longitudinal axis of the housing (10) into its inside volume.

**Sealing element:** the sealing element (16) has been designed as a ring element with an L-shaped cross-section and exhibits in the area of its longer leg (22) a sealing surface (24) for making contact at the inside of the housing (10).

The shorter leg (26) of the sealing element (16) exhibits a contact surface (28) for making contact at the ring shaped face side of the housing (10) so that the end area of the shorter leg (26) comes to rest between the ring shaped face side of the housing (10) and section B of the larger diameter of the end cap (12).

The longer leg (22) of the sealing element (16) is so designed that it, in its uncompressed state, projects in the direction of the counter-pressure disk (14) (i.e. in the direction of the longitudinal axis of the housing) over section A with the smaller diameter of the end cap (12). Thus there exists in the uncompressed state of the sealing element (16) (see Fig. 2) between the facing surfaces (30), (32) of counter-pressure disk (14) and end cap (12) a gap (34) the width of which corresponds to the excess of the sealing element (16) projecting beyond end cap (12).

The sealing element (16) exhibits in the area of its longer leg (22) a circumferential slot (36), extending in parallel to the longitudinal axis of the housing (10) and which is open towards section B of the greater diameter of the end cap (12). The longer arm (22) of the sealing element (16) exhibits a basically U-shaped cross-section.

**Compression of the sealing element:** If counter-pressure disk (14) and end cap (12) are moved towards each other by a suitable tension lock in the direction of the arrows shown in Fig. 2, the longer leg (22) of the sealing element (16) is compressed. During the compression process, slot (36) is closed at least in some areas. Moreover, owing to the compression process, the sealing element (16) tries to expand in a direction at right angles with respect to the longitudinal axis of the housing (10). Thus between section A with the smaller diameter of the end cap (12) and the end area on the face side of the housing (10) a clamping effect is produced, providing a dust- and moisture-tight seal for the face side end of the housing (10). When the compression process of the sealing element (16) is continued, the end cap (12) is only slightly pulled into the face side end area of the housing (10), so that between section B with the greater diameter of the end cap (12) and the ring shaped face side of the housing (10) only a slight approach is effected. Thus the shorter leg (26) of the sealing element (16) is clamped between the two aforementioned areas.

Fig. 3 depicts an arrangement in accordance with Fig. 2 after the compression process of the sealing element (16) has been completed; respectively after end cap (12) and counter-pressure disk (14) have been moved as far as possible towards each other by the tension lock. In accordance with Fig. 3, the slot (36) of the sealing element (16) is mostly closed, and the sealing element (16) provides between the housing (10) and the end cap (12) a dust and moisture-tight joint which can only be released when opening the tension lock and moving the counter-pressure disk (14) and the end cap (12) away from each other. In doing so, the tension on the sealing element (16) is relieved.

Fig. 4 depicts a three-dimensional view of end cap (12), counter-pressure disk (14) and sealing element (16). In addition to the elements depicted in Fig. 2 and Fig. 3, a cable feedthrough (38) is depicted in Fig. 4 allowing the power supply cable to be run into the inside of the housing (10) in a dust- and liquid-tight manner. The necessary opening for this in the area of the counter-pressure disk (14) has been omitted in Fig. 4 for the sake of clarity.

Fig. 5 depicts an arrangement in accordance with Fig. 4 in the assembled state and with compressed sealing element (16). Here the arrangement is not inserted into a housing (10) as depicted in Fig. 2 and Fig. 3. For this reason, the sealing element (16) depicted in Fig. 5 arches in its compressed state to the outside. This is not possible when it is located inside housing (10).

**Tension lock:** in contrast to Fig. 2 and Fig. 3 the tension lock is depicted in Fig. 5. It is designed as follows:

Both in the end cap (12) and also in the counter-pressure disk (14) there are present in each case central step-shaped through holes (40), (42). Introduced into through hole (40) of the end cap (12) is a closure element (44) actuated by a rotary movement, where the axis of rotation corresponds to the centre axis of end cap (12) and counter-pressure disk (14). The closure element (44) is completely counter-sunk in the end cap (12) and exhibits in the area of the end surface on the face of side (46) of the end cap (12) a hexagon recess, for insertion of a corresponding tool. A pin (50) of the closure element (44) projects through the area of the reduced diameter of the central through hole (40) into recess (42) of the counter-pressure disk (14). Here the pin (50) is located within a sleeve (52) which is inserted into the recess (42) of the counter-pressure disk (14) and which is supported by means of a helical spring (54) at the counter-pressure disk (14). Thus the movement of the sleeve (52) in the direction of the end cap (12) effects through the effect of the helical spring (54) also a movement of the counter-pressure disk (14) in direction of the end cap (12).

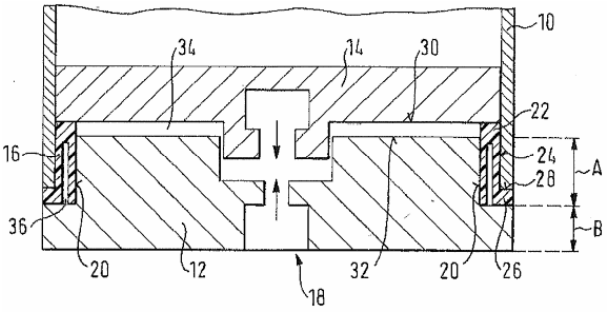


**Fig. 2.** Schematic cross-section of a face side end area of a luminaire with protection tube, with uncompressed sealing element

The pin (50) of the closure element (44) is provided with two actuating pins (56) extending radially towards the outside, suited for engaging within a cam plate (58) provided within the sleeve (52). A rotation of the closure element (44) by 90°, for example, causes at least one of the two actuating pins (56) engage the cam plate (58). This moves the sleeve (52) in the direction of the end cap (12). Owing to the linkage of the sleeve (52) via the spring (54) to the counter-pressure disk (14), also the counter-pressure disk (14) follows the type of movement stated, so that counter-pressure disk (14) and end cap (12) move towards each other. By means of this movement, the already detailed compression of the sealing element (16) is attained.

**Tension lock with torque end point:** An important aspect for the tension lock is a well-defined torque end point so as to avoid any system damage.

If a cover arrangement in accordance with Fig. 5 shall be released again from a housing (10) in accordance with Fig. 2 and Fig. 3, the closure element (44) is simply turned in the opposite direction. In doing so the counter-pressure disk (14) and the end cap (12) move away from each other. The tension on the sealing element (16) is relieved and the clamped connection detailed is released.

**Summary of Important Design Aspects**

The item numbers in the following description relate to figures Fig. 2 to Fig. 5.

1. The luminaire with protection tube is equipped with a tubular housing (10) for an elongated illuminant. Here the housing (10) is sealed off on at least one face side with a detachable cover. The cover exhibits two axially movable pressure absorbing surfaces between which an elastic sealing element (16) is maintained which exhibits a sealing surface (24) for making contact at the inside of the tubular housing (10). The sealing element (16) is provided with a contact surface (28) extending perpendicularly or at an angle with respect to a sealing surface (24) for the purpose of making contact at the ring shaped face side of the tubular housing (10).

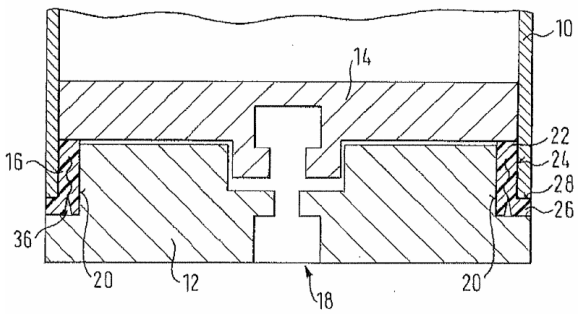


**Fig. 3.** Illustration according Fig. 2 with compressed sealing element. Key to Fig. 2 to Fig. 5: 10 – Housing; 12 – End cap; 14 – Counter-pressure disk; 16 – Sealing element; 18 – Area; 20 – Contact surface; 22 – Longer leg; 24 – Sealing surface; 26 – Shorter leg; 28 – Contact surface; 30, 32– Surface; 34 – Gap; 36 – Slot; 38 – Cable feedthrough; 40 – Central through hole; 42 – Central through hole; 44 – Closure element; 46 – End surface; 48 – Hexagon recess; 50 – Pin; 52 – Sleeve; 54 – Helical spring; 56 – Actuating pins; 58 – Cam plate

2. The sealing element (16) is designed by way of a ring element with a basically L-shaped cross-section.

3. The peripheral surface of the end cap area (section B in Fig. 2) follows with a greater diameter and aligns with the section of the sealing element (16) facing this end cap area.

4. The end cap is provided with an engaging quick lock, see Fig. 5, with a bolt-and-spring system accommodated captively in a dome.

5. The captive bolt-and-spring system inside is designed to exhibit a well-defined torque cut-off point (stop), similar to a ratchet. This prevents destruction of the lock and guarantees the tightness of the system. Tables 2–5 provide information on the system data of the luminaire and the fluorescent lamp. Luminous efficiency is considered relating to system power.

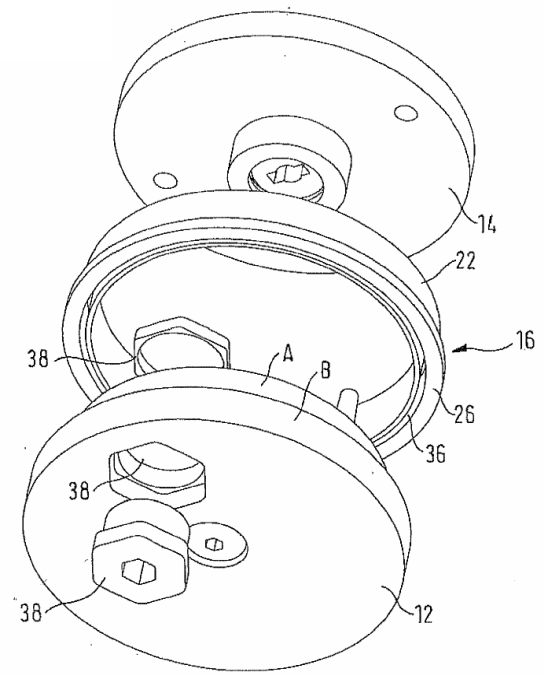


**Fig. 4.** Three-dimensional exploded view of an embodiment of a cover arrangement

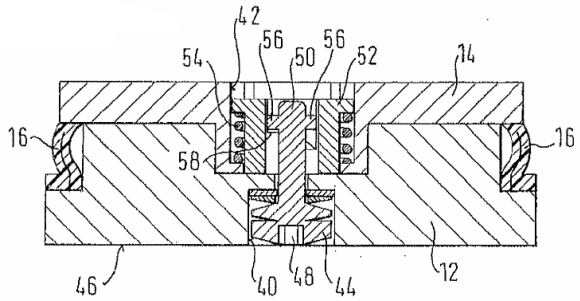


**Fig. 5.** Sectional view of a cover arrangement in accordance with Fig. 4 in the assembled state with compressed sealing element.

**Table 1**. Illuminant T8/26 mm and TC-L: fluorescent lamp data

| **Designation** | **Length [mm]** | **Diameter [mm]** | **Nominal power rating [W]** |
|---|---|---|---|
| T8/26 mm | 590 | 26 | 18 |
| T8/26 mm | 590 | 26 | 18 |
| T8/26 mm | 1200 | 26 | 36 |
| T8/26 mm | 1200 | 26 | 36 |
| T8/26 mm | 1500 | 26 | 58 |
| T8/26 mm | 1500 | 26 | 58 |
| TC-L | 317 | - | 24 |
| TC-L | 533 | - | 55 |

**Table 2.** Illuminant T8/26 mm and TC-L: system data

| **Designation** | **Ballast unit** | **Power rating [W]** | **Luminous flux [lm]** | **Luminous efficiency [lm/W]** |
|---|---|---|---|---|
| T8/26 mm | VVG | 22 | 1350 | 61 |
| T8/26 mm | EVG | 19 | 1300 | 68 |
| T8/26 mm | VVG | 42 | 3350 | 80 |
| T8/26 mm | EVG | 35 | 3200 | 91 |
| T8/26 mm | VVG | 66 | 5200 | 79 |
| T8/26 mm | EVG | 55 | 5000 | 91 |
| TC-L | EVG | 26 | 1800 | 69 |
| TC-L | EVG | 60 | 4200 | 70 |

VVG = low-loss ballast. EVG = electronic ballast

**Table 3**. Illuminant T5/16 mm: fluorescent lamp data

| **Designation** | **Length [mm]** | **Diameter [mm]** | **Nominal power rating [W]** |
|---|---|---|---|
| T5/16 mm | 549 | 16 | 14 |
| T5/16 mm | 549 | 16 | 24 |
| T5/16 mm | 1149 | 16 | 28 |
| T5/16 mm | 1449 | 16 | 35 |
| T5/16 mm | 1149 | 16 | 54 |
| T5/16 mm | 1449 | 16 | 49 |
| T5/16 mm | 1449 | 16 | 80 |

**Table 4**. Illuminant T5/16 mm: system data

| **Designation** | **Ballast unit** | **Power rating [W]** | **Luminous flux [lm]** | **Luminous efficiency [lm/W]** |
|---|---|---|---|---|
| T5/16 mm | EVG | 16 | 1200 | 75 |
| T5/16 mm | EVG | 27 | 1750 | 65 |
| T5/16 mm | EVG | 31 | 2600 | 84 |
| T5/16 mm | EVG | 38 | 3300 | 87 |
| T5/16 mm | EVG | 61 | 4450 | 73 |
| T5/16 mm | EVG | 54 | 4300 | 80 |
| T5/16 mm | EVG | 86 | 6150 | 72 |

EVG = electronic ballast

**Table 5** Thermotechnical measurement data

| Measurement points | Temperature limit [°C] | Measured values in °C for tubular luminaire with 1 x 58 W | |
|---|---|---|---|
| | | VVG | EVG |
| Mounting surface | 90 | 34.1 | 30.7 |
| Ballast unit | 130 | 81.4 | - |
| EVG TC point | 75 | - | 63.6 |
| 5-LV at 16 A | 105 | 85.4 | 64.6 |
| Lamp socket | 120 | 83.7 | 74.2 |
| Starter housing | 100 | 64.9 | - |
| Terminal | 100 | 74.6 | 62.4 |
| Luminaire surface, horizontal | 90 | 43.5 | 39.9 |
| Luminaire surface, vertical | 150 | 45.0 | 40.8 |

VVG = low-loss ballast. EVG = electronic ballast

**Thermotechnical Measurements**

For safe and reliable subsequent application of the luminaires and for protection of the components, temperature limits which must not be exceeded have been laid down in the applicable standards for selected measurement points. The laboratory measurement results given in are significantly below the in each case demanded temperature limits.

For the light measurement of the luminous intensity distribution curves (Fig. 6 and Fig. 7), the tubular luminaire was equipped with one, respectively two fluorescent lamps (T8/26 mm, 58 W; VVG with starter). The polar curves depict the distribution of the standardised luminous intensity in a single plane.

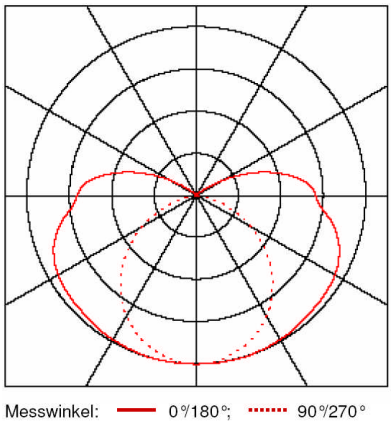


**Fig. 6.** Light distribution curve of a tubular luminaire equipped with one fluorescent lamp

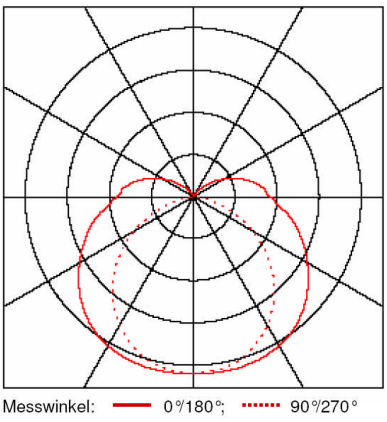


**Fig. 7.** Light distribution curve of a tubular luminaire equipped with two fluorescent lamps

## Summary

High protection category tubular luminairs must be capable of resisting rough ambient conditions like high humidity and severe contamination. An important factor in this is, besides the materials which are used, a secure closure system.

The bolt-and-spring system captively integrated within the cover offering a defined torque end point guarantees at all times a secure seal for the luminaire system. This avoids damage to the system, and to the subsequent user it ensures rapid and secure maintenance even when for cost reasons the maintenance work is left to unskilled staff. Thus neither dust nor humidity can penetrate the housing so that the requirements of protection category IP 68 in accordance with DIN EN 60529 are complied with. Moreover, owing to the cover construction the sealing element is always subjected to the same well-defined pressure. This increases the service life of the sealing element in consideration of product responsibility according to KrW-/AbfG, and the environment aspects are taken into account.

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**F. Pracht. Tubular Luminaire System in the Sense of Product Responsibility // Electronics and Electrical Engineering. – Kaunas: Technologija, 2009. – No. 1(89). – P. 95–100.**

In Europe, the topic of recycling and energy efficiency is currently much at the focus. At the start of a new development process it is necessary to observe under all circumstances the aspect of product responsibility, like multiple reusability, long service life and suitability for environmentally compatible recycling and waste disposal. The scientifically-founded new tubular luminaire system discussed, with its extremely short sealing surfaces is specially suited for humid and dusty environments through an architecturally pleasing design and it fulfils these criteria in view, of the utilisation of modern materials and highest energy efficiency. Due to the modular design, all current electronic ballast units with the latest T5/16 mm lamp technology can be used. The use of most modern LED technology is also catered for by design. Ill. 7, bibl. 13 (in English; summaries in English, Russian and Lithuanian).

**Ф. Прахт. Трубчатая система светильника выполняющая требования соответствия изделия // Электроника и электротехника. – Каунас: Технология, 2009. – № 1(89). – С. 95–100.**

В настоящее время в Европе, тема рециркуляции и эффективности энергии является в центре внимания. В начале проектирования нового процесса необходимо соблюдать, при всех других обстоятельствах, аспект соответствия изделия возможности многократного использования, долгого обслуживаемого цикла эксплоатации, а также пригодности для экологически совместимой переработки и удаления отходов. Созданная новая трубчатая система светильника, с ее чрезвычайно короткими поверхностями герметизации особенно подходит для влажных и пыльных сред, а также имеет приятный архитектурный дизайн. Использование современных материалов и самой высокой эффективности энергии позволяет выполнить перечисленные критерии. Из-за модульного дизайна, все сегодняшние электронные балласты могут использоваться совместно с последней технологией T5/16 мм ламп. Также рассматривается использование самой современной светодиодной технологии. Ил. 7, библ. 13 (на английском языке, рефераты на английском, русском и литовском яз.).

**F. Prachtas. Vamzdinė šviestuvų sistema tenkinanti gaminio atitikties reikalavimus // Elektronika ir Elektrotechnika. – Kaunas: Technologija, 2009. – Nr. 1(89). – P. 95–100.**

Šiuo metu Europoje didelis dėmesys skiriamas perdirbimo ir energijos vartojimo efektyvumo temai. Naujo projektavimo proceso pradžioje reikia visuomet laikytis produkto atitikties reikalavimų, kaip antai, daugkartinio panaudojimo patogumo, ilgo veikimo laiko bei tinkamumo ekologiškai suderinamam jų perdirbimui ir atliekų išvežimui. Sukurta nauja vamzdinė šviestuvų sistema, su jos nepaprastai trumpais sandarinimo paviršiais ypač tinka drėgnoms ir dulkėtoms aplinkoms, turi malonų architektūrinį dizainą. Šiuolaikinių medžiagų ir aukščiausio energijos vartojimo efektyvumo panaudojimas leidžia įvykdyti išvardintus kriterijus. Modulinė konstrukcija leidžia naudoti visus dabartinius elektroninių balastų tipus su naujausia T5/16 mm lempos technologija. Taip pat svarstomas šiuolaikiškiausių šviesos diodų technologijų panaudojimas. Il. 7, bibl. 13 (anglų kalba; santraukos anglų, rusų ir lietuvių k.).

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